Santos

Site-Specific Environmental Authority

Petroleum Lease (PL) (1058) Bearcat

Response to Notice of Information Request

1. Introduction

Santos Limited (Santos) lodged an application for a new site-specific Environmental Authority (EA) with the Department of Environment and Science (DES) on 11th May 2021. Santos received a Notice of Information Request (Notice) on 22nd June 2021 (refer to Appendix A). The Notice outlines the further information requested by DES to assess the application.

Santos provides the following information in response to all of the information requested in the Notice, prior to the end of the information response period of 24th February 2022.

2. Information Request and Response

Sections 2.1 to 2.8 provide the elements of the DES Notice and the Santos response to the request.

2.1. DES Information Request Element (1)

Proposed activities

a. *As described in section 2.2. of the supporting information report, the application is seeking approval for 11 wells, all of which require authorisation for stimulation. It is also discussed that some will be gas wells targeting formations in the Cooper Basin and some will be oil wells targeting the Eromanga Basin. Section 2.3.3.2. states that well stimulation techniques may be used to increase the recovery of resources, in this case, gas.*

   Provide the following information:

   i. *the number of conventional oil wells proposed, and the number of conventional gas wells proposed*
   ii. *confirmation as to whether the stimulation approval is intended for both the gas and oil wells, or just the gas wells, and*
   iii. *if the oil wells are to be stimulated, provide a description on how the process varies from stimulation of gas wells.*

b. *Section 2.3.2 states that each proposed well lease will be between 1 to 1.5 hectares, or 1.65 ha if stimulation is required. The Ecology Assessment has applied a 1.6 ha disturbance area per well pad. Provide confirmation as to what disturbance area is being sought for each of the proposed 11 wells and what the total proposed disturbance for well pads is expected to be. Also provide confirmation on the quantities (i.e., 1, 1.5 or 1.65ha) that have been applied to calculate the prescribed environmental matter disturbances, as considered in section 6.2 of the supporting information report, and hence the accuracy of the disturbances proposed.*

Santos Response to Element 1a(i)

Santos proposes to drill and operate a combination of up to 11 conventional oil and/or gas wells in PL 1058 (comprised of one (1) existing conventional gas well (Bearcat-1) and up to 10 new conventional oil or gas wells). The proportion of oil vs gas wells is unknown at this stage and is subject to further exploration and appraisal. Based on information gained from the Bearcat-1 gas well, primary hydrocarbon targets in PL 1058 are expected to be gas (Cooper Basin). However, the drilling results from Bearcat-1 also identified a potential oil resource, which is to be investigated further by Santos.

The findings of future exploration studies and drilling activities will determine if the proposed new wells target oil or gas (or both) resources in PL 1058 i.e. if a new well is drilled, that successfully intercepts oil, additional oil wells may be drilled to target the same reservoir and so on. On this basis Santos requires flexibility to be able to respond to on-ground findings. Therefore, a determination of the explicit number oil versus gas wells for the tenure is not possible at this stage.

Santos has conservatively modelled cumulative drawdown impacts from oil and gas extraction (from the Cooper and Eromanga basins) from up to 11 gas wells and 13 oil wells (a total of 24 wells) in

PL 1058 (refer to the UWIR in Appendix D and the Golder Technical Memorandum in Appendix E in the application for further information).

The modelling identified that extraction from up to 24 petroleum wells on PL 1058 is not predicted to result in any significant change to the predicted impact to groundwater resources (refer to Section 5.5 of the application for further information). Santos is therefore of the view that the level of risk to the environment as presented in the application is acceptable and largely not influenced as to the number of wells targeting either oil or gas formations. The practices used to extract oil and gas, the mitigation and management measures as well as the risk and hazards described in the application contemplate the extraction of both of these conventional resources.

Santos Response to Element 1a(ii)

For the purposes of this application, it has been assumed stimulation will be required at all well locations, whether they be conventional gas or oil.

Santos Response to Element 1a(iii)

The hydraulic stimulation process, including well design, for both conventional oil and gas development is provided in Section 3, Vol. 1 of the *Stimulation Risk Assessment - Santos Southwest Queensland Tenements* (SRA) (Refer to Appendix B of this RFI Response).

Importantly, all Santos stimulation completions are designed, tested, undertaken, monitored and reported in accordance with the *Code of Practice - For the construction and abandonment of petroleum wells and associated bores in Queensland* (Queensland Government, December 2019) (the Code) including relevant legislative requirements identified in the *Queensland Petroleum and Gas (General Provisions) Regulation 2017*.

Hydraulic stimulation is employed to improve production efficiency of the oil and gas producing wells. This is achieved by increasing the conductivity within the reservoir and by increasing the fracture permeability, which in turn increases the efficient for oil and/or gas to flow to the well.

Conventional oil reservoirs in SWQ are associated with sandstone formations of the Eromanga Basin. As with gas wells, fracture stimulation is used in oil wells to achieve economic flowrates and production volumes. However, the oil-bearing formations in SWQ are less frequently dependent on stimulation to be economically viable compared with gas formations.

Conventional gas in SWQ is produced from sandstone reservoirs within the Toolachee and Patchawarra Formations of the Cooper Basin. The gas within these formations is stored as free gas within the pore spaces of the reservoirs, with much of the porosity as primary intergranular porosity. These sandstone reservoirs often have low permeability, and stimulation is necessary to achieve economic gas flowrates and production volumes.

For the most part, the stimulation process for conventional oil and gas wells is the same. The stimulation fluids currently applied to both oil and gas wells in SWQ is the same. The key difference between gas and oil well stimulations in SWQ relates to target depth and the associated variations in subsurface settings (e.g. pressure, temperature). Oil reservoirs in the Eromanga Basin are located at depths from 700 to 1,200 metres below ground level (mbgl) and gas reservoirs in the Cooper Basin at depths of 1,500 mbgl to greater than 2000 mbgl.

Generally speaking, these differences translate to variances in the scale of equipment required to complete the stimulation. For example, smaller oil reservoir fracturing treatments typically require less pumping horsepower and less fluid and proppant, and therefore require smaller equipment set-up than gas reservoir fracturing treatments (refer to Figure 33 and Appendix D in Volume One of the SRA for a typical equipment set up). Deeper gas reservoirs usually require higher pumping horsepower and therefore a larger equipment set-up.

Production wells may be subject to multiple stimulation events during the stimulation process. As detailed in the SRA, Santos employs methods to selectively isolate and individually fracture each hydrocarbon-bearing zone. A typical gas well will generally have more than one fracturing treatment; the current average is about six fracturing treatments per gas well. The typical Santos oil well will rarely have more than one fracturing treatment, due to the limited number of oil-bearing formations targeted by oil wells in SWQ.

Chemicals that may be used in the stimulation process by Santos in SWQ are detailed in Section 3 of Volume Two of the SRA. At present, the same stimulation fluids are used for both oil and gas stimulation activities in SWQ. Toxicity information is described in Volume Two and detailed Human Health Hazard Summaries and Ecological Information Sheets (Profiles) are provided in Appendix C to Appendix E of Volume Two of the SRA (attached to this RFI response as Appendix B). Relevant safety data and chemical information sheets are provided in Appendices C and F of Vol. 2 and 3 of the SRA, respectively. Chemicals not included in the SRA will be risk assessed prior to their use. This adaptive management is in line with that provided for by the streamlined model conditions (and conditions proposed by Santos in Schedule K, Appendix B (Proposed EA Conditions and Definitions) of the application). Refer to the Santos Response to Element 4h for further information on current chemicals intended to be used in the stimulation process.

Santos Response to Element 1b

Santos is seeking a well lease disturbance area of up to 1.65 ha, with a total combined maximum disturbance of 18.15 ha for well leases.

The ecological assessment (inclusive of the prescribed environmental matter disturbance assessment) undertaken for PL 1058 has been revised to consider the maximum disturbance area per well lease of 1.65 ha. This has resulted in an additional 0.5 ha of disturbance to that described in the submitted application material. This minor increase has resulted in no change to the outcomes of the prescribed environmental matter disturbance assessment. Please refer to Appendix C of this RFI response for the updated ecological assessment.

2.2. DES Information Request Element (2)

c. *The application proposes the inclusion of streamline model condition (SMC) Waste 16, varied to include a commencement date, as outlined in Appendix A of the supporting information report. This proposed condition would authorise the use of mix-bury cover as a method for disposing residual drilling material on site. No information has been provided on what the mix-bury cover method entails and what environmental risks are associated.*

Provide the following information:

i. *confirmation the mix-bury cover method proposed is consistent with the method detailed in the department's SMC for petroleum activities.*
ii. *quality characteristic criteria that are justified for the purpose of demonstrating the method is sustainable and will not cause environmental harm. As required under section 125(l)(i) of the Environmental Protection Act 194 (EP Act), consideration should be made to the site-specific characteristics of the environment i.e., flooding, Channel Country, when assessing the environmental values, emissions or releases, and risks and likely magnitudes of the proposed impacts, and*
iii. *with consideration to the site-specific characteristics of the landscape, demonstrate how the waste management hierarchy has been implemented, consistent with section 125(l)(i)(D) and 125(l)(ii) of the EP Act.*

d. *Section 4.9 of the supporting information report states that produced water may be re-used for the purposes of dust suppression, drilling and hydraulic fracture activities. Section 5.8 states that disposal may be undertaken in accordance with either the mix-bury over method or in accordance with method and quality certified by a suitably qualified third party. To achieve the*

water quality required by the proposed conditions for each of the proposed disposal methods, it is possible that treatment of produced water may be required.
Provide information that describes the water management practices proposed including any treatment methods to be undertaken. Include a copy of the most up to date proposed water management plan.

Santos Response to Element 2c (i to iii)

Residual drilling materials (RDM) will be managed on-site or off-site in accordance with the EA conditions proposed as part of the application, including the approved quality criteria where applicable.

In accordance with these conditions, RDM will be either be lawfully disposed off-site to an appropriately licenced facility or managed on-site either by the standard approved mix-bury-cover methodology, as defined in the proposed EA conditions, or via an alternate certified methodology.

For on-site management, Santos will ensure the sump contents meet the approved quality criteria prescribed in the proposed EA conditions to safely undertake the mix, bury, cover methodology, or alternatively they will be managed via a different method which has been certified by a suitably quality third party to not result in environmental harm and complies with other conditions of the EA e.g. RDM disposal must not result in direct or indirect release of contaminants to any waters. Such a methodology will have to consider the relevant environmental values and conditions of the region to ensure it is appropriate and the risk to the environment remains acceptable.

When RDM is buried at depth and capped with compacted clay rich soil there is no ability for direct interaction between the RDM and surface water should a wellsite become inundated. Moreover, the clay lining of the sump walls minimises risk of any seepage and passage of the wetting front. The compacted fine grey clays used as sump lining and capping material for RDM management have a very low hydraulic conductivity, providing for very limited infiltration potential into the buried RDM. Therefore, during a potential inundation event, there is no potential for dissolution and movement of RDM to surface water.

As discussed in the application, despite being situated in the Channel Country bioregion, PL 1058 is predominantly located in a flat alluvial herbland, with sporadic isolated sand dunes, and minor areas of channel country / wetland areas located at the extremities of the western tenure boundary (refer to Figure 1 at Element 7 below). PL 1058 may therefore be exposed to shallow inundation risk during larger Cooper Creek flood events, however, the land systems present suggest the majority of the tenure is less severely inundated and holds water for shorter periods of time compared with channel country / wetland areas. The minor areas of channel country / wetland areas located near the western tenure boundary will likely flood more frequently and hold water for extended periods. Larger Cooper Creek flood events (with the potential to reach Lake Eyre) occur approximately once in every ten years.

Due to the slow-moving nature of flood waters in the Cooper Creek, if the tenure were exposed to inundation risk, sufficient time (i.e. several weeks to months) is generally available to prepare operational areas for potential flood impacts. This includes prioritising drilling sumps located in low-lying areas for decommissioning following completion of drilling activities.

Whilst the generation of RDM cannot be avoided, the ability to safely manage residual drilling material on-site results in reduced volumes of waste going to landfill. This is preferred in accordance with the waste management hierarchy under the *Waste Reduction and Recycling Act 2011*. Recycling and recovery of RDM for beneficial use is impractical in the region due to the significant transportation requirements and remote location of the activities. Further, beneficial uses of RDM are limited, of low economic benefit, and the material poses a limited risk to the receiving environment when disposed of onsite appropriately.

Santos Response to Element 2d

Santos assumes the reference to the disposal of RDM by mix bury cover method at Element 2 (d) is an error.

No centralised produced water management ponds or petroleum-processing infrastructure are proposed to be constructed/undertaken or located within PL 1058. As specified in Section 2.3.7 of the application supporting information, produced petroleum product (petroleum product and water) may be temporarily stored in above-ground tanks (totalling approximately 100-150 m^3, and less than 500 m^3) in accordance with relevant Australian Standards. Produced total fluids will either be transferred off-tenure via trucking from the above-ground tanks or transferred via pipelines to a centralised processing facilities and water management facilities. Produced total fluids generated on PL 1058 will be transferred to existing Santos facilities such as the Ballera Gas Facility, or potentially Jackson, Watson or Patroclus Oil Facilities.

Consistent with the waste hierarchy, and in accordance with the requirements and outcomes of proposed EA conditions (e.g. I8 and I9), produced water may be re-used on PL 1058 for the purposes of dust suppression, drilling and hydraulic fracture activities. If the water is not of an appropriate quality, it will not be used for these purposes. No on-site water treatment is proposed.

2.3. DES Information Request Element (3)

Waste

e. *Section 2.3.3.1 of the supporting information report states that drilling fluid would be used and continuously circulated through the drill pipe and surface equipment and drilling fluid will be stored using a drilling sump.*

Provide the following information:

- *the types of drilling fluids to be used in the process and whether they are oil-based or synthetic based fluids,*
- *the proposed management practices of waste drilling fluids and cuttings,*
- *the design features of the drilling sumps (i.e., enclosed or open systems, construction details, what materials are used, how impervious the materials are), and*
- *description of the management practices proposed including measures to mitigate and minimise contaminants being released to the environment.*

f. *It is stated in section 4.9 of the supporting information report that, similar to the use of produced water for dust suppression, drilling and hydraulic fracturing activities, hydro-test water may be released to land at the end of the testing for disposal.*

Provide the following information:

- *details as to what constitutes hydro-test water,*
- *a description of the risk and likely magnitude of impacts on the environment as a result of releasing hydro-test water to land, and*
- *details of the management practices proposed to be implemented to prevent or minimise adverse impacts including what the appropriate quality is to release to land.*

Santos Response to Element 3e

Drilling fluids will be water based, and not oil or synthetic based in accordance with proposed EA condition K1 - *Oil based or synthetic based drilling muds must not be used in the carrying out of the petroleum activity(ies).*

Proposed management practices for waste drilling fluids, cuttings and the design of drilling sumps would be undertaken to ensure compliance with proposed EA conditions. Refer to Santos response to Element 2 for further information on proposed management practices for waste drilling fluids and cuttings.

Drilling sumps are designed, constructed and operated in accordance with the following criteria to minimise contaminants being released to the environment:

- contain fluids for no longer than 24 months;
- sump volume is rig / well specific (typically ranges from 600 to 3,000 m^2);
- sump is located on the well lease, which is typically elevated above surrounding landform;
- open sump void with straight sides and sloped front and back;
- sump walls are lined with locally sourced clay to minimise the risk of seepage and passage of the wetting front;
- sump capacity is conservatively calculated assuming 1 m of additional freeboard for expected contents volume – this ensures additional freeboard is provided.
- sump capacity is monitored during drilling activities to ensure appropriate freeboard is maintained;
- fenced to mitigate large fauna entering the sump;

- a low berm is constructed around the perimeter of the sump (to mitigate potential for surface water inflows);
- drilling sumps located in areas subject to potential seasonal inundation or overland flows are prioritised for decommissioning; and
- upon decommissioning, the sump capping material is rolled and compacted using a bulldozer, with an additional volume of compacted material placed on top of the sump (typically 300mm above the surrounding well lease level) in case any minor slumping occurs.

Santos Response to Element 3f

Upon review of proposed activities to be undertaken within PL 1058, Santos no longer proposes to release hydro-test water to land. Instead hydrotest water will be either captured in tanks or lined pits for reuse/recycling or it will be transported to an existing Santos waste facility located outside of PL 1058 for disposal.

Santos proposes to remove condition I14 from proposed EA conditions for PL 1058.

2.4. DES Information Request Element (4)

Hydraulic Fracturing

g. The application is accompanied by Appendix G: SWQ Hydraulic Fracture Risk assessment that contains:

- *Site Setting and Hydraulic Fracturing Process report dated 20 December 2012 and*
- *Human Health and Ecological Risk Assessment – Schlumberger Chemicals dated 5 February 2014.*

i. The documents within Appendix G are generic and broadly covers the activities across South West Queensland, therefore have not been provided specific to the proposed activities to which the application relates. Provide reference to the particular information/sections of these documents that are relevant and are to be considered for this site-specific application.

ii. Noting the dates of the two reports, provide confirmation that these documents provide information that is still current, relevant and accurate for the activities being proposed.

h. It is stated in section 2.3.3.2 of the supporting information report that approximately 99.5% of the material pumped into the well is water and sand, while minor quantities of additives make up the remaining 0.5% of the fluid. The purpose of these additives is explained but what constitutes the fluid is not.

Provide the following information:

- *the chemicals intended to be used in the stimulation/hydraulic fracturing process and the toxicity of the ingredients and mixtures,*
- *an environmental risk assessment for wells to be stimulated,*
- *details of the proposed hydraulic fracturing operations, and*
- *details of any stimulation impact monitoring program.*

Santos Response to Element 4g (i to ii)

The Santos SWQ Hydraulic Fracture Risk Assessment was revised in June 2020 and is attached to this RFI response as Appendix B. The revised version of the risk assessment is referred to as the *Stimulation Risk Assessment - Santos Southwest Queensland Tenements* (SRA). The information provided in the June 2020 SRA is current, relevant and accurate for the activities proposed in the site-specific EA application.

The SRA has been written as a single overarching risk assessment that covers all relevant matters for Santos' operations in SWQ. The SRA has been written to address the regulatory requirements of proposed EA conditions (K6 and K7) as detailed in the Appendix B of the application.

In addition to meeting the regulatory requirements contained with the proposed EA conditions, the SRA, which serves to consolidate a range of internal technical assessments, monitoring and reporting processes completed for each well prior to, during and following completion of stimulation activities into an overarching risk assessment document. In doing so it synthesises the findings of several hydraulic fracturing risk assessments completed to date and includes details of processes and procedures undertaken prior to, during and post stimulation activities occurring, including evaluation of the regional conditions, design and operational processes, constraints planning and evaluation of chemicals used in the hydraulic fracturing process.

Evaluation of these requirements must be considered in the context of other approval and regulatory requirements. As described further in the SRA, the drilling, completion and hydraulic fracturing is conducted in accordance with the *Code of Practice for the Construction and Abandonment of Petroleum Wells and Associated Bores in Queensland* (version 2 December 2019) [Code of Practice], which is overseen by the Department of Resources (DOR). No well can be drilled or hydraulically fractured without completion of DOR's prescribed process and reporting requirements.

The SRA includes an assessment of the nature, extent and potential impact of stimulation activities in SWQ and allows for the proper and efficient management of activities that have the potential to cause environment harm. The SRA also describes the process by which hydraulic fracturing is conducted and monitored.

As all wells have the potential to be hydraulically stimulated at one or more point in time, the single SRA approach is considered appropriate to cover all wells. The document includes information and assessment on all the hydraulic fracturing fluids currently used by Santos in SWQ and provides a framework for inclusion of new fluids systems within the risk assessment as required. To facilitate the assessment and compilation of risk assessments completed on multiple fluid systems, the SRA is presented in two volumes:

- Volume One of the SRA discusses the environmental and geological settings within which Santos' stimulation activities take place, and the general techniques for the drilling, completion and stimulation of wells. The report also discusses why stimulation sis essential in SWQ and outlines Santos's current froward programme for fracture-stimulations (noting that this is frequently reviewed and subject to change).
- Volume Two relates specifically to the stimulation fluids proposes to be used by Santos' service provides on both conventional oil and gas wells in SWQ. The report considers the ecological and human health toxicity of the chemical constituents in the stimulation fluids and includes an exposure pathway assessment and risk characterisations based on a review of complete exposure pathways and controls to mitigate exposure.

Table 1, Section 1.3.2, Volume One of the SRA provides a detailed guide to the sections of the SRA specifically relevant to the site-specific EA application e.g. environmental values of groundwater in the project area, environmental hazard assessment of chemicals used during stimulation (including mixtures and the resultant chemicals formed after stimulation).

The SRA utilises multiple assessment hazard and risk assessment methodologies (in accordance with International Best Practices) to assess the hazards/risks associated with the hydraulic fracturing process and/or posed by hydraulic fracturing fluids / individual chemicals. Through this process it has been demonstrated that through the implementation of the Code of Practice, International Best Practice (for well completions and hydraulic fracturing) and Santos Management controls (which meet

other regulatory requirements and/or were informed by the risk assessment), the probability and consequence of environmental harm from hydraulic fracturing is considered low and acceptable.

The framework of the SRA has been developed to be readily applied to all wells across Santos' SWQ tenures, inconsideration of well specific geological, hydrogeological and environmental settings. As such the SRA, including discussion of processes and procedures required to be implemented on a specific, is applicable to the proposed activities to which the application relates. The area is sparsely developed, and generally comprises remote rural communities and homesteads that are largely engaged in agriculture, such as livestock grazing.

Well specific documentation showing the implementation of management controls detailed within the SRA will be developed once location(s) are finalised. As required by the Code of Practice, and consistent with Santos' reporting requirements to DoR (in accordance with the relevant resource legislation), each stimulation operation is risk assessed and the process is documented prior to execution. This process demonstrates that the well has been specifically designed, and appropriate management controls have been implemented, for the (subsurface) conditions encountered in the relevant well in accordance with the SRA. Well specific documentation is completed via Santos processes - such as subsurface well planning, integrated disturbance planning, well construction planning, formation and hydraulic fracturing design evaluation to:

- support well siting (avoid sub-surface and/or surface areas of concern or areas where Environmental Authorities preclude well installation and/or hydraulic fracturing),
- verify the suitability of well construction (including testing of wells); and
- ensure robust design and testing is completed for all hydraulic fracturing assignments.

Santos Response to Element 4h

Chemicals that may be used in the stimulation process by Santos in SWQ are detailed in Section 3 of Volume Two of the SRA. Toxicity information is described in Volume Two and detailed Human Health Hazard Summaries and Ecological Information Sheets (Profiles) are provided in Appendix C to Appendix E of Volume Two of the SRA (attached to this RFI response as Appendix B).

The SRA has been compiled to ensure its scope adequately assesses risks associated with stimulation operations in all of Santos' SWQ tenures, inclusive of proposed activities in PL 1058. Refer to Santos' response to RFI Element 1a for further information on the stimulation process.

As discussed above, Volume Two of the SRA relates specifically to the stimulation fluids proposed to be used by Santos' service providers on both conventional oil and gas wells in SWQ. The report considers the ecological and human health toxicity of the chemical constituents in the stimulation fluids and includes an exposure pathway assessment and risk characterisations based on a review of complete exposure pathways and controls to mitigate exposure.

Volume Two specifically relates to the stimulation fluids proposed by Santos' current stimulation service provide Halliburton. These are all chemicals that may be used in the stimulation process at this point in time. The document also provides a framework for inclusion of new stimulation fluids within the risk assessment document as required as operations mature. The report details the environmental risk assessment of the fluid systems including:

- an exposure assessment including identification of potential and complete exposure pathways
- detailed description of products including chemical constituents and mass balance calculations
- an aquatic and terrestrial toxicity assessment
- a human health toxicity assessment, and
- risk characterisation.

The SRA has been completed using best practice methodologies. The SRA has been undertaken in general accordance with the *Guideline on Ecological Risk Assessment* (NEPM, Schedule B(5), 2013 and draft guidance prepared by EPA Victoria (Gibson et al., 1997) and national guidelines for risk assessment recommended by enHealth (enHealth-Environmental Health Risk Assessment, *Guidelines for Assessing Human Health Risks from Environment Hazards*, June 2012).

Refer to Section 3, Volume 1 of the SRA (attached to this RFI response as Appendix B) for a detailed description of proposed hydraulic fracturing operations. Hydraulic fracturing operations / methods will only be utilised where necessary, but they are assumed to be required for all wells for the purposes of the application.

Stimulation impact monitoring will be undertaken in accordance with proposed EA conditions K10 to K13, and in accordance with the Santos *South-West Queensland Stimulation Impact Monitoring Program* (SIMP). The SIMP has been compiled to ensure stimulation operations are undertaken in accordance with the monitoring requirements of proposed EA conditions (the SIMP is attached to this RFI response as Appendix D).

Refer to Santos Response to Element 4g above for information on environmental risk assessments undertaken for wells to be stimulated.

2.5. DES Information Request Element (5)

Air Emissions

i. Section 2.3.2 of the supporting information report states that each proposed well lease would be established to accommodate several activities including flares. Throughout section 5 it is described that direct and indirect impacts to certain environmental values may result from ignition sources resulting from activities. However, no assessment has been provided for flaring or ignition in the proposal.

Provide the following information:

- *a description of releases from flaring or ignition activities, including location and expected air emissions (quality and frequency of release),*
- *expected impacts on each of the environmental values of air (as listed in section 4.7 of the supporting information report)*
- *background air quality data that may be source and available from adjacent or local tenure holders (Note: the air quality monitoring data provided cannot be considered since they are not relevant to the proposed site), and*
- *proposed mitigation and management practices to avoid and minimise impacts to environmental values.*

Santos Response to Element 5i

Section 5 of the EA application identifies and assesses potential impacts, mitigation measures (control strategies), and environmental risks to relevant environment values resulting from carrying out proposed activities as required by Section 125 of the EP Act.

Risk assessments for a proposed activity identify a wide range of risks and potential impacts to relevant environmental values as a result of carrying out a proposed activity. This should not be interpreted to assume that all identified potential impacts will occur as a result of carrying out the activities. Once initial unmitigated risks and potential impacts are identified as part of a risk assessment, appropriate control strategies are identified and implemented. Appropriately implemented control strategies will typically mitigate the likelihood of a potential impact from occurring, and/or reduce the severity/consequences of the potential impact.

Santos will not undertake flaring activities in an ongoing basis for petroleum activities located on PL 1058. The utilisation of flaring is not advantageous to Santos and would only be undertaken for the purposes of short-term safety or emergency measures as part of well drilling, stimulation activities and initial production testing operations on PL 1058. Santos preferentially flows gas into tanks or existing gathering infrastructure to capture the resource as opposed to flaring.

The main instance of flaring for proposed activities on PL 1058 will be upon completion of stimulation operations when residual stimulation fluid (in the well and target formations) is flowed back to surface and into a gas-water separator. The water is flowed to a tank or lined pond, and any residual gas is flared as there is no alternative safe disposal method. Flaring in this instance typically occurs over 5-7 days. Where a well can be connected into existing gathering infrastructure, flaring can be avoided as gas can be flowed directly into existing gathering and onto production facilities. However, exploration wells located in remote areas do not typically have nearby gathering infrastructure to easily connect into.

Flaring operations in PL 1058 would be minimised wherever possible, and are localised to the well lease, with a short-term and intermittent frequency. As such, emissions generated by flaring operations are not expected to result in any substantial impacts to air quality environmental values. Where wells are successful, Santos aims to connect them to the greater gathering network as soon as possible to commercialise the resource. Flares will be designed and operated in accordance with relevant petroleum legislation and Australian standards.

Potential air quality impacts from the proposed flaring activities within PL 1058 will be localised and highly unlikely to significantly impact the air quality environmental values of PL 1058. This is primarily due to the very short duration of flaring at any given well. In consideration of this, an additional air quality impact assessment has not been undertaken. The existing risk assessment for the proposed development and as presented in Table 5-1 of the application, remains appropriate for the proposed activities given the small number of temporary new emission sources proposed, the remote nature of the location, the lack of other industry/pollutant sources in the region, and the absence of sensitive receptors. The nearest sensitive receptor is Orientos Pastoral Station homestead, which is located approximately 30 km south-west of PL 1058 boundary.

Ignition sources discussed in Section 5 of the EA application refer to the potential for fires (e.g. bushfires) to occur due to undertaking proposed activities i.e. “fire (ignition sources resulting from activities)”. Although unlikely, bushfires have the potential to occur when undertaking a range of industrial and agricultural activities in natural environments e.g. vehicle exhausts interacting with dry grass can cause bushfires. These events are unlikely to occur as a result of undertaking the proposed activities, and have been mitigated, and risk assessed as such. Management (control) strategies, risk sources, potential impacts and the level of risk associated with the proposed activities are summarised in Table 5-1 in the application. The results of the risk assessment indicate that residual risks to air quality values as a result of the proposed activities are classified as ‘low’.

Existing air quality of PL 1058 is typical of a remote environment influenced by the existing petroleum activities and agricultural industries. Air quality in the region will be very good due to the general lack of urban or industrial development in the region, and the absence of large emissions generating industry located in the broader region. Further, there are no potential sensitive receptors for air located in PL 1058. The closest sensitive receptor is the Orientos Pastoral Station homestead, which is located approximately 30 km south-west of PL 1058 boundary.

There are no ambient air quality monitoring stations (AQMSs) located within the vicinity of PL 1058, and there is no other source of air quality data available to Santos to the best of our knowledge. The closest DES AQMS is located at Moranbah, approximately 900 km northeast of PL 1058. This monitoring station has been operational since 2011 and was established to measure particle levels (particulate matter (PM10 and PM2.5)) from coal mining operations in the community and surrounding

area. The Toowoomba AQMS was the closest station for oxides of nitrogen (NOx) and carbon monoxide (CO) (located approximately 1,000 km east of PL 1058). This station was operational from 2003 to 2010. Consequently, given the urban and/or industrial nature of these regions, Table 4-5 in the EA application provides a very conservative estimate of the background air quality in SWQ. There is an alternative DES AQMS located in south-western Qld (e.g. Miles Airport), but this AQMS is still located ~850 km east of PL 1058 (refer to Table 1 below).

Table 1: Air Quality – Miles Airport, Queensland (Current measurements at 18 January 2022)

Parameter	Measurement	Running average
Particle $PM_{2.5}$	4µg/m³	6.8µg/m³ (24hr avg)
Particle PM_{10}	10µg/m³	22.9µg/m³ (24hr avg)
Carbon monoxide	0.2ppm	0.1ppm (8hr avg)
Nitrogen dioxide	0.001ppm	0.001ppm (1hr avg)

Source: DES Available online at: https://apps.des.qld.gov.au/air-quality/stations/?station=mil

2.6. DES Information Request Element (6)

Blasting

j. It is stated in section 5.7 of the supporting information report that the application is seeking to adopt the department's SMCs for petroleum activities to authorise blasting. However, no information has been provided to describe the frequency, intensity and level of impacts to environmental values from blasting activities.

Provide the following information:

- *details of any emissions or releases likely to be generated from blasting at the proposed site,*
- *an assessment of the risk and likely magnitude of impacts on the environmental values (including protecting the biodiversity of ecosystems) and*
- *details of the management practices proposed to be implemented to prevent or minimise adverse impacts.*

Santos Response to Element 6j

Although unlikely to be required for proposed activities on PL 1058, small-scale blasting activities may be used as part of the proposed petroleum activities for specific purposes such as for blasting large areas of rock encountered when trenching during pipeline construction, or as an alternative energy source for seismic surveys (shot holes). In the rare event blasting is require, these small-scale activities would be very localised, short-term and transient activities only. The blasting will not be associated with the extraction of material for use for other purposes (i.e. quarrying).

Santos would undertake blasting activities in accordance with proposed EA conditions (G4 to G6) and relevant Australian Standards. If blasting is required to be undertaken on PL 1058, Santos would develop a blast management plan in accordance with proposed EA condition G4.

Further, any noise or vibrations generated by the proposed activities is highly unlikely to cause nuisance to the nearest sensitive receptor, which is located approximately 30 km from the boundary of PL 1058.

2.7. DES Information Request Element (7)

Significant Residual Impact (SRI) Assessments

k. The SRI criteria response for regulated vegetation does not reference the Regional Ecosystems (REs) relevant to the disturbance or the expected disturbance infrastructure. Therefore, it is not clearly demonstrated to what extent disturbance will occur within RE areas

and how the applicant will guarantee that the SRI thresholds, in accordance with the 'Queensland Environmental Offsets Policy Significant Residual Impact Guideline, Nature Conservation Act 1992, Environmental Protection Act 1994, Marine Parks Act 2004,' dated December 2014 (SRI Guideline), will not be exceeded. Note: the SRI limits must be determined cumulatively per RE type. For example, clearing other than linear infrastructure within RE 5.6.4. (sparse) must not exceed 2ha of clearing across the project, otherwise a SRI is triggered, and authorisation is required. Provide information on the details considered to determine whether SRI will occur for regulated vegetation matters, including the relevant identified REs and quantities of areas required for linear and non-linear infrastructure. Also, it must be demonstrated how it will be ensured that activities will cumulatively not exceed the SRI limits.

l. *Table 6-6 provides an impact assessment of PL 1058 MSES for wetlands and watercourses. In response to the criteria states "…. areas of the wetland or watercourse being destroyed or artificially modified". The response also states that this is "unlikely." However, 0.9ha of wetland is proposed to be cleared, suggesting that an area of the wetland will be destroyed. It is also not confirmed when revegetation of the area will be guaranteed suggesting that the area will be modified, and for an unknown period.*

   A reassessment of this criteria in Table 6-6 is required that directly addresses whether the proposed activities are destroying or artificially modifying the landscape. Note: Rehabilitation and timing is not a prompted consideration in the SRI guideline, therefore is not relevant to the criteria.

m. *In accordance with section 5.1. of the SRI guideline, an action is likely to have a SRI on endangered or vulnerable wildlife or species of least concern if the activity causes disruption to ecologically significant locations. Examples of such areas include breeding, feeding or nesting sites. The response provided for the grey grasswren and echidna against potential disruption to ecologically significant locations does not satisfy that this requirement is met.*
   For the grey grasswren it is acknowledged that 11.55ha of habitat will be cleared. The reasoning for not causing disruption of ecologically significant locations focusses on the recovery of the species habitat (of which only 3.9ha will be rehabilitated), and the presence of the species habitat within other areas of the petroleum lease. This response does not address how clearing 11.55ha of habitat would not cause disruption to ecologically significant locations.

   In relation to the echidna, the response states that 115.5ha of habitat clearing will likely include breeding, feeding and nesting habitat. The response disregards the criteria to be triggered due to the distribution of the species and long-term population sustainability, which are considerations relevant to other criteria (described in section 5.1. of the SRI guideline) and are not relevant to the disruption to ecologically significant locations (breeding, feeding or nesting sites). Provide a reassessment of the SRI of the grey grasswren and echidna with justification that is specific to each criteria, as outlined in section 5.1 of the SRI guideline.

n. *Throughout the Ecological Assessment report (document reference: QEJ19010_PL 1058_EcoAssessment_Rev2) makes reference to Figure 5 relating to threatened species habitat to be presented on page 17. However, this figure is not contained within the document. Provide a revised copy of the report which contains Figure 5.*

Santos Response to Element 7k

Santos will not exceed the MSES Significant Residual Impact (SRI) disturbance limits for each Regional Ecosystem (RE) that is Regulated Vegetation, as specified in Section 2 "*Significant residual impact test – criteria Table 1*" of the *Queensland Environmental Offsets Policy Significant Residual Impact Guideline* (2014) (SRI Guideline). Santos has an understanding of the prospective areas for oil and gas within the PL 1058 tenure based on the findings of previous seismic surveys and drilling results. However, Santos does not yet know the precise location of the majority of proposed wells and associated infrastructure to be located within PL 1058.

Conventional petroleum activities typically involve drilling a small number of deep, precisely located wells targeting small-localised accumulations of hydrocarbons (unlike CSG activities, which typically target a relatively shallow broad resource i.e. coal seams). Further, unlike CSG, the precise location of a proposed conventional oil or gas well is typically contingent on detailed assessment of the findings of previous nearby well drilling and seismic survey activities. Once the precise "bottom hole" (BH) location of a well is determined for geological purposes, the surface location may be subject to a range of restrictions and sensitivities, and the well lease (and supporting infrastructure) may need to be shifted to avoid these areas e.g. cultural heritage and environmental sensitivities. In some cases, the well bore may even be "deviated" to avoid surface sensitivities, but still target the BH location.

Therefore, total disturbance within each RE that is Regulated Vegetation cannot be determined until the precise BH location of each proposed well is finalised, and the surface location is assessed for environmental and other sensitivities. Santos will utilise internal pre-activity approval processes and disturbance tracking methodologies to ensure proposed activities do not exceed the SRI limits. Final well locations (and supporting infrastructure) will be subject to site-specific assessment.

The proposed petroleum activities are conservatively estimated to impact up to 116 hectares of remnant native vegetation comprising 'least concern' RE (refer to Santos Response to Element 1b for further information). Least concern RE is not a prescribed environmental matter. Prescribed environmental matters are limited to remnant Endangered and Of Concern REs only. The only place regulated vegetation that is a prescribed environmental matter may be impacted is where the disturbance lies within a mapped wetland, and is within 50 m of the defining bank of the wetland, or within the defined distance of a watercourse, and within 5m of the defining bank.

For the purposes of impact assessment, a large proportion of the proposed disturbance footprint has been located within 'high constraint' areas, where appropriate (refer to Figure 5-1 in the ecological assessment report in Appendix C). As such, the assessment of impacts within the application takes a precautionary approach and simulates a conservative disturbance scenario.

At any point, if the proposed activities were expected to cumulatively exceed SRI disturbance limits for regulated vegetation, Santos would seek appropriate regulatory authorisations i.e. EA amendment.

Santos Response to Element 7l

HES wetlands intersected by PL 1058 are located at the far north-western and south-western tenure boundaries. Only 0.7 % (35.9 ha) of PL 1058 is mapped as a HES wetland. These small HES wetland areas are connected to a significantly broader area of HES (and GES) mapped wetland in the surrounding region (refer to Figure 1 below). This broader area is essentially one large intermittently flooded wetland system i.e. the Cooper Creek drainage basin wetland area. To provide context, there is more than 100,000 ha of interconnected HES wetland mapped within 30 km of PL 1058. The HES wetlands mapped in PL 1058 are not isolated confined wetlands, but rather minor areas of a significantly larger interconnected wetland system (floodplain).

As part of the proposed activities in PL 1058, Santos conservatively estimates 0.9 ha of vegetation located in a HES wetland will require clearing. The clearing of an area of vegetation within a wetland will not necessarily result in the environmental values of the wetland being "destroyed or artificially modified" as the activities are not substantial enough to impact the function of the wetland, particularly given implementation of proposed EA conditions and other mitigation measures outlined in the application. Further, as discussed in the application, proposed petroleum activities will be scheduled to be completed when no surface water is expected to be present within the PL, and outside of flood events/inundation periods.

Moreover, the terms "destroyed" and "artificially modified" are not defined by the SRI Guideline. However, "*Wetland environmental values*" are defined in the SRI Guideline to include the following:

a) the health and biodiversity of the wetland's ecosystem;

b) the wetland's natural state and biological integrity;
c) the presence of distinct or unique features, plants or animals and their habitats, including extinct in the wild wildlife, vulnerable wildlife, near threatened wildlife and least concern wildlife under the *Nature Conservation Act 1992*;
d) the wetland's natural hydrological cycle;
e) the natural interaction of the wetland with other ecosystems, including other wetlands.

Clearing up to 0.9 ha of vegetation in the HES wetland in PL 1058 is unlikely to result in:

a) any of the wetland environmental values listed above from being significantly or substantially negatively affected (given implementation of proposed EA conditions and the mitigation measures discussed in the application); and
b) the Cooper Creek wetland being "destroyed" or "artificially modified".

Further, potential impacts resulting from proposed activities are largely considered to be short-term in nature (e.g. pipeline construction), or will otherwise be mitigated through compliance with proposed EA conditions and mitigation measures discussed in the application.

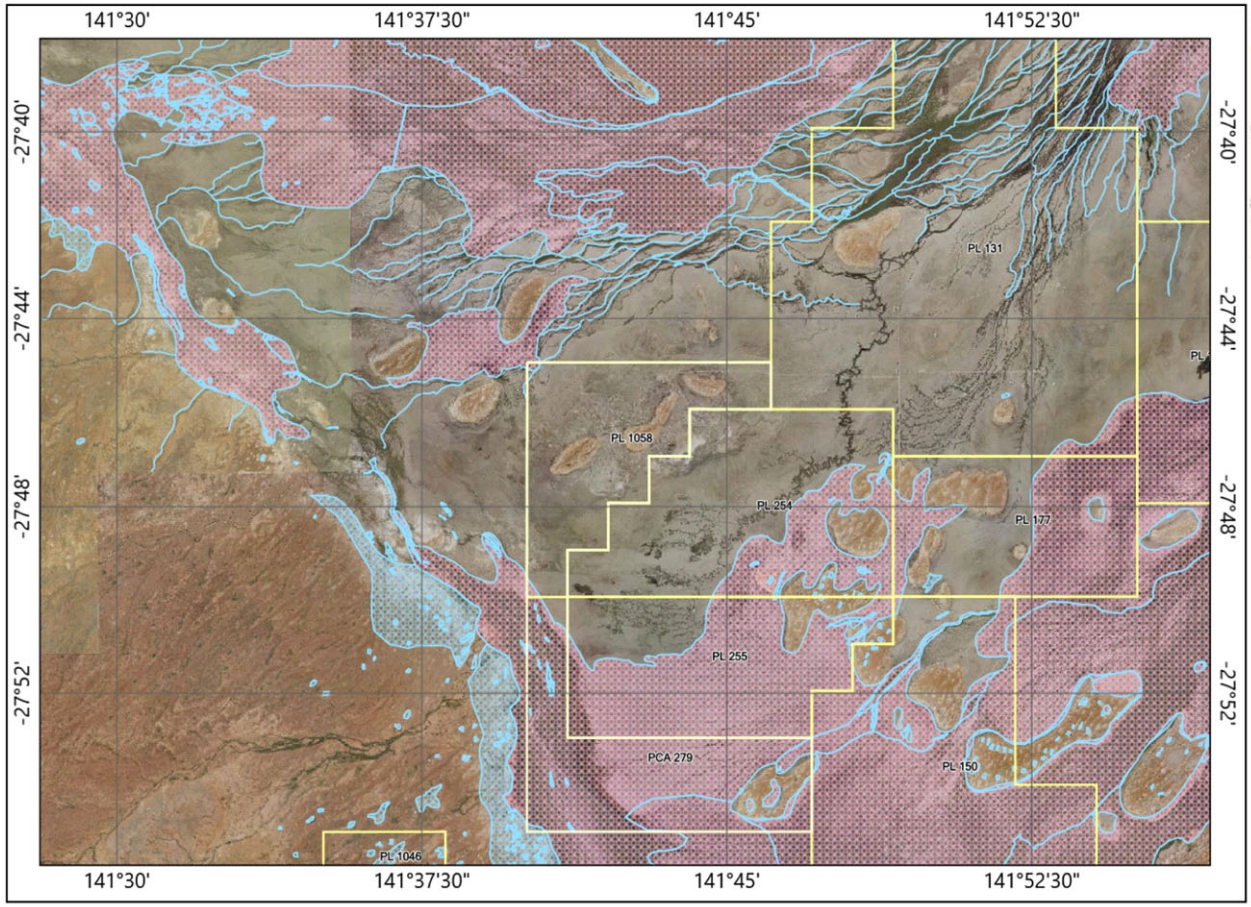
Santos will undertake the proposed activities in accordance with proposed Schedule B 'Water' EA conditions. These conditions appropriately mitigate and minimise disturbance to watercourses and wetlands, for example:

- Proposed condition (B10) and (B11) prohibit activities from changing the existing surface water hydrological regime, impacting on the flow of surface water, impacting on surface water quality and impacting on bank stability within GES and HES wetlands; and
- Activities in floodplains, as required by proposed condition (B17) must be carried in a way that does not concentrate flood flows, divert flood flows from natural drainage paths, alter flow distribution, increase the local duration of floods or increase the risk of detaining flood flows.

In summary, the proposed petroleum activities in PL 1058 are unlikely to cause a significant residual impact to HES wetland values as defined in Section 4 of the SRI Guideline.

Santos

Figure 1: PL 1058 - HES and GES Mapped Wetlands



Santos Response to Element 7m

The term "ecologically significant location" is not defined in the SRI Guideline, but it is stated to include "breeding, feeding, nesting, migration or resting sites" for endangered and vulnerable wildlife, and "breeding, feeding or nesting sites" for special least concern (non-migratory) species. In relation to grey grasswren and echidna, these species have broad areas of occupancy in the region, and relatively broad habitat suitability requirements i.e. breeding, feeding, nesting, migration or resting sites would be present in all suitable vegetation communities for each species in the region. Further, unless a vegetation community is not suitable for either species, it would be very difficult to justify ruling out areas of suitable vegetation as not providing at least one of the ecological significant location attributes in accordance with the SRI Guideline. Due to this, the SRI assessment undertaken by E2M considered that all suitable habitat within PL 1058 for each species represented ecologically significant locations for the species. In the context of listed species that have broad habitat requirements and extensive areas of occupancy, the application of "ecologically significant location" SRI criteria is therefore erroneous.

Further, the proposed activities will not result in disruption to ecologically significant locations for the grey grasswren and echidna because these species have significant widespread suitable breeding, feeding, nesting, migration or resting habitat available in the immediate and broader region surrounding PL 1058. Disruption to very minor areas of habitat for these species in PL 1058 will therefore be insignificant to the size, extent and distribution of the local population of the species. Further justification on why the proposed disturbance would not be significant for grey grasswren and echidna is provided below.

Grey Grasswren

In SWQ, the grey grasswren is known to be present in shrubland vegetation communities dominated by Lignum (*Duma florulenta*), Queensland bluebush (*Chenopodium auricomum*), Swamp canegrass (*Eragrostis australasica*) and *Samphire* spp. Of these vegetation communities, Lignum and Swamp canegrass communities provide suitable foraging and breeding habitat, and *Samphire* spp. and other *Chenopod* spp. communities provide suitable foraging habitat. Within PL 1058 and the surrounding region, these vegetation communities are captured in Regional Ecosystem (RE) mapping descriptions 5.3.7, 5.3.8a, 5.3.13a, 5.3.16a and 5.3.18a. These REs may be classified as ecologically significant areas in accordance with the SRI guideline.

PL 1058 is predominantly mapped as a variable-sparse open herbland vegetation community dominated by REs 5.3.18b, 5.3.19, 5.6.4 and 5.6.8 (83% or 4032 ha of the tenure). These REs do not provide suitable foraging and breeding habitat for grey grasswren i.e. they would not be ecological significant locations in accordance with the SRI Guideline.

For comparison, only 17% (or 818 ha) of the tenure is mapped to be REs 5.3.13a and 5.3.18a, which may represent suitable foraging and breeding habitat for grey grasswren. Of these 2 RE's, only RE 5.3.13a provides highly suitable foraging and breeding habitat (that being Lignum - *Duma florulenta* vegetation) for the species, with RE 5.3.18a providing foraging habitat.

For context, the region immediately surrounding PL 1058 (~20 km radius of the tenure boundary) is DES mapped to contain more than 20,000 ha of REs 5.3.7, 5.3.8a, 5.3.13a, 5.3.16a and 5.3.18a – which represent suitable foraging and breeding habitat for grey grasswren. Further, these REs form a dominant component of the broader Cooper Creek floodplain in the region. For context, the broader region surrounding PL 1058 is DES mapped to support ~200,000 ha of these REs.

Further, Santos will maximise avoidance of disturbance to ground-truthed RE 5.3.13a in PL 1058 as far as reasonably practicable; and implement field and desktop based assessments to preferentially place infrastructure / disturbance outside of areas that are likely to represent Grey Grasswren habitat wherever practicable.

To summarise, PL 1058 contains minor areas of suitable habitat for grey grasswren, whereas the areas surrounding PL 1058 provide extensive suitable breeding and foraging habitat for the species, and Santos will implement mitigation measures to maximise avoidance of disturbance to potential grey grasswren habitat in PL 1058.

As per Section 5.1 of the SRI Guideline, an action is likely to have a significant impact on endangered and vulnerable wildlife if the impact on the habitat is likely to:

- lead to a long-term decrease in the size of a local population; or
- reduce the extent of occurrence of the species; or
- fragment an existing population; or
- result in genetically distinct populations forming as a result of habitat isolation; or
- result in invasive species that are harmful to an endangered or vulnerable species becoming established in the endangered or vulnerable species' habitat; or
- introduce disease that may cause the population to decline, or
- interfere with the recovery of the species; or
- cause disruption to ecologically significant locations (breeding, feeding, nesting, migration or resting sites) of a species.

Given the substantial areas of suitable foraging and breeding habitat in the areas immediately and more broadly surrounding PL 1058, the proposed activities (clearing of up to 11.55 ha of grey grasswren habitat) are highly unlikely to result in any of the abovementioned SRI criteria for the grey grasswren.

Further, the proposed activities will not result in disruption to ecologically significant locations for the grey grasswren because the species has significant widespread suitable breeding, feeding, nesting, migration or resting habitat available in the immediate and broader region surrounding PL 1058. Disruption to 11.5 ha of grey grasswren habitat in PL 1058 will therefore be insignificant to the size, extent and distribution of the local population of the species.

Refer to the ecological assessment report attached as Appendix C to this RFI response for further justification, which is specific to each SRI criteria, on why the proposed activities will not result in an SRI for the species.

Echidna

The echidna is Australia's most widespread native mammal (Archer, 1983).

The species has very broad breeding, feeding and nesting habitat requirements, and it can be found breeding, feeding and nesting in almost every habitat type that occurs across the entirety of the Australian continent (including Tasmania and offshore islands such as Kangaroo Island, King Island and Flinders Island).

The species can be found present (breeding, feeding or nesting) in undisturbed and disturbed deserts, forests, woodlands, shrublands, grasslands, rocky outcrops, agricultural lands, rainforests and alpine areas. The species is widely distributed and has no particular habitat preferences, except for the supply of ants and termites(Van Dyck & Strahan 2008).

As per Section 5.1 of the SRI Guideline, an action is likely to have a significant impact on a special least concern (non-migratory) animal wildlife habitat if it is likely that it will result in:

- a long-term decrease in the size of a local population; or
- a reduced extent of occurrence of the species; or
- fragmentation of an existing population; or
- result in genetically distinct populations forming as a result of habitat isolation; or
- disruption to ecologically significant locations (breeding, feeding or nesting sites) of a species.

The proposed activities (clearing of up to 116 ha of echidna breeding, feeding and nesting habitat) will not result in any of the abovementioned SRI criteria for the echidna. Further, the proposed activities will not result in disruption to ecologically significant locations for the echidna because the species has general and diverse breeding, feeding and nesting habitat requirements i.e. Echidna's have no particular habitat preferences, except for the supply of ants and termites (Van Dyck & Strahan 2008). Further, potential habitat for Echidna is present across the entirety of PL 1058 and/or the entirety of the surrounding bioregion, inclusive of all habitats. Disruption to 116 ha of echidna habitat in PL 1058 will therefore be insignificant to the sustainability, extent, size or distribution of the local population of the species. Further, where threatened species nests are identified to be present, disturbance would be avoided. If disturbance cannot be avoided, clearing of the nest and a surrounding area would be postponed until after the relevant breeding season and/or incubation period.

Refer to the ecological assessment report (attached as Appendix C to this RFI response) for further justification, which is specific to each SRI criteria, on why the proposed activities will not result in an SRI for these species.

References:
Archer. M. (1983). *Mammals in Australia*. Australian Museum. New South Wales, Australia.
Van Dyck. S. and Strahan, R. (2008). *The Mammals of Australia.* New South Wales, Australia.

Santos Response to Element 7n

The ecological assessment report has been amended to include the correct Figure 5 (refer to Appendix C of this RFI response).

2.8. DES Information Request Element (8)

Rehabilitation

o. *Sections 4.10 and 5.9 of the supporting information report address rehabilitation. However, the same information is provided in both sections. Provide confirmation as to whether section 5.9 should provide further information tailored to section 5: potential impacts, mitigation measures and environmental risk assessment.*

Santos Response to Element 8o

The EA amendment application form lists 'rehabilitation' as an "environmental value" that is required to be address by EA amendment applications. To meet the EA application requirements, rehabilitation has been addressed as an environmental value in Section 4 of the application supporting information.

However, "rehabilitation" is not an environmental value that has potential to be impacted by the proposed activities, and therefore it is not a value that can be easily described. For this reason, similar information has been provided in Sections 4.10 and Section 5.9 of the supporting information. The information provided in Sections 4.10 and 5.9 has been compiled to summarise how rehabilitation and decommissioning of disturbed land in PL 1058 will be undertaken in accordance with proposed EA conditions to ensure potential risks and impacts posed to other identified environmental values will be mitigated, and ultimately rehabilitated.

Final rehabilitation of disturbed areas in PL 1058 would be undertaken to achieve the final rehabilitation criteria of proposed EA conditions (refer to Schedule J, Appendix B (Proposed EA Conditions and Definitions) of the application). Information on rehabilitation activities is also included in the risk assessment presented in the application as a control strategy for several potential impacts to identified environmental values. The table below outlines standard methods Santos employs to rehabilitate disturbances associated with various petroleum activities in southwest Queensland.

Standard Rehabilitation Methods

Activity	Summary of rehabilitation methodology	When rehabilitation works will be undertaken	Final land use
Exploration	Seismic: • Replace cuttings and debris from shotholes; seal and level excess materials; install traffic barriers of natural materials at road crossings as required. • Re-establish natural drainage; install diversion berms on long slopes as required. • Create roughened surface by gouging or scarifying; re-spread cut brush and compact with bulldozer if necessary to promote establishment of seed.	The majority of modern seismic survey activities do not typically require active rehabilitation. If small areas of significant disturbance do occur, rehabilitation will be undertaken immediately following the activity.	Grazing natural vegetation unless otherwise agreed with the landowner and DES.
Roads, tracks, laydowns and borrow pits	Roads, tracks and laydowns: • Strip surface gravels (where present) for reuse; remove culverts; re-contour according to end land use; round-off cut slopes to smooth transition; uncompact by ripping (except in gibber plains areas); respread topsoil where available. • Re-establish natural drainage; install diversion berms on long slopes; terraces on cut slopes as required. • Create roughened surface by gouging or scarifying to promote natural establishment of vegetation. Borrow pits: • Re-contour according to end land use; round-off cut slopes to smooth transition; uncompact by ripping as required (except in gibber plains areas); respread topsoil where available. • Install diversion berms and terraces on cut slopes as required. • Create roughened surface by gouging or scarifying to promote natural establishment of vegetation.	Rehabilitated at the end of the asset's life.	Grazing natural vegetation unless otherwise agreed with the landowner and DES.
Camps	• Removal of infrastructure. • Strip surface gravels (where present) for reuse or bury in cut to prevent surface exposure; re-contour according to end land use if necessary; round-off cut slopes to smooth transition; uncompact by ripping (except in gibber plains areas); respread topsoil where available. • Re-establish natural drainage; install diversion berms on long slopes as required. • Create roughened surface by gouging or scarifying to promote natural establishment of vegetation.	Rehabilitated at the end of the asset's life.	Grazing natural vegetation unless otherwise agreed with the landowner and DES.

Activity	Summary of rehabilitation methodology	When rehabilitation works will be undertaken	Final land use
Wells pads and associated infrastructure	• Sumps and pits backfilled and re-contoured consistent with surrounding land contours • Removal of infrastructure. • Strip surface gravels (where present) for reuse or bury in cut to prevent surface exposure; re-contour according to end land use if necessary; round-off cut slopes to smooth transition; uncompact by ripping (except in gibber plains areas); respread topsoil where available. • Re-establish natural drainage; install diversion berms on long slopes as required; terraces on cut slopes as required. • Create roughened surface by gouging or scarifying to promote natural establishment of vegetation.	Rehabilitated at the end of the asset's life.	Grazing natural vegetation unless otherwise agreed with the landowner and DES.
Pipelines	• Decommissioning of pipelines. • Remove aboveground pipelines. • Backfill trenches and compact; mound to allow for settling; grade as required; install traffic barriers of natural materials at road crossings as required; respread topsoil. • Re-establish natural drainage; install diversion berms on long slopes as required • Create roughened surface by gouging or scarifying to promote natural establishment of vegetation.	Pipeline right of ways are rehabilitated following construction. Pipeline removal or decommissioning will occur at the end of the asset's life.	Grazing natural vegetation unless otherwise agreed with the landowner and DES.
Other Non-Linear Disturbances (i.e. Production Facility)	• Removal of infrastructure. • Strip surface gravels (where present) for reuse or bury in cut to prevent surface exposure; re-contour according to end land use if necessary; round-off cut slopes to smooth transition; uncompact by ripping (except in gibber plains areas); respread topsoil where available. • Re-establish natural drainage; install diversion berms on long slopes as required. • Create roughened surface by gouging or scarifying to promote natural establishment of vegetation.	Rehabilitated at the end of the asset's life.	Grazing natural vegetation unless otherwise agreed with the landowner and DES.

Appendices

Appendix A – Notice of Information Request

Notice

Environmental Protection Act 1994

Information request

This information request is issued by the administering authority under section 140 of the Environmental Protection Act 1994 *to request further information needed to assess an application for a site-specific environmental authority.*

To: Santos Limited, c/- Beach Energy (Operations) Limited, Delhi Petroleum Pty Ltd, Santos Petroleum Pty Ltd and Vamgas Pty Ltd
60 Flinders Street
ADELAIDE SA 5000

Elizabeth.Dunlop@santos.com

ATTN: Liz Dunlop

Our reference: Petroleum Lease (PL) 1058

Further information is required to assess an application for environmental authority

1. Application details

The application for a site-specific environmental authority was received by the administering authority on 11 May 2021.

Land description: Petroleum Lease (PL) 1058

Information request

The administering authority has considered the abovementioned application and is writing to inform you that further information is required to assess the application (an information request).

The information requested is provided below:

Proposed activities

a) As described in section 2.2. of the supporting information report, the application is seeking approval for 11 wells, all of which require authorisation for stimulation. It is also discussed that some will be gas wells targeting formations in the Cooper Basin and some will be oil wells targeting the Eromanga Basin. Section 2.3.3.2. states that well stimulation techniques may be used to increase the recovery of resources, in this case, gas.

ABN 46 640 294 485

Queensland Government

Provide the following information:

- the number of conventional oil wells proposed, and the number of conventional gas wells proposed,
- confirmation as to whether the stimulation approval is intended for both the gas and oil wells, or just the gas wells, and
- if the oil wells are to be stimulated, provide a description on how the process varies from stimulation of gas wells.

b) Section 2.3.2 states that each proposed well lease will be between 1 to 1.5 hectares, or 1.65 ha if stimulation is required. The Ecology Assessment has applied a 1.6 ha disturbance area per well pad.

Provide confirmation as to what disturbance area is being sought for each of the proposed 11 wells and what the total proposed disturbance for well pads is expected to be. Also provide confirmation on the quantities (i.e., 1, 1.5 or 1.65ha) that have been applied to calculate the prescribed environmental matter disturbances, as considered in section 6.2 of the supporting information report, and hence the accuracy of the disturbances proposed.

Produced water management

c) The application proposes the inclusion of streamline model condition (SMC) Waste 16, varied to include a commencement date, as outlined in Appendix A of the supporting information report. This proposed condition would authorise the use of mix-bury cover as a method for disposing residual drilling material on site. No information has been provided on what the mix-bury cover method entails and what environmental risks are associated.

Provide the following information:

- confirmation the mix-bury cover method proposed is consistent with the method detailed in the department's SMC for petroleum activities,
- quality characteristic criteria that are justified for the purpose of demonstrating the method is sustainable and will not cause environmental harm. As required under section 125(l)(i) of the *Environmental Protection Act* 194 (EP Act), consideration should be made to the site-specific characteristics of the environment i.e., flooding, Channel Country, when assessing the environmental values, emissions or releases, and risks and likely magnitudes of the proposed impacts, and
- with consideration to the site-specific characteristics of the landscape, demonstrate how the waste management hierarchy has been implemented, consistent with section 125(l)(i)(D) and 125(l)(ii) of the EP Act.

d) Section 4.9 of the supporting information report states that produced water may be re-used for the purposes of dust suppression, drilling and hydraulic fracture activities. Section 5.8 states that disposal may be undertaken in accordance with either the mix-bury over method or in accordance with method and quality certified by a suitably qualified third party.
To achieve the water quality required by the proposed conditions for each of the proposed disposal methods, it is possible that treatment of produced water may be required.

Provide information that describes the water management practices proposed including any treatment methods to be undertaken. Include a copy of the most up to date proposed water management plan.

Waste

e) Section 2.3.3.1 of the supporting information report states that drilling fluid would be used and continuously circulated through the drill pipe and surface equipment and drilling fluid will be stored using a drilling sump.

Provide the following information:

- the types of drilling fluids to be used in the process and whether they are oil-based or synthetic-based fluids,
- the proposed management practices of waste drilling fluids and cuttings,
- the design features of the drilling sumps (i.e., enclosed or open systems, construction details, what materials are used, how impervious the materials are), and
- description of the management practices proposed including measures to mitigate and minimise contaminants being released to the environment.

f) It is stated in section 4.9 of the supporting information report that, similar to the use of produced water for dust suppression, drilling and hydraulic fracturing activities, hydro-test water may be released to land at the end of the testing for disposal.

Provide the following information:

- details as to what constitutes hydro-test water,
- a description of the risk and likely magnitude of impacts on the environment as a result of releasing hydro-test water to land, and
- details of the management practices proposed to be implemented to prevent or minimise adverse impacts including what the appropriate quality is to release to land.

Hydraulic Fracturing

g) The application is accompanied by Appendix G: SWQ Hydraulic Fracture Risk assessment that contains:

- *Site Setting and Hydraulic Fracturing Process* report dated 20 December 2012 and
- *Human Health and Ecological Risk Assessment – Schlumberger Chemicals* dated 5 February 2014.

The documents within Appendix G are generic and broadly covers the activities across South West Queensland, therefore have not been provided specific to the proposed activities to which the application relates.

Provide reference to the particular information/sections of these documents that are relevant and are to be considered for this site-specific application. Noting the dates of the two reports, provide confirmation that these documents provide information that is still current, relevant and accurate for the activities being proposed.

h) It is stated in section 2.3.3.2 of the supporting information report that approximately 99.5% of the material pumped into the well is water and sand, while minor quantities of additives make up the remaining 0.5% of the fluid. The purpose of these additives is explained but what constitutes the fluid is not.

Provide the following information:

- the chemicals intended to be used in the stimulation/hydraulic fracturing process and the toxicity of the ingredients and mixtures,
- an environmental risk assessment for wells to be stimulated,
- details of the proposed hydraulic fracturing operations, and
- details of any stimulation impact monitoring program.

Note: if any relevant information is provided in the attached hydraulic risk assessment documents, it is satisfactory to reference the relevant sections of these reports to confirm these are still an accurate representation of the proposed additives (where appropriate) for the targeted information above.

Air Emissions

i) Section 2.3.2 of the supporting information report states that each proposed well lease would be established to accommodate several activities including flares. Throughout section 5 it is described that direct and indirect impacts to certain environmental values may result from ignition sources resulting from activities. However, no assessment has been provided for flaring or ignition in the proposal.

Provide the following information:

- a description of releases from flaring or ignition activities, including location and expected air emissions (quality and frequency of release),
- expected impacts on each of the environmental values of air (as listed in section 4.7 of the supporting information report)
- background air quality data that may be source and available from adjacent or local tenure holders (Note: the air quality monitoring data provided cannot be considered since they are not relevant to the proposed site), and
- proposed mitigation and management practices to avoid and minimise impacts to environmental values.

Blasting

j) It is stated in section 5.7 of the supporting information report that the application is seeking to adopt the department's SMCs for petroleum activities to authorise blasting. However, no information has been provided to describe the frequency, intensity and level of impacts to environmental values from blasting activities.

Provide the following information:

- details of any emissions or releases likely to be generated from blasting at the proposed site,
- an assessment of the risk and likely magnitude of impacts on the environmental values (including protecting the biodiversity of ecosystems) and

- details of the management practices proposed to be implemented to prevent or minimise adverse impacts.

Significant Residual Impact (SRI) assessments

k) The SRI criteria response for regulated vegetation does not reference the Regional Ecosystems (REs) relevant to the disturbance or the expected disturbance infrastructure. Therefore, it is not clearly demonstrated to what extent disturbance will occur within RE areas and how the applicant will guarantee that the SRI thresholds, in accordance with the 'Queensland Environmental Offsets Policy Significant Residual Impact Guideline, Nature Conservation Act 1992, Environmental Protection Act 1994, Marine Parks Act 2004,' dated December 2014 (SRI Guideline), will not be exceeded.

Note: the SRI limits must be determined cumulatively per RE type. For example, clearing other than linear infrastructure within RE 5.6.4. (sparse) must not exceed 2ha of clearing across the project, otherwise a SRI is triggered, and authorisation is required.

Provide information on the details considered to determine whether SRI will occur for regulated vegetation matters, including the relevant identified REs and quantities of areas required for linear and non-linear infrastructure. Also, it must be demonstrated how it will be ensured that activities will cumulatively not exceed the SRI limits.

l) Table 6-6 provides an impact assessment of PL1058 MSES for wetlands and watercourses. In response to the criteria states "…. *areas of the wetland or watercourse being destroyed or artificially modified*". The response also states that this is "*unlikely."* However, 0.9ha of wetland is proposed to be cleared, suggesting that an area of the wetland will be destroyed. It is also not confirmed when revegetation of the area will be guaranteed suggesting that the area will be modified, and for an unknown period.

A reassessment of this criteria in Table 6-6 is required that directly addresses whether the proposed activities are destroying or artificially modifying the landscape. Note: Rehabilitation and timing is not a prompted consideration in the SRI guideline, therefore is not relevant to the criteria.

m) In accordance with section 5.1. of the SRI guideline, an action is likely to have a SRI on endangered or vulnerable wildlife or species of least concern if the activity causes disruption to ecologically significant locations. Examples of such areas include breeding, feeding or nesting sites. The response provided for the grey grasswren and echidna against potential disruption to ecologically significant locations does not satisfy that this requirement is met.

For the grey grasswren it is acknowledged that 11.55ha of habitat will be cleared. The reasoning for not causing disruption of ecologically significant locations focusses on the recovery of the species habitat (of which only 3.9ha will be rehabilitated), and the presence of the species habitat within other areas of the petroleum lease. This response does not address how clearing 11.55ha of habitat would not cause disruption to ecologically significant locations.

In relation to the echidna, the response states that 115.5ha of habitat clearing will likely include breeding, feeding and nesting habitat. The response disregards the criteria to be triggered due to the distribution of the species and long-term population sustainability, which are considerations relevant to

other criteria (described in section 5.1. of the SRI guideline) and are not relevant to the disruption to ecologically significant locations (breeding, feeding or nesting sites).

Provide a reassessment of the SRI of the grey grasswren and echidna with justification that is specific to each criteria, as outlined in section 5.1 of the SRI guideline.

n) Throughout the Ecological Assessment report (document reference: QEJ19010_PL1058_EcoAssessment_Rev2) makes reference to Figure 5 relating to threatened species habitat to be presented on page 17. However, this figure is not contained within the document.

Provide a revised copy of the report which contains Figure 5.

Rehabilitation

o) Sections 4.10 and 5.9 of the supporting information report address rehabilitation. However, the same information is provided in both sections.

Provide confirmation as to whether section 5.9 should provide further information tailored to section 5: potential impacts, mitigation measures and environmental risk assessment.

2. Actions

The abovementioned application will lapse unless you respond by giving the administering authority -

(a) all of the information requested; or
(b) part of the information requested together with a written notice asking the authority to proceed with the assessment of the application; or
(c) a written notice –
    i. stating that you do not intend to supply any of the information requested; and
    ii. asking the administering authority to proceed with the assessment of the application.

A response to the information requested must be provided by 22 December 2021 (the information response period). If you wish to extend the information response period, a request to extend the period must be made at least 10 business days before the last day of the information response period.

The response to this information request or a request to extend the information response period can be submitted to the administering authority by email to EnergyandExtractive@des.qld.gov.au.

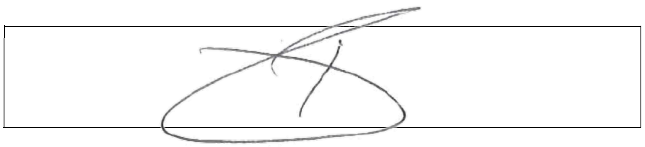
If the information provided in response to this information request is still not adequate for the administering authority to make a decision, your application may be refused as a result of section 176 of the *Environmental Protection Act 1994,* where the administering authority must have regard to any response given for an information request.

3. Review and appeal rights

You may apply to the administering authority for a review of this decision within 10 business days after receiving this notice. Information about your review rights is attached to this notice or search ‘DES Internal

review and appeals' at business.qld.gov.au. This information is guidance only and you may have other legal rights and obligations.

If you require more information, please contact Hannah Stevens on the telephone number listed below.



Signature

22/06/2021

Date

Tristan Roberts
Department of Environment and Science
Delegate of the administering authority
Environmental Protection Act 1994

Enquiries:
Energy and Extractive Resources Business Centre
GPO Box 2454, Brisbane QLD 4001

Phone: 1300 130 372

Email: EnergyandExtractive@des.qld.gov.au

Attachments

Information sheet: Internal review and appeals (ESR/2015/1742)

Appendix B - Stimulation Risk Assessment - Santos Southwest Queensland Tenements (SRA)

Report

Stimulation Risk Assessment - Santos Southwest Queensland Tenements

Site Setting and Stimulation Process

Submitted to:

Santos Ltd
Santos Centre
60 Flinders Street
ADELAIDE SA 5000

Submitted by:

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118 Franklin Street, Adelaide, South Australia 5000, Australia

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127666004-011-R-Rev0

June 2020

Distribution List

Golder Associates - 1 electronic copy

Santos Ltd - 1 electronic copy

Executive Summary

Introduction

Santos Ltd (Santos) engaged Golder Associates Pty Ltd (Golder) to prepare a desktop risk assessment of stimulation (previously referred to as hydraulic fracturing) activities for conventional oil and gas production in their Southwest Queensland (SWQ) tenements. This Stimulation Risk Assessment (SRA) is undertaken to meet Department of Environment and Science (DES; formerly Department of Environment and Heritage Protection (DEHP)) Environmental Authority (EA) consent conditions.

This version of the SRA report updates a 2012 version of the report (127666004-011-R-Rev0, December 2012). Updated content includes reference to the updated Environmental Authority (EA) Blueprint conditions (updated December 2019), updated tenements (as of January 2020), historical well stimulation events and potential dates for future stimulation events. Background information, such as the geological setting, hydrogeology, environmental values and stimulation process, etc has largely not changed in this version of the SRA.

This desktop SRA is presented in two report volumes, as follows:

- Volume One (this report) discusses the environmental and geological settings within which Santos' stimulation activities take place and the general techniques for the drilling, completion and stimulation of wells. The report also discusses why stimulation is essential in SWQ and outlines Santos' current forward programme for fracture-stimulation, although it should be noted that for a variety of reasons (including but not limited to future production performance and / or access-related issues such as the flooding of the Cooper Creek system), the forward programme is frequently reviewed and is subject to change.
- Volume Two relates specifically to the stimulation fluids proposed to be used by *Stimulation Service Providers*[1] on Santos wells in the SWQ conventional oil and gas fields. The report considers the ecological and human health toxicity of the chemical constituents in the stimulation fluids and includes an exposure pathway assessment and risk characterisation based on a review of complete exposure pathways and controls to mitigate exposure.

In the future, specific data relating to the stimulation fluids used by other Stimulation Service Providers may be submitted as a subsequent Volume Two of this report, to allow Department of Environment and Science (DES) approval for fracture-stimulation operations by these contractors.

Golder previously prepared an Underground Water Impact Report (UWIR) for the SWQ conventional oil and gas operations, which was prepared for Santos in accordance with the requirements of the Water Act 2000 (Golder, 2012a; updated January 2020). This SRA report considers the geological and hydrogeological conceptual model developed in the UWIR, any updates to the UWIR (January 2020), additional information provided by Santos, and the requirements of DES to provide a formal risk assessment of stimulation activities in the SWQ Project Areas.

Comparison of Conventional Oil and Gas Operations to Coal Seam Gas (CSG) Operations

There are key differences between CSG and conventional oil and gas production, both in the geographic and geological setting of the resource and the methodology for accessing the resource, that have a substantial bearing on the risk profile presented by stimulation activities. These include:

[1] At the time of reporting (January 2020) 31 Haliburton products only were in use in SWQ hydraulic fracturing operations. No Schlumburger fracturing products were in use.

- Santos' conventional oil and gas operations in SWQ are located in an arid, sparsely populated area of central Australia. Whilst groundwater is an important water supply to support the rural land uses, the extent of water supply development is limited (commensurate with the small population base).
- In Santos' SWQ operations, the hydrocarbon reservoirs generally occur in anticlines capped with thick, laterally-extensive, low permeability formations that isolate the reservoirs from overlying water-bearing formations.
- The oil and gas reservoirs in the SWQ study area are very deep, of the order of 1500 to 3000 m below ground level, which provides hundreds to over a thousand metres vertical separation between the formations in which stimulation activities are proposed and the shallow groundwater resources. There is also no requirement to remove formation water in order to facilitate gas flow, with the possible exception of well blow downs on a case by case frequency.

Environmental Setting

Santos operates conventional gas and oil fields across petroleum tenements within an approximately 30,000 km^2 portion of SWQ. The terrain in the study area is generally characterised by low undulating topography (hills and ridges) between the drainage channel systems of the Cooper Creek. The area is sparsely developed, and generally comprises rural communities and homesteads that are largely engaged in pastoralism.

The stratigraphy primarily comprises the Eromanga and underlying Cooper Basins, where the oil and gas reservoirs are respectively located. These Basins contain the proposed target formations for stimulation activities. A detailed description of key geological and hydrogeological features is provided in the text, including geological models for the study area, identification of the target hydrocarbon-bearing sandstone formations (oil in the Eromanga Basin formations at depths ranging from 700 to 1,200 m below ground level (mbgl); and gas in the Cooper Basin formations at depths of 1,500 to greater than 2,000 mbgl), their hydraulic characteristics, adjacent aquifers and aquitards, structural features including faults and fracture characteristics (and their potential to behave as barriers or conduits), regional and local seismicity characteristics, aquifer environmental values and the location of groundwater users.

In terms of the environmental setting, this document has provided specific information that addresses the requirements anticipated of the EA conditions regarding stimulation that will apply to new areas proposed for development.

These specific inclusions are located within the logical flow of the description of the existing environment in the SWQ study area.

Key Environmental Values

Based on an understanding of the environmental setting, this risk assessment considered the following key environmental values:

Groundwater Environmental Values:

- Town water supply;
- Stock and domestic water supply;
- Sandstone aquifers of the GAB; and
- Groundwater Dependant Ecosystems (GDEs).

Surface Water Environmental Values:

- Protection of aquatic ecosystems;
- Recreation and aesthetics: primary recreation with direct contact, and visual appreciation with no contact; and
- Cultural and spiritual values.

Terrestrial Environmental Values:

- Protection of flora and fauna, particularly small mammals, reptiles and birds.

The report considers the applicable environmental values in the context of the proposed stimulation activities within the study area.

Stimulation Process Description Summary

With regard to the process of stimulation, the requirements of the EA approval conditions are considered within the stimulation description as they are proposed to be employed in the SWQ study area, with the specific information included as follows:

- Practices and procedures to ensure that the stimulation activities are designed to be contained within the target gas producing formation;
- Details of where, when and how often stimulation is to be undertaken on the tenures covered by this environmental authority;
- A description of Santos' well mechanical integrity testing program;
- Process control and assessment techniques to be applied for determining extent of stimulation activity(ies) (e.g. microseismic measurements, modelling etc); and
- A process description of the stimulation activity to be applied, including equipment and a comparison to best international practice.

Conclusions

Based on the available geological information for the study area, the following key points are noted:

- The DEHP database[2] and the interim results of the WBBA program (WBBA 2012; UWIR 2020) indicate that groundwater supply development in the vicinity of Santos' tenements is limited to the Glendower and Winton Formations, and to a lesser extent the Hooray Sandstone. The minimum vertical offset between the Glendowner and Winton Formations and the shallowest hydrocarbon reservoirs (oil reservoirs of the Cadna-Owie Formation) is 400 to 800 m, which includes the low permeability formations of the Wallumbilla Formation and Allaru Mudstone, which form a thick, competent and regionally extensive seal between the Cadna-Owie Formation and the shallower aquifers. The vertical offset to gas reservoirs is much greater (1,000 m to 1,800 m).
- Within formations that host both aquifers and hydrocarbon reservoirs (e.g. Hooray Sandstone), the water-bearing zones are separated from hydrocarbon reservoirs by intra-formational seals. However, there is not enough information available to discretise the internal stratigraphy of these formations. Where petroleum activities (including stimulation) occur within a formation that hosts both aquifers and hydrocarbon reservoirs, the lateral distance of the water supply bores accessing the aquifer to Santos' tenements was considered.
- Based on information from 2012, and information provided by Santos (January 2020), the closest functioning beneficial use bore to the Santos tenements targeting the Hooray Sandstone in the DEHP database records is the Coothero Bore, which is located at least 25 km from the closest tenement

[2] DEHP database accessed in 2012

proposed for stimulation and more than 80 km from the closest tenement with activities proposed at a similar depth. The Coothero Bore is monitored by Santos as part of the UWIR monitoring program.

Based on the available site setting information for the study area, the following key points are noted:

- Cooper Creek is largely influenced by surface water flows and evaporation, with negligible contribution from groundwater. Waterholes and billabongs occur throughout the Cooper Creek floodplain and channel complex, some of which coincide directly with Santos tenements. Cooper Creek resides within the Channel Country Strategic Environmental Area under the Regional Planning Interests Act.
- Three of the identified wetlands (Cooper Creek – Wilson River Junction, Bulloo Lake and Cooper Creek Swamps – Nappa Merrie) are within the boundaries of Santos' tenements. It should be noted that stimulation activities may be completed within any tenement boundary over the life of the Project.
- The Cooper Creek catchment and downstream Lake Eyre are popular recreational fishing destinations. Popular fishing spots include Bulloo River at Thargomindah, Wilson River at Nockatunga and Cooper Creek flows (episodically).

Based on the stimulation process information provided by Santos, the following key points are noted:

- Buffers are assigned during establishment of well leases between petroleum operations and potential "environmentally sensitive areas" identified though database review and site-specific ecological assessment where warranted.
- The procedures employed by Santos' and its contractors follow a design philosophy predicated on the guidance, specifications and recommended practices of the American Petroleum Institute (API), considered to represent international best practice.
- The procedures employed by Santos' and its contractors for mechanical integrity and surveillance follow a design philosophy with international best practice. Practices for ensuring well mechanical integrity consist of a robust surveillance plan.
- OH&S procedures are implemented during stimulation operations to prevent workers from direct contact with chemicals during spills and when handling flowback water or sediments. Golder understands that there has not been a recordable spill since stimulation commenced in 1987.
- Santos operational procedures monitor fracture/stimulation design to stay within the target formation.
- Santos implement spill containment procedures during operations to prevent migration of and exposure to chemicals.

Hence, the combination of the remote project location, sparse local population density (and limited water supply development), different production methods and the substantial vertical separation of oil and gas reservoirs from primary groundwater supply aquifers results in an inherently low risk profile with regard to stimulation activities. In addition, Santos procedures and operational controls are design to mitigate residual risk.

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1.0 INTRODUCTION

1.1 Preamble

Santos Ltd (Santos) is a holder of numerous existing Environmental Authorities (EAs) for activities and operations throughout Southwest Queensland (SWQ), collectively referred to as "SWQ". To meet EA consent conditions, a formal risk assessment of stimulation activities is required and subsequently, Golder Associates Pty Ltd (Golder) has been engaged by Santos to prepare this Stimulation Risk Assessment (SRA).

This version of the SRA updates a 2012 version (127666004-011-R-Rev0, December 2012 previously referred to as a Hydraulic Fracturing Risk Assessment (HFRA)). Updated content includes reference to the updated Environment Authority (EA) Blueprint conditions (updated December 2019), updated tenements (as of January 2020), historical well stimulation events and potential future stimulation dates. Background information, such as the geological setting, hydrogeology, environmental values and stimulation process, etc has not changed in this version of the SRA.

This desktop SRA is presented in two volumes, as follows:

- Volume One discusses the environmental and geological settings within which Santos' stimulation operations take place and the general techniques for the drilling, completion and stimulation of wells. The report also discusses why stimulation is essential in SWQ and outlines Santos' current forward programme for fracture-stimulation, although it should be noted that for a variety of reasons (including but not limited to future production performance and / or access-related issues such as the flooding of the Cooper Creek system), the forward programme is frequently reviewed and is subject to change.
- Volume Two relates specifically to the stimulation fluids proposed to be used by *Stimulation Service Providers*[3] on Santos wells in the SWQ conventional oil and gas fields. The report considers the ecological and human health toxicity of the chemical constituents in the stimulation fluids and includes an exposure pathway assessment and risk characterisation based on a review of complete exposure pathways and controls to mitigate exposure.

In the future, specific data relating to the stimulation fluids used by other Stimulation Service Providers may be submitted as a subsequent Volume Two of this report, to allow DES approval for fracture-stimulation operations by these contractors.

Golder previously prepared an Underground Water Impact Report (UWIR) for the SWQ conventional oil and gas operations, which was prepared for Santos in accordance with the requirements of the Water Act 2000 (Golder, 2012a; updated January 2020). The current report considered the geological and hydrogeological conceptual model developed in the UWIR, any updates to the UWIR (January 2020), additional information provided by Santos, and the requirements of DES to provide a formal risk assessment of stimulation activities for the future development of the SWQ Project Areas.

1.2 Limitations

Your attention is drawn to the document - "Limitations", which is included in APPENDIX A of this report. The statements presented in this document are intended to advise you of what your realistic expectations of this report should be. The document is not intended to reduce the level of responsibility accepted by Golder, but rather to ensure that all parties who may rely on this report are aware of the responsibilities each assumes in so doing.

[3] At the time of reporting (January 2020) 31 Haliburton products only were in use in SWQ hydraulic fracturing operations. No Schlumburger fracturing products were in use.

1.3 Santos SWQ Project – Overview

Santos currently operates a significant number of conventional gas and oil fields within SWQ (Figure 1). The area covered by the petroleum tenements within which these fields encompass is approximately 30,000 km^2 of largely semi-arid agricultural land and was first developed for petroleum operations in the early 1970's. Within the Cooper-Eromanga Basin as a whole (including that part which lies in South Australia), Santos operates approximately 114 gas fields and 87 oil fields, the majority of which are currently in production (Figure 2).

- *Conventional oil* is produced from the formations of the Eromanga Basin (a sub-basin within the Great Artesian Basin (GAB)). The oil is present in discontinuous oil reservoirs within interbedded sandstones beds or larger sandstone formations. There are several types of oil reservoirs resulting from the process of "trapping" of the oil (Section 2.4.3.4).
- *Conventional gas production* is undertaken from porous sandstone formations and as such does not require the depressurisation of the target beds (with respect to groundwater). Some water is produced as a by-product however the volumes are limited (refer to the UWIR (2020) for detailed discussion). The conventional gas production is typically associated with the deeply-buried formations of the Cooper Basin (separate from and underlying the GAB). Very limited volumes of gas have also been produced from within the Eromanga Basin Production Areas.

For the purposes of this assessment, the term "*study area*" refers to the area applicable to this assessment: all SWQ tenements operated by S*antos* and the land immediately surrounding the Santos tenement boundaries (Figure 2).

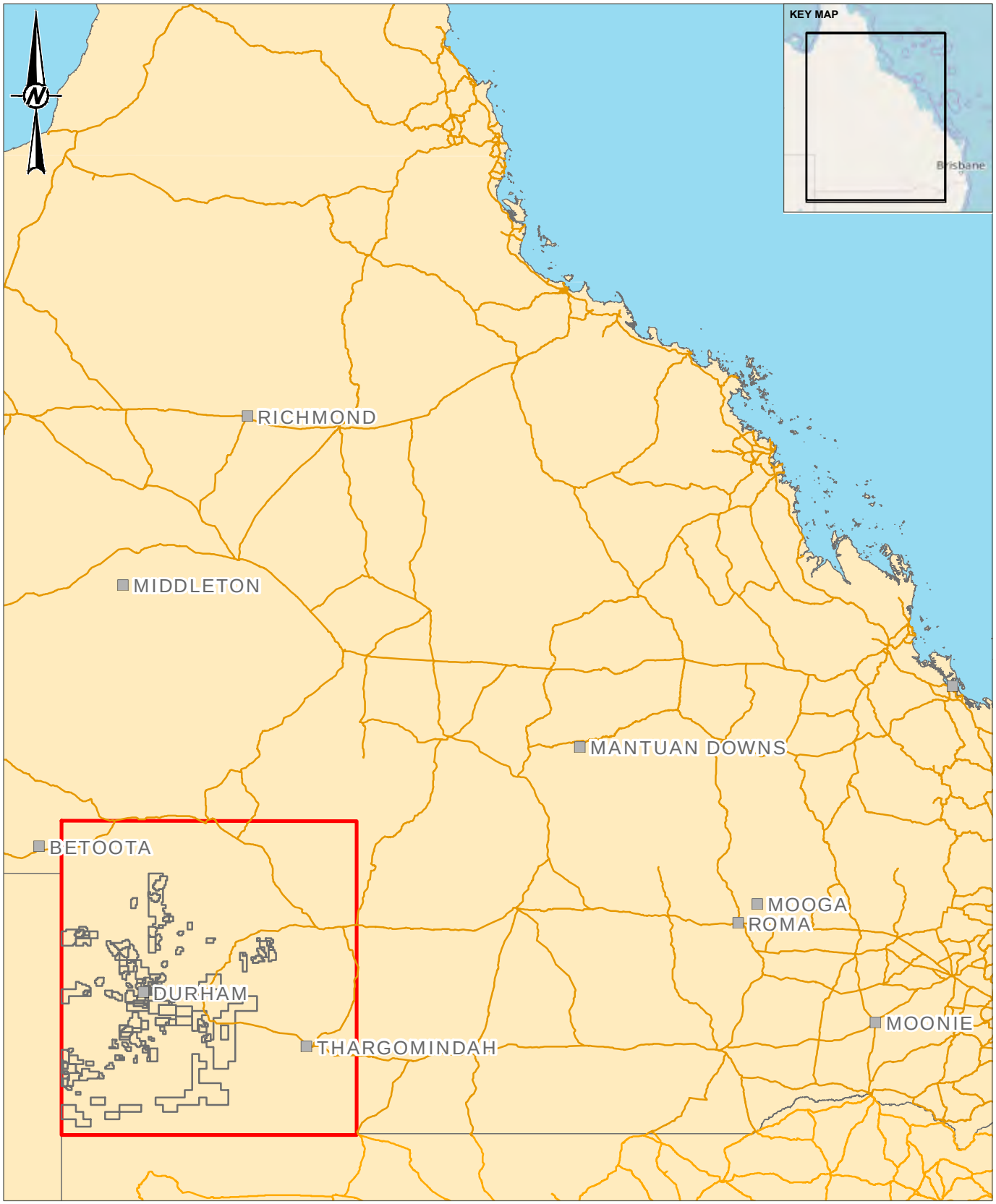
1.3.1 Proposed Stimulation Operations

The use of stimulation is essential in order to achieve economically-viable flow-rates and recoverable volumes from the majority of the production wells that are drilled in SWQ.

Between March 2013 and May 2019, 101 oil and gas wells underwent stimulation activities with another 67 oil and gas wells potentially undergoing stimulation activities between 2020 and 2022.

It should be noted that for a variety of reasons (including but not limited to future production performance and / or access-related issues such as the flooding of the Cooper Creek system), the forward drilling and stimulation programme is frequently reviewed and is subject to change.

The oil and gas production field and lease areas are further discussed in Section 1.5.



LEGEND

- Town/Locality
- Highway/Major Road
- Santos Tenements
- Study Area

0 KILOMETERS 250

1:7,000,000 GCS GDA 1994

NOTE(S)

REFERENCE(S)

1. BASE INFORMATION COPYRIGHT MAPINFO AUSTRALIA PTY LTD
2. ATP/PL TENURE SUPPLIED BY SANTOS, NOVEMBER 2019

CLIENT
SANTOS

PROJECT
HYDRAULIC FRACTURING RISK ASSESSMENT – SANTOS SOUTHWEST QUEENSLAND TENEMENTS

TITLE
SANTOS SWQ STUDY AREA

CONSULTANT
GOLDER

DD-MM-YYYY	19-03-2020
DESIGNED	KB
PREPARED	KB
REVIEWED	CB
APPROVED	CB

PROJECT NO.	CONTROL	REV.	FIGURE
127666004	011-R	2	1

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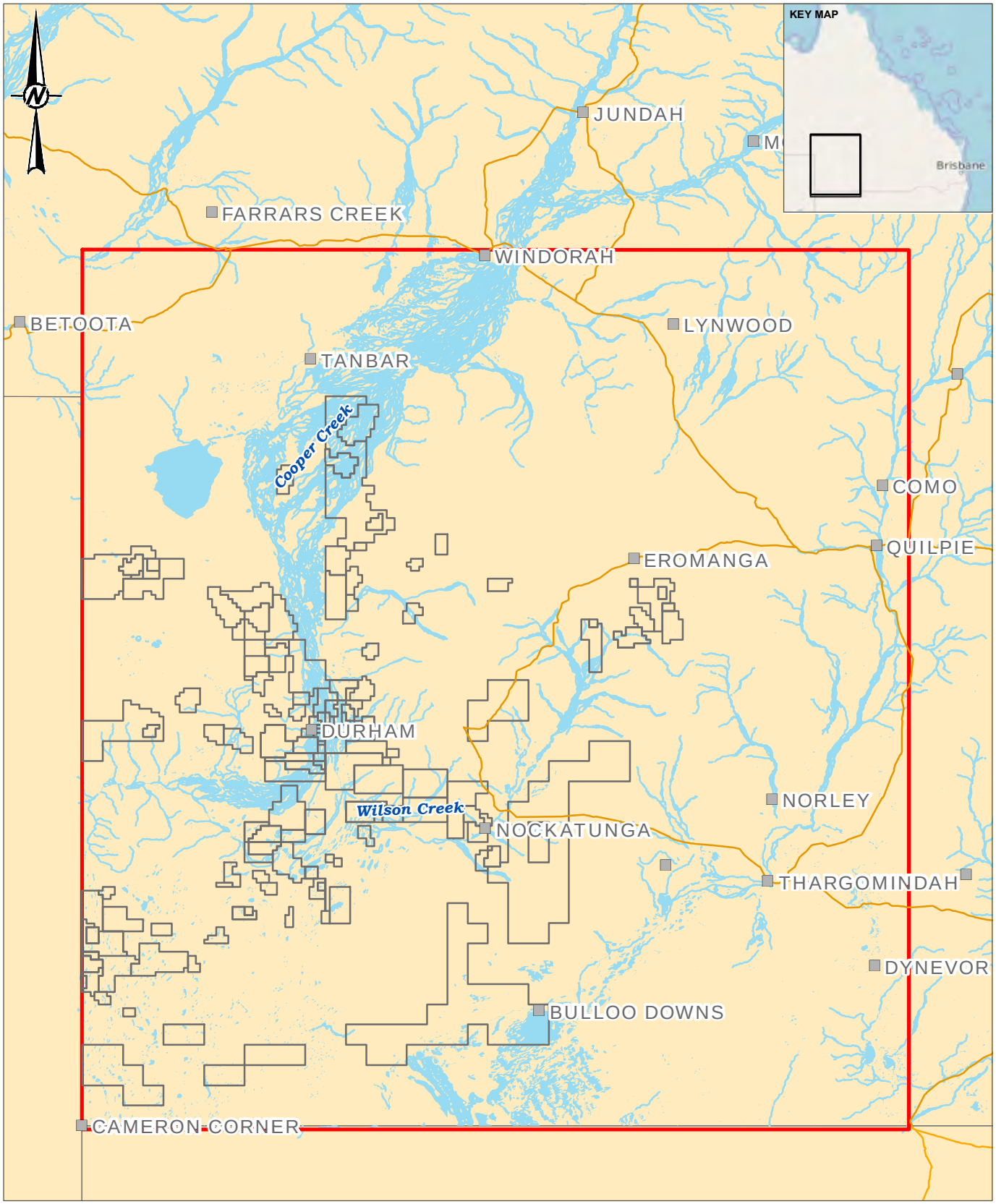


LEGEND

- Town/Locality
- Highway/Major Road
- River/Creek
- Santos Tenements
- Study Area

0 KILOMETERS 100

1:2,500,000 GCS GDA 1994

NOTE(S)

REFERENCE(S)

1. BASE INFORMATION COPYRIGHT MAPINFO AUSTRALIA PTY LTD
2. ATP/PL TENURE SUPPLIED BY SANTOS, NOVEMBER 2019

CLIENT
SANTOS

PROJECT
HYDRAULIC FRACTURING RISK ASSESSMENT – SANTOS SOUTHWEST QUEENSLAND TENEMENTS

TITLE
OIL AND GAS FIELDS FOR THE SWQ PROJECT

CONSULTANT
GOLDER

DD-MM-YYYY	19-03-2020
DESIGNED	KB
PREPARED	KB
REVIEWED	CB
APPROVED	CB

PROJECT NO.	CONTROL	REV.	FIGURE
127666004	011-R	2	2

1.3.2 EA Conditions

The Environmental Authority (EA) approval requirements for the Santos' SWQ operations necessitate the collection and provision of information on stimulation. Detailed regulatory requirements contained in these approvals and the sections of this risk assessment where the conditions are met are provided in Table 1. Conditions related to stimulation risk assessments can vary between Santos SWQ EAs and can also vary to those included within DES' Streamlined model conditions for petroleum activities Guideline (ESR/2016/1989).

Table 1: Summary of Consent Conditions*

Condition		Report Volume	Report Section
(a)	a process description of the **stimulation** activity to be applied, including equipment	One	3.3
(b)	provide details of where, when and how often **stimulation** is to be undertaken on the tenures covered by this environmental authority	One	3.4.1
(c)	a geological model of the field to be stimulated including geological names, descriptions and depths of the target gas producing formation(s)	One	2.4 and 2.5
(d)	naturally occurring geological faults	One	2.4.3.5 and 2.4.5
(e)	seismic history of the region (e.g. earth tremors, earthquakes)	One	2.4.5
(f)	proximity of overlying and underlying aquifers	One	2.6
(g)	description of the depths that aquifers with environmental values occur, both above and below the target formation	One	2.6
(h)	identification and proximity of **landholders' active groundwater bores** in the area where **stimulation** activities are to be carried out	One	2.5.7
(i)	the environmental values of groundwater in the area	One	2.6
(j)	an assessment of the appropriate **limits of reporting** for all water quality indicators relevant to **stimulation** monitoring in order to accurately assess the risks to environmental values of groundwater	Refer Stimulation Impact Monitoring Program	-
(k)	description of overlying and underlying formations in respect of porosity, permeability, hydraulic conductivity, faulting and fracture propensity	One	2.4.4 and 2.5.5
(l)	consideration of barriers or known direct connections between the target formation and the overlying and underlying aquifers	One	2.5.2.3, 3.3.4 and 3.3.7
(m)	a description of the well mechanical integrity testing program	One	3.2.2

Condition	Report Volume	Report Section
(n) process control and assessment techniques to be applied for determining extent of **stimulation** activities (e.g. microseismic measurements, modelling etc.)	One	3.3.4 and 3.3.7
(o) practices and procedures to ensure that the **stimulation** activities are designed to be contained within the target formation	One	3.3.4 and 3.3.7
(p) groundwater transmissivity, flow rate, hydraulic conductivity and direction(s) of flow	One	2.5.3, 2.5.4 and 2.5.5
(q) a description of the chemicals used in **stimulation** activities (including estimated total mass, estimated composition, chemical abstract service numbers and properties), their mixtures and the resultant compounds that are formed after **stimulation**	Two	3.0
(r) a mass balance estimating the concentrations and absolute masses of chemicals that will be reacted, returned to the surface or left in the target formation subsequent to **stimulation**	Two	3.2
(s) an environmental hazard assessment of the chemicals used including their mixtures and the resultant chemicals that are formed after **stimulation** including: (i). toxicological and ecotoxicological information of chemical compounds used (ii). information on the persistence and bioaccumulation potential of the chemical compounds used (iii). identification of the chemicals of potential concern in stimulation fluids derived from the risk assessment	Two	4.0, 5.0, 6.0 and 7.3.2
(t) an environmental hazard assessment of the chemicals used including mixtures and the resultant chemicals that are formed after stimulation	Two	4.0, 5.0, 6.0 and 7.3.2
(u) identification and an environmental hazard assessment of using radioactive tracer beads in **stimulation** activities where such beads have been used or are proposed to be used	One	3.3.7.10
(v) an environmental hazard assessment of leaving chemical compounds in **stimulation fluids** in the target formation for extended periods subsequent to **stimulation**	Two	
(w) human health exposure pathways to operators and the regional population	Two	6.0
(x) risk characterisation of environmental impacts based on the environmental hazard assessment	Two	7.0
(y) potential impacts to landholder bores as a result of **stimulation** activities	Two	2.2.3.1

Condition		Report Volume	Report Section
(z)	an assessment of cumulative impacts, spatially and temporally of the **stimulation** activities to be carried out on the tenures covered by this environmental authority	Two	7.5
(aa)	potential environmental or health impacts which may result from **stimulation** activities including but not limited to water quality, air quality (including suppression of dust and other airborne contaminants), noise and vibration	One and Two	1.3 (Report Version One) 4.0, 5.0, 6.0 and 7.3.2 (Report Version 2)

*Consent conditions from Schedule K (Well Construction, Maintenance and Stimulation), subsection K6, 21 December 2019

1.4 Risk Assessment Process

Risk assessment provides a systematic framework for characterising the nature and magnitude of risks from stressors (in this case, stimulation chemicals). Risk assessment is an important tool for decision-making. Australian risk assessment guidance has been used in the preparation of this report, namely draft guidance for ecological risk assessment provided by the Environment Protection Authority (EPA) Victoria (Gibson *et al.*, 1997) and enHealth-Environmental Health Risk Assessment, "Guidelines for Assessing Human Health Risks from Environmental Hazards", June 2004 (enHealth, 2004).

The scope of the qualitative risk assessment comprises of:

- **Issue Identification** (Volume One) - A description of the current environmental setting (including a description of potential receiving environments and the various factors which act upon them, including climatic influences), detailed geological and hydrogeological information, gas well integrity and a description of the stimulation process including an identification of the constituents of the stimulation fluid(s);
- **Exposure Assessment** (Volume Two) – The exposure assessment comprises an evaluation of surface and subsurface exposure pathway assessment;
- **Hazard Assessment** (Volume Two) – An evaluation of the environmental hazard of relevant chemical additives in the stimulation fluid based on aquatic toxicity, environmental persistence and bioaccumulation. The environmental hazard assessment provides a relative ranking of the chemical additives and those chemicals considered to represent a high hazard are identified as chemicals of potential concern (COPC) for further assessment. An evaluation of terrestrial and human health toxicity will also be presented;
- **Risk Characterisation** (Volume Two) – A qualitative evaluation of environmental and human health risk associated with the stimulation activities based on the identification of complete exposure pathways and hazard identification.

The evaluation of exposure pathways includes both *subsurface* and *surface* processes. The principles for ecological and human health risk assessment consist of the following steps: issue identification, hazard (or toxicity) assessment, exposure assessment, and risk characterisation. Human health risk assessment is limited to assessment of effects on one receptor: *humans*. Ecological risk assessment is concerned with assessment of effects on the ecosystem (populations and communities) and therefore is not limited to one receptor. The guidance framework for ecological risk assessment in Australia is the "Guideline on Ecological Risk Assessment" (NEPM, Schedule B(5), 1999; updated 2013) which refers to draft guidance prepared by EPA Victoria (Gibson *et al.*, 1997). These guidance documents focus on risks to terrestrial environments although the overall approach for assessment or risk is the same. The risk assessment was undertaken in

general accordance with these guidelines and national guidelines for risk assessment recommended by enHealth (enHealth-Environmental Health Risk Assessment, “Guidelines for Assessing Human Health Risks from Environmental Hazards”, June 2012).

If, in the future, conditions, stimulation methodologies and/or regulatory requirements change, and/or additional exposure pathways to additional receiving environments are identified, further evaluation of the associated risks *may* be warranted.

1.5 Study Area

Santos’ Production Licences in SWQ cover an area of over 17,000 km^2. The development of petroleum fields in SWQ started in the early 1970s. Santos currently produces conventional gas and oil from approximately 212 gas wells from 53 fields and 250 oil wells from 47 fields in SWQ.

The land is generally characterised by low undulating topography (hills, ridges and valleys) between the various fluvial systems (e.g. the Cooper Creek). The areas occupied by these creek systems are regionally referred to as “Channel Country” and consist of a system of braided or anastomosing channels and associated inter-channel areas and floodplains. Surrounding the floodplains are gravel plains, dunefields and low ranges. The area is sparsely developed, and generally comprises rural communities and homesteads that are largely engaged in pastoralism.

The Cooper Basin underlies, but is considered to be geologically separate from, the Eromanga Basin, which is the largest sub-basin within the Great Artesian Basin (GAB). Some of the sedimentary formations associated with the GAB are recognised as regionally significant aquifers (Figure 3). There are no outcrops of the GAB formations within the study area, which is overlain by quaternary alluvium. With a couple of localised exceptions, conventional gas is produced from formations within the Cooper Basin, at depths exceeding 2000 m, while oil is mainly produced from formations within the Eromanga Basin at depths of approximately 700 to 1,200 m below ground level.

Santos activities are described in the SWQ *Project Areas* Environmental Management Plans (Santos, 2014). The summary information on activities and infrastructure reported below has been extracted from these environmental management plans.

As a summary, the SWQ study area includes a combination of gas and oil production, associated transport, storage and processing infrastructure and ongoing exploratory, appraisal and development drilling. The operations are grouped in “processing satellites” or centres where Santos has developed all the facilities necessary to the operations of the fields. Santos has developed the following infrastructure within the Cooper-Eromanga Basin as a whole (including that part which lies in South Australia):

- Approximately 29 Oil and Gas Processing Satellites, the main ones for SWQ are discussed in Section 1.5.1; and
- Approximately 212 producing gas wells and 250 producing oil wells in SWQ.

1.5.1 Oil and Gas Occurrences and Production

A consequence of the geological setting of the Cooper and Eromanga Basins is the location of *gas* fields within the centre of the basin system (Figure 2) and the *oil* fields mainly around the edges of the study area (mainly in the centre and the east of Santos tenements in SWQ).

The petroleum fields proposed for production, the corresponding lease areas and infrastructures are discussed in the following sections.

1.5.1.1 Target Gas Formations

Gas is primarily extracted from the formations of the Cooper Basin. The geology of the Cooper Basin is presented in Section 2.4.3.1. The main consequence of the geological setting is the very deep location of the target gas reservoirs at depths of 2,000 m or more. The gas fields are located in the centre of Santos tenements in SWQ and in SA (Figure 2).

The primary gas reservoirs (discussed in Section 2.4.3.4) targeted for stimulation are sandstones within:

- The Paning and Doonmulla Members (Nappamerri Group);
- The Toolachee Formation (Gidgealpa Group);
- The Epsilon Formation (Gidgealpa Group); and
- The Patchawarra Formation (Gidgealpa Group).

These reservoirs are stacked porous sandstones, separated by coals and / or finer-grained siltstones mudstones (refer to detailed stratigraphy in Section 2.5.2). These impermeable layers are typically referred to as the seal or cap rock beds where they are located immediately above the reservoirs. The sandstone reservoirs often have low porosities and permeabilities (usually of the order of 1-10 milliDarcies), such that fracture-stimulation is essential in order to achieve economic flow-rates and production volumes.

In addition, other sediments may become targets for stimulation if encountered in future wells.

Operation of tenements is likely to change in the future and assessment of additional tenements will be considered prior to stimulation being undertaken following due consultation with DES and the Department of Natural Resources, Mines and Energy (DNRME).

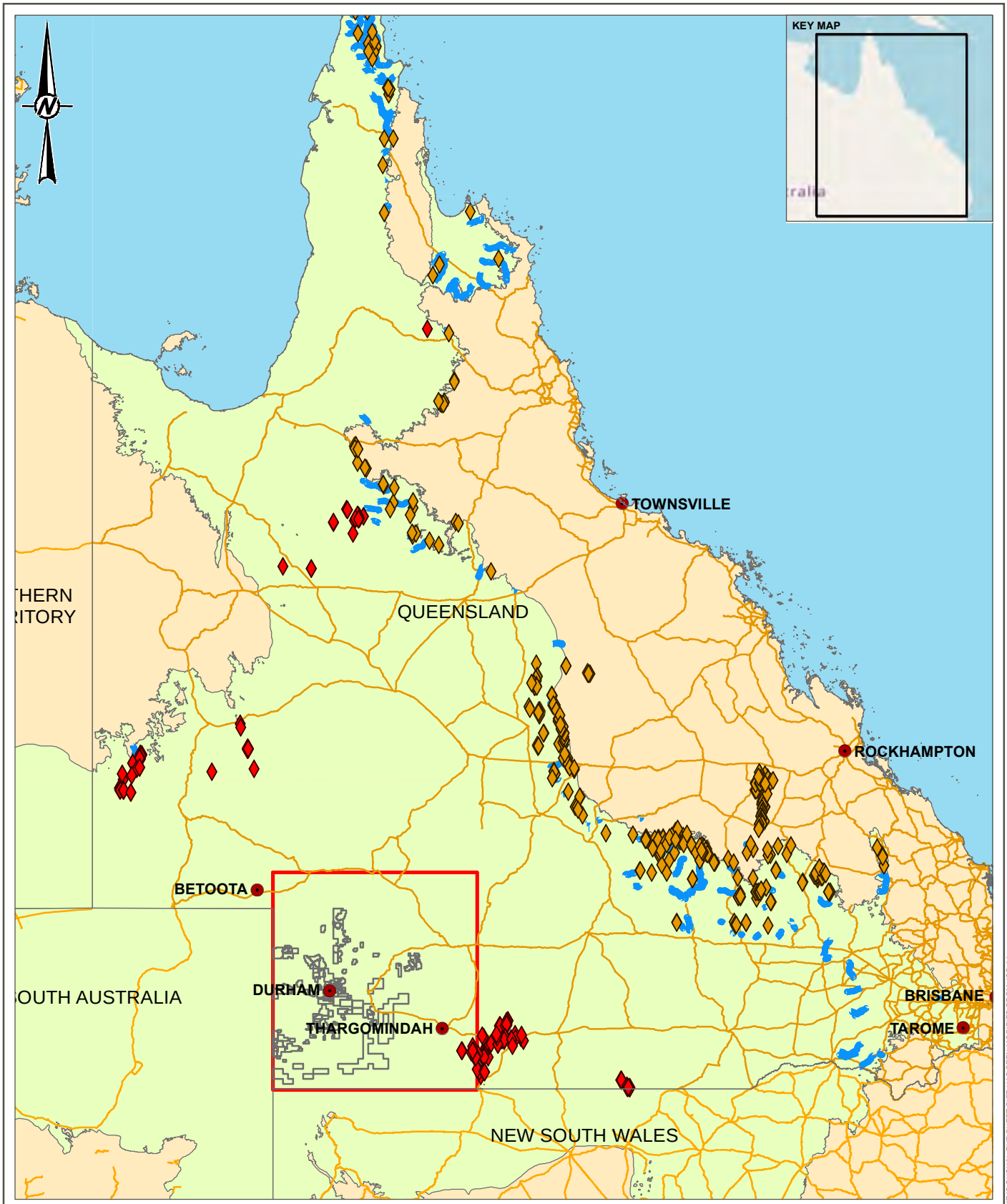
1.5.1.2 Target Oil Formations

Oil is produced from sediments within the formations of the Eromanga Basin (part of the Great Artesian Basin), at depth of approximately 700 to 1,200 m below ground level. There are 227producing oil wells within Santos tenements in SWQ.

The oil reservoirs (discussed in Section 2.4.3.4) targeted for stimulation are:

- The Murta Formation (Upper Hooray Sandstone). Oil reservoirs are abundant in the Murta Formation (interbedded mudstones, siltstones and fine grained sandstones);
- The Birkhead Formation, comprising interbedded siltstone, mudstone and fine sandstone. Oil reservoirs are present mostly in the Lower Birkhead unit, scattered oil reservoirs also occur in the Middle Birkhead unit; and
- The Wyandra Sandstone Member (upper unit of the Cadna-Owie Formation), oil occurrence is less frequent.

Operation of tenements is likely to change in the future and assessment of additional tenements will be considered prior to stimulation being undertaken following due consultation with DES and DNRME.



LEGEND

- Town
- GAB ROP Discharge Spring
- GAB ROP Recharge Spring
- GAB ROP Water Course Spring
- Highway/Major Road
- Santos Tenements
- Study Area

0 KILOMETERS 250

1:10,000,000 GCS GDA 1994

NOTE(S)

REFERENCE(S)

1. BASE INFORMATION COPYRIGHT MAPINFO AUSTRALIA PTY LTD
2. ATP/PL TENURE SUPPLIED BY SANTOS, NOVEMBER 2019
3. GAB BOUNDARY, SOURCED FROM HTTPS://DATA.GOV.AU, SOURCED 18.12.2019

CLIENT
SANTOS

PROJECT
HYDRAULIC FRACTURING RISK ASSESSMENT – SANTOS SOUTHWEST QUEENSLAND TENEMENTS

TITLE
LOCATION OF THE GREAT ARTESIAN BASIN

CONSULTANT
GOLDER

DD-MM-YYYY	19-03-2020
DESIGNED	KB
PREPARED	KB
REVIEWED	CB
APPROVED	CB

PROJECT NO.	CONTROL	REV.	FIGURE
127666004	011-R	2	3

1.6 Comparison of Conventional Oil and Gas Operations to Coal Seam Gas Operations

HFRA (now referred to as SRA) reports have previously been prepared to address stimulation activities related to Santos' coal seam gas (CSG) developments as part of the Gladstone Liquefied Natural Gas (GLNG) Project. There are key differences between CSG and conventional oil and gas production, both in the geological setting of the resource and the methodology for access, that have a substantial bearing on the risk profile presented by stimulation activities.

Santos' conventional oil and gas operations in SWQ are located in an arid, sparsely populated area of central Australia. Whilst groundwater is an important water supply to support the rural land uses, the extent of water supply development of the productive aquifers is limited (commensurate with the low population base) and is almost entirely within the upper sedimentary formations of the Eromanga Basin. The lateral equivalents of the GAB aquifers in Eastern Queensland that support substantial beneficial uses have little or no water supply development in in the study area.

The nature of the hydrocarbon resources in SWQ is also fundamentally different from CSG targets. Conventional oil and gas reservoirs are formed when hydrocarbons in a porous (typically sandstone) formation are "trapped" and accumulate as a result of encountering a low permeability sedimentary or structural "seal". In Santos' SWQ operations, the hydrocarbon reservoirs generally occur in anticlines capped with thick, laterally-extensive, low permeability formations that isolate the reservoirs from overlying water-bearing formations. The nature of the geological and hydrogeological setting provides for substantial separation of fracturing and production activities from the shallower groundwater resources that support the majority of water supply development in the region. There is also no requirement to remove formation water in order to facilitate gas flow, with the possible exception of well blow downs on a case by case frequency. In addition, the oil and gas reservoirs in the SWQ study area are very deep, in the order of 1500 to 3000 m bgl, which provides hundreds to over a thousand metres vertical separation between the formations in which stimulation activities are proposed and the shallow aquifers that provide the majority of private groundwater supply.

Hence, the combination of the remote project location, sparse local population density (and limited water supply development), different production methods and the substantial vertical separation of oil and gas reservoirs from primary groundwater supply aquifers results in an inherently low risk profile with regard to stimulation activities.

2.0 SITE SETTING AND ISSUE IDENTIFICATION

The description of the site setting, and issue identification is covered under the following headings:

- Description of the climate in SWQ;
- Description of the topography;
- Description of the hydrology;
- Description of the continental geological setting and basin stress regime;
- Description of the regional geology and stratigraphy of the GAB;
- Description of the local geology and oil and gas field models;
- Seismic history of the region;
- Description of the GAB hydrogeological setting and hydrostratigraphy;
- Description of the hydrogeological context of oil and gas production;
- Groundwater quality and use in the study area;
- Environmental values of groundwater and surface water in the study area, which comprise the potential receptors considered in the exposure analysis for stimulation activities; and
- Proximity of overlying and underlying aquifers to the target oil or gas formations, and proximity of surface operations to sensitive receptors.

2.1 Climate

The Cooper Basin of SWQ is an isolated arid to semi-arid region of central Australia where the average rainfall is low (<300 mm per year) and is significantly exceeded by the pan evaporation potential (approximately 3,000 mm per year). The seasons are generally characterised by hot summers with significant thunderstorm activity and mild dry winters. December to February are the wettest and hottest months where temperatures generally exceed 35°C. The Bureau of Meteorology (BOM) provides monthly average data for temperature and rainfall for anywhere in Australia. For a more detailed description please refer to http://www.bom.gov.au/.

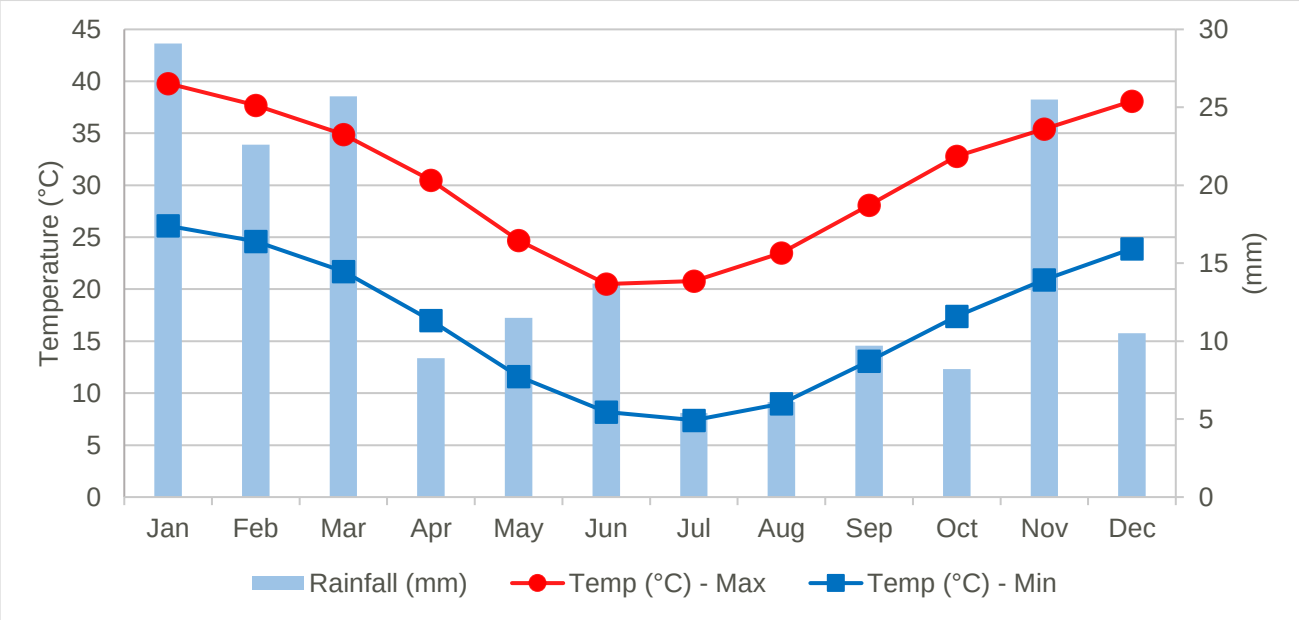
Table 2 and Figure 4 present the average minimum and maximum monthly temperatures and average monthly total rainfall from Ballera Gas Field, the closest BOM facility to Durham (approximately 16 km to the west). These data are averages for number of years. Annual average values are presented for temperature while average annual total amount of rainfall are presented in the same table. Maximum values are in red and minimum values in blue. No data on evaporation for the Ballera Gas Field site was available. However, data for evaporation was available for Windorah Evaporation Station located approximately 220 km to the north of Durham. Evaporation for Windorah ranged from 3.7 mm daily evaporation in June to 12.4 mm daily evaporation in December (data collected from 1969 to 2019). It should be noted that for this location the mean rainfall was higher than for Ballera and ranged from 10.0 mm mean monthly rainfall in August to 48.3 mm mean monthly rainfall in February approximately double that seen for Ballera in the same months.

Table 2: Mean Climate Characteristics within the Cooper Basin Operations Area – Ballera Gas Field

Mean	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	Years
Temp (°C) - Max	39.8	37.7	34.9	30.5	24.7	20.5	20.8	23.5	28.1	32.8	35.4	38.1	30.6	2002-2019
Temp (°C) - Min	26.1	24.6	21.7	17.0	11.6	8.2	7.4	9.0	13.1	17.4	20.9	23.9	16.7	2002-2019
Rainfall (mm)	29.1	22.6	25.7	8.9	11.5	13.7	5.4	6.1	9.7	8.2	25.5	10.5	181.8	2000-2019

* Estimated from the average *daily* pan evaporation as reported by BOM.

Figure 4: Rainfall and Temperature Diagram - Monthly Averages from 1931-2012 for Ballera Gas Field



Source: BOM, 2012

2.2 Topography

The study area is situated across a large, relatively flat drainage area of the Cooper Creek river system referred to as the 'Channel Country' of far south-western Queensland (extending into South Australia).

The topography of the study area comprises low undulating hills and ridges between the drainage channel systems. The Channel Country is characterised by extensive alluvial plains with braided channel networks of the Diamantina and Coopers Plains. Surrounding the floodplains are gravel or gibber plains, dune fields and low ranges. The low resistant hills and tablelands present in the study area are remnants of the flat-lying Cretaceous (65 to 140 million years ago) sediments.

The drainage system of the study area is dominated by the Cooper Creek Basin and is discussed further in Section 2.3.

2.3 Surface Water

The surface water drainage system within the study area (Figure 5) is dominated by Cooper Creek Basin, which drains southwest towards Lake Eyre. This Basin comprises almost a quarter of the overall Lake Eyre Basin catchment. During periods of monsoonal rainfall in its headwaters, the flat topography and drainage

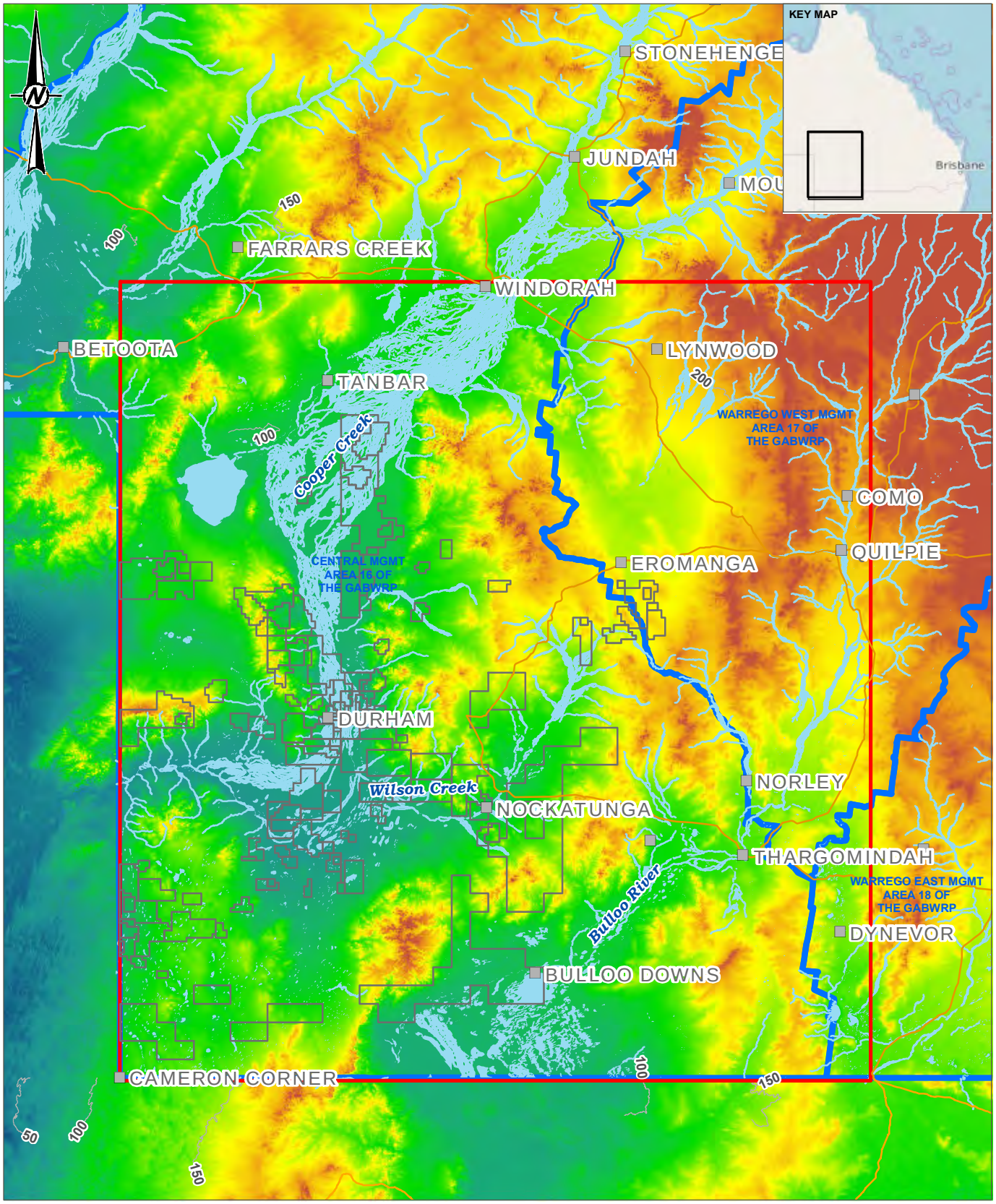
channel system forms a large floodplain. The surface water flow bottlenecks where Cooper Creek crosses the Queensland-South Australia border.

Cooper Creek is an internal (i.e. no outlet to the ocean) ephemeral river of 1,500 km in length and covering a catchment area of 306,000 km^2. Water flows vary greatly over time and are predominantly controlled by the occurrence of monsoonal rains in the headwaters of the Cooper Creek drainage system (Kotwicki and Allen, 1998).

Generally, Cooper Creek stream flows are confined to the main channels, but every three to four years flows are sufficient to inundate parts of the Cooper Creek floodplain, via a network of tributary channels. The cyclic nature of flows in Cooper Creek has been reported to correlate with La Nina events, which result in monsoon rains penetrating further into inland Australia (Kotwicki and Allen, 1998). During extended periods of no flow, the Cooper Creek drainage contracts to a series of disconnected, semi-permanent waterholes that form in deeper portions of the river channels, which provide drought refuges for a variety of flora and fauna. Two minor flood events were observed in 2019 and the latest large flood event was observed in early to mid 2010 (Figure 6).

Within the study area (largely confined to the Cooper Creek catchment basin), there are also intermittent surface water flows following storm events that cause ponding of surface water on interdune clay pans, predominantly in the dunefield regions and other areas.

There are only a handful of major water storages in the Cooper Creek Basin, with no in-stream dams. There are a number of small weirs for stock and domestic purposes, and a limited number of larger weirs that are mainly used for town water supply including at the northern margin of the study area at Wombunderry. Waterholes are the biggest storages in the basin with some entitlements to divert water to off-stream storages for domestic use. There is no supplemented water supply scheme in the Cooper Creek Basin.



LEGEND

- Town/Locality
- Highway/Major Road
- River/Creek
- Groundwater Management Area
- Santos Tenements
- Study Area

Elevation

High : 475

Low : 0

0 KILOMETERS 100

1:2,750,000 GCS GDA 1994

NOTE(S)

REFERENCE(S)

1. BASE INFORMATION COPYRIGHT MAPINFO AUSTRALIA PTY LTD
2. ATP/PL TENURE SUPPLIED BY SANTOS, NOVEMBER 2019
3. SRTM - NGA AND NASA

CLIENT
SANTOS

PROJECT
HYDRAULIC FRACTURING RISK ASSESSMENT – SANTOS SOUTHWEST QUEENSLAND TENEMENTS

TITLE
TOPOGRAPHY AND DRAINAGE OF THE STUDY AREA

CONSULTANT
GOLDER

DD-MM-YYYY	19-03-2020
DESIGNED	KB
PREPARED	KB
REVIEWED	CB
APPROVED	CB

PROJECT NO.	CONTROL	REV.	FIGURE
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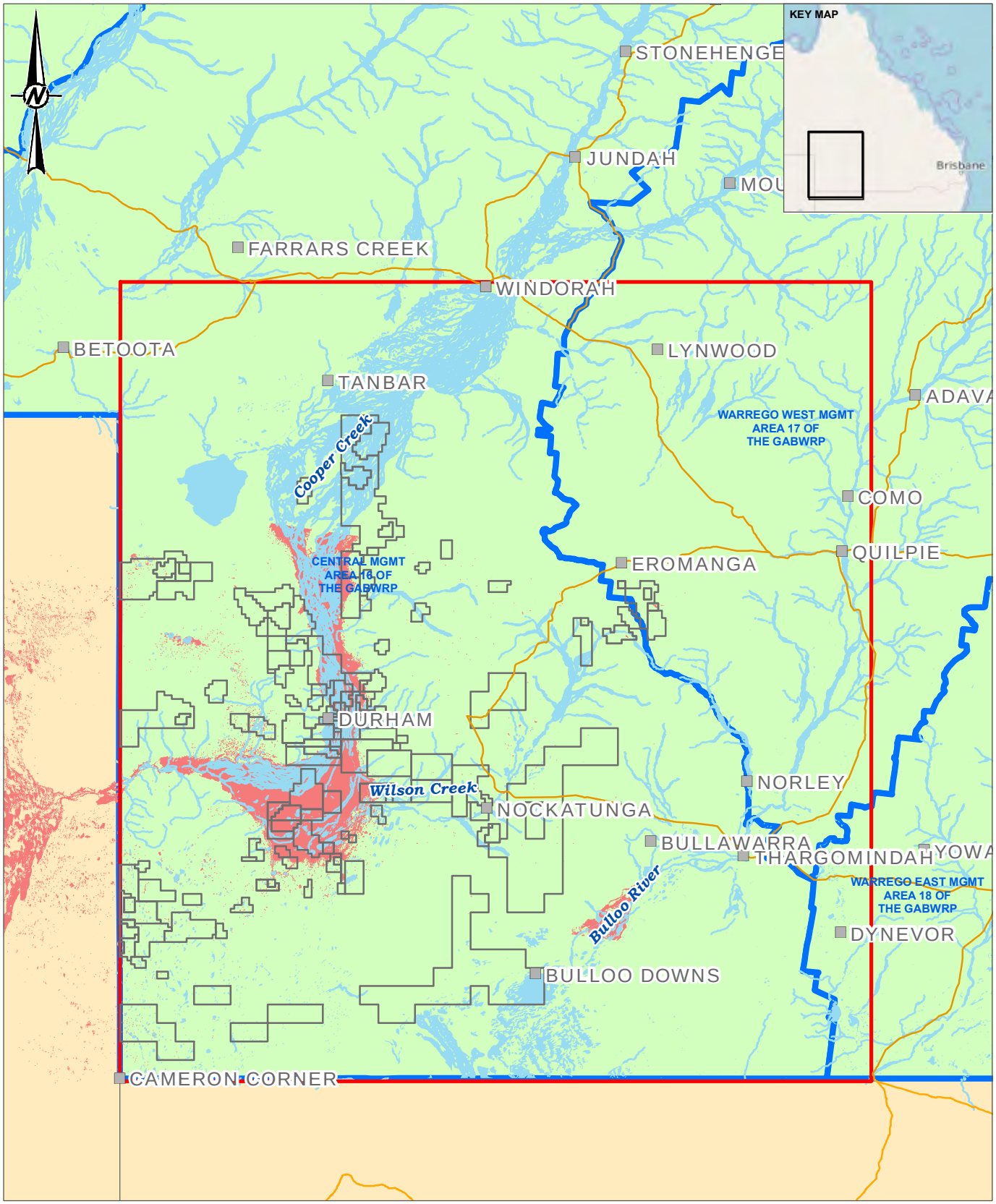

LEGEND

- Town/Locality
- Highway/Major Road
- River/Creek
- Flood Area 2010 Extent
- Groundwater Management Area
- Santos Tenements
- Study Area

0 KILOMETERS 100

1:2,750,000 GCS GDA 1994

NOTE(S)

REFERENCE(S)

1. BASE INFORMATION COPYRIGHT MAPINFO AUSTRALIA PTY LTD
2. ATP/PL TENURE SUPPLIED BY SANTOS, NOVEMBER 2019
3. FLOOD EXTENTS PROVIDED BY SANTOS, 2011

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HYDRAULIC FRACTURING RISK ASSESSMENT – SANTOS SOUTHWEST QUEENSLAND TENEMENTS

TITLE
STUDY AREA DURING A FLOOD EVENT (2010)

CONSULTANT
GOLDER

DD-MM-YYYY	19-03-2020
DESIGNED	KB
PREPARED	KB
REVIEWED	CB
APPROVED	CB

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2.4 Geological Setting

2.4.1 Continental Setting

The study area is located in the south-western portion of the Great Artesian Basin (GAB). The GAB is a hydrogeological basin that underlies approximately one fifth of the Australian continental area and extends beneath a large portion of Queensland, South Australia, New South Wales and the Northern Territory; stretching between the Great Dividing Range to the Lake Eyre depression (Figure 3). The GAB consists of three large sedimentary basins (the Eromanga, Carpinteria and Surat Basins), comprising layered sedimentary sequences up to 3,000 m thick in the deepest portions of the basin. The sub-basins of the GAB unconformably overlay a number of older depositional basins including the Cooper Basin in SWQ (Figure 7).

It has been an historical convention in Queensland's groundwater management framework to include the upper sedimentary sequences of certain older basins underlying the GAB (specifically, the Bowen, Galilee and Cooper Basins) in the broader definition of the GAB groundwater resource. Whilst this convention was adopted for administrative convenience, in a strict geological sense these basins are considered to be distinct and separate from the sub-basins of the GAB.

2.4.2 Regional Geological Setting

The study area is situated over portions of the Eromanga and Cooper Basins in SWQ. The geology within the study area includes a late Carboniferous to Triassic age sequence of interbedded sandstones, coals and siltstones associated with the Cooper Basin, which is unconformably overlain by the Jurassic to Cretaceous sedimentary deposits of the Eromanga Basin (Figure 7).

The Eromanga Basin is the largest of the main sub-basins of the GAB. It contains two major centres of basin subsidence: the Central Eromanga depositional centre and the Poolowanna Trough separated by the Birdsville Track Ridge (Figure 7).

The Cooper Basin is entirely buried below the Eromanga Basin and they are vertically separated by a major unnamed unconformity. Although considered structurally separate sedimentary depositional centres, they are stratigraphically and, to a very limited extent, hydraulically connected. Formations of the Cooper Basin and the GAB have varying nomenclature in stratigraphic successions from one area to another. Habermehl (1986) and others have tried to provide basin-wide correlations between nomenclatures for the GAB. This section adopts the geological nomenclature defined for SWQ by Draper (2002). Reference to "equivalent naming" is required in order to link with the nomenclature used in the QLD GAB regulation.

At the surface, the regional geological maps indicate a predominance of consolidated sediments of the Glendower Formation (Tertiary) or Winton Formation (Cretaceous) on the higher ground structures and also Quaternary alluvial deposits (Figure 8 and Figure 9) associated with the Cooper Creek flood plains. The Quaternary surface sedimentation of the Cooper Creek catchment was described by Nanson et al. (2008) as comprising extensive late Quaternary fluvial and aeolian deposits, overlain by thick floodplain and channel mud deposits.

The general stratigraphic sequence for the study area is presented in Table 3.

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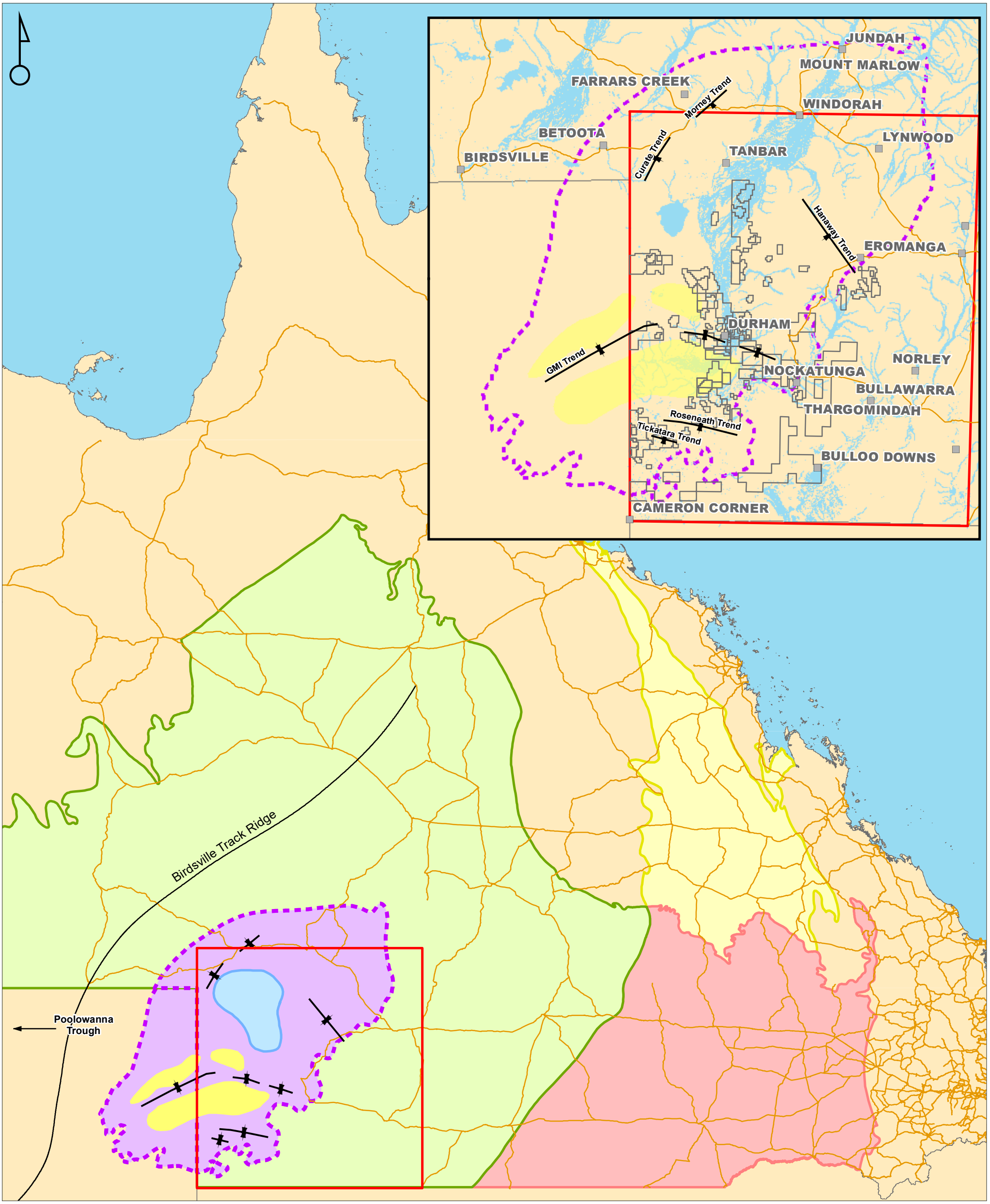

LEGEND

- Town/Locality
- Birdsville Ridge (Approximate Location)
- Highway/Major Road
- Structural Trend
- Geological/Structural Trough
- Cooper Basin
- Barrolka Trough
- Bowen Basin
- Eromanga Basin
- Surat Basin
- Santos Tenements
- Study Area

0 KILOMETERS 400

1:6,000,000 GCS GDA 1994

NOTE(S)

REFERENCE(S)
1. BASE INFORMATION COPYRIGHT MAPINFO AUSTRALIA PTY LTD
2. ATP/PL TENURE SUPPLIED BY SANTOS, NOVEMBER 2019
3. STRUCTURAL GEOLOGY OF GAB, DERM
4. STRUCTURAL ELEMENTS OF THE COOPER AND EROMANGA BASINS DIGITISED FROM LOWE YOUNG ET AL 1997

CLIENT
SANTOS

PROJECT
HYDRAULIC FRACTURING RISK ASSESSMENT – SANTOS SOUTHWEST QUEENSLAND TENEMENTS

TITLE
GAB STRUCTURAL GEOLOGY OF THE STUDY AREA

CONSULTANT
GOLDER

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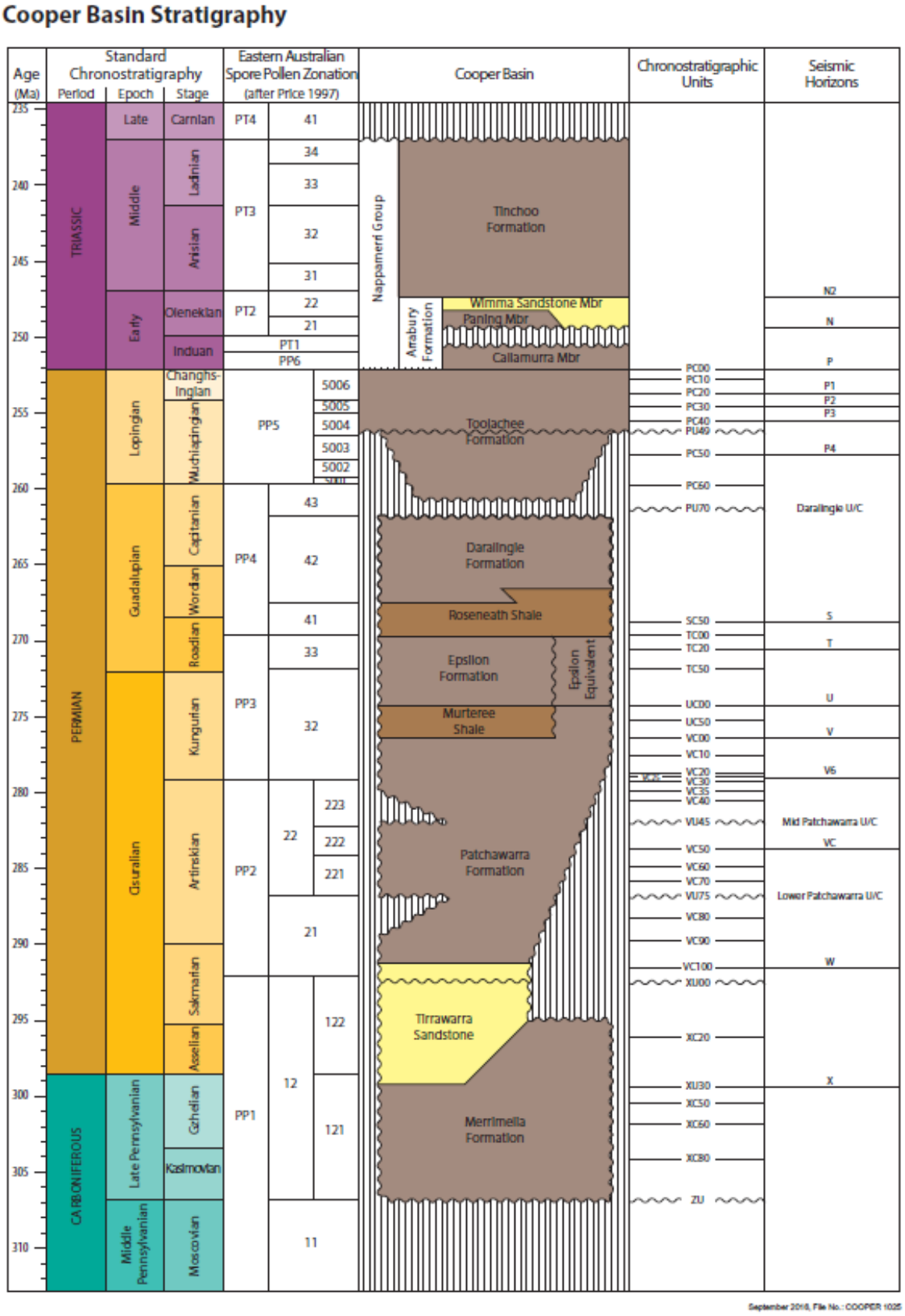
0 25mm

Table 3: Stratigraphic Sequence for the Study Area

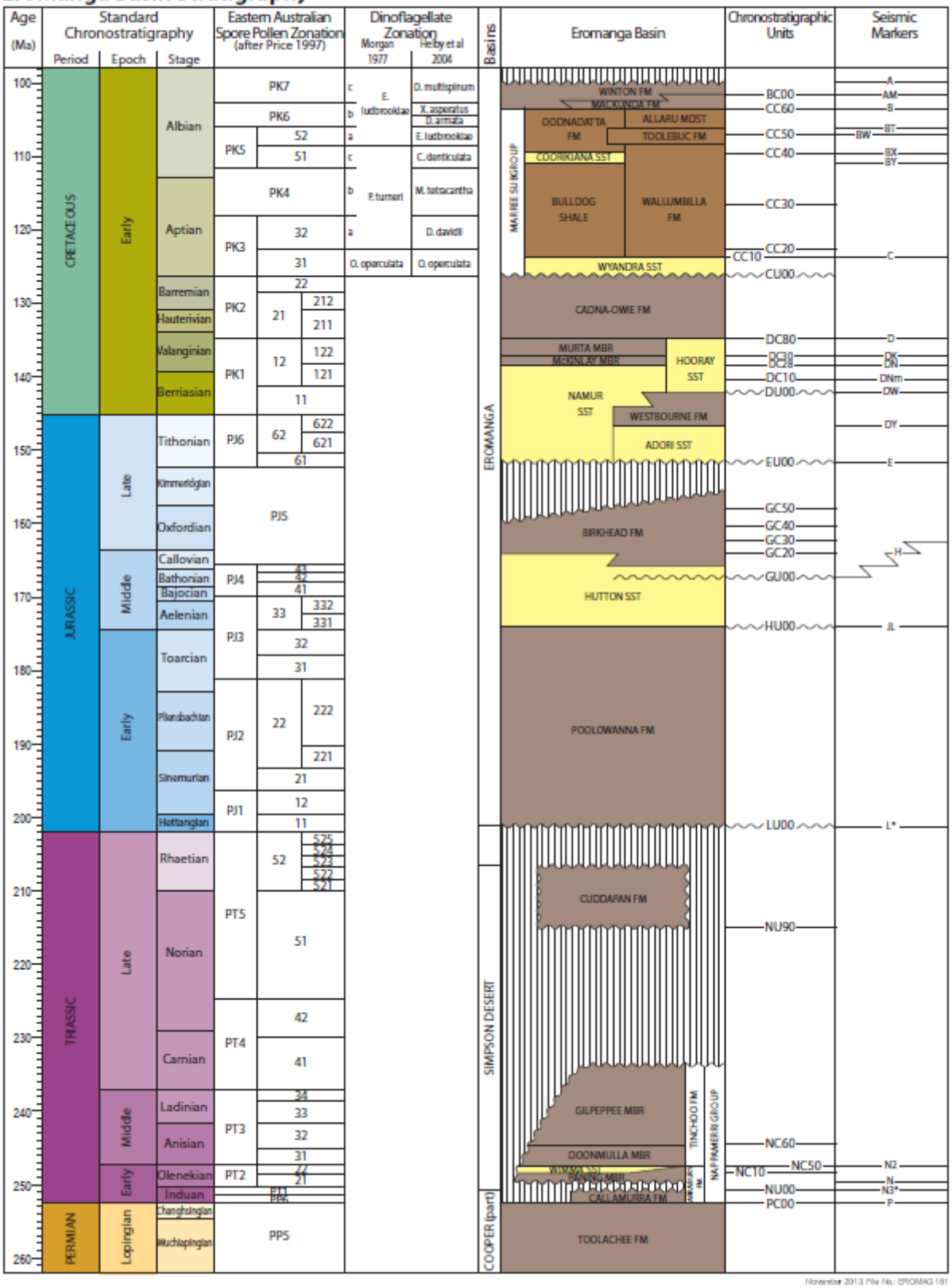
WRP Management Units		Litho-stratigraphy									
Central GMA16	Warrego West GMA 17		Unit name	Sub-unit	Equivalent Formation in GAB **	Deposits environment *	Uthology Description*	Geological Age	Thickness*	Santos Current Production Reservoir (Oil&Gas)	Hydrogeological Chracteristics
		Eromanga Basin	Tertiary sediments (Glendower Formation)			Fluvial deposits	Sandstone, silty siltstone, conglomerate and minor mudstone	Tertiary	maximum 145***	No	Aquifer
			Winton Formation			Terrestrial deposition environment. Fluviolacustrine.	Interbedded fine to coarse-grained sandstone, shale, siltstone and coal seams with intraclast conglomerates.	Cretaceous	Over 400 m in the Cooper region, maximum thickness of 1100 m in the northern Patchawarra Trough	No	Aquifer
			Mackunda Formation			Marine environment	Interbedded, partly calcareous very fine-grained sandstone, siltstone and shale in the basin centre.		60–120 m thick in the Cooper region	No	Aquifer
			Allaru Mudstone			Low-energy, shallow marine environment	Mudstone with thin calcareous siltstone and minor thin, very fine-grained sandstone interbeds		100–240 m thick in the Cooper region, but reaches thicknesses >600 m in the Patchawarra Trough.	No	Water bearing
Central 1	Warrego West 1		Toolebuc Formation		Surat Silstone	Marine environment	Mudstone		5 to 75 m **	No	Confining bed
			Wallumbilla Formation	Coreena Member	Wallumbilla Formation	Marine environment	Mudstone and siltstone with minor interbeds of fine grained sandstone		maximum known of 269 m (Poolowanna Trough)	No	Aquifer
Central 2	Warrego West 2		Cadna-Owie Formation	Wyandra Sandstone Member	Cadwa-Owie Formation	Lowstand system infilling fluvial channels then transgressive systems	Medium to coarse-grained, quartzose to labile sandstone with scattered pebbles		From 3 to 18 m in Queensland	Oil (not frequent)	Aquifer
				Lower Cadna-Owie		Transition from terrestrial to marine deposition environment	Siltstone with very fine to fine-grained sandstone interbeds and minor carbonaceous daystone . Pebbly layers, diamictites and coarse breccia layers occur around the basin margin.		Typically 10–20 m thick around the basin margin, increasing to 75–100 m in the deeper parts of the basin. Maximum thickness of >115 m in the Nappamerri Trough.	No	Confining bed
Central 3	Warrego West 3		Hooray Sandstone	Murta Formation	Mooga-Gubberamunda Sandstone	meandering fluvial, floodplain and lacustrine environment	Thinly interbedded siltstone, shale, very fine to fine-grained sandstone and minor medium and coarse-grained sandstone. A basal siltstone is widespread in the Cooper region.		Maximum thickness of >90 m (incl. McKinlay Member) reached in the Nappamerri Trough.	Oil, some gas (not frequent) Seal	Aquifer
				McKinlay Member	Hooray Sandstone	lacustrine conditions	Fine to medium-grained sandstone interbedded with carbonaceous siltstone		Typically <30 m thick, and is often absent in the Cooper region	Oil (not frequent)	
				Namur Sandstone		meandering braided fluvial systems	Fine to coarse-grained sandstone with minor interbedded siltstone and mudstone. The basal Namur Sandstone, like the Adori Sandstone, has been strongly cemented with diagenetic calcite in places.		40 to 240 m thick in the Cooper region	Oil (not frequent)	
Central 4	Warrego West 4		Westbourne Formation		Injune Creek Group	lacustrine deposits (transgression)	Interbedded dark grey shale and siltstone with minor sandstone interbeds	Jurassic	30 to 140 m thick in the Cooper region	Oil (not frequent)	Confining bed
			Adori Sandstone			Amalgamated braided fluvial sandstone deposited in lowstand system tract.	Well-sorted, subrounded, cross-bedded, fine to coarse-grained sandstone. Calcite cemented zones up to 45 m thick are developed locally in the basal Adori and Namur sandstones		20 to 130 m thick in the Cooper region.	Oil (not frequent)	Aquifer
			Birkhead Formation	Upper Birkhead Middle Birkhead Lower Birkhead		Meandering to lacustral deposition. Birkhead "lake", largest	Interbedded siltstone, mudstone and fine to medium grained sandstone with thin, lenticular coal seams (<0.3 m thick)		A maximum thickness of >150 m occurs in the Patchawarra and Nappamerri troughs	oil - Basal Birkhead and Middle Birkhead (scattered)	Water bearing
Central 5	Warrego West 5		Hutton Sandstone			Erosion then lowstand system	Fine to coarse-grained quartzose sandstone with minor siltstone interbeds		From 40 m to over 360 m in the Patchawarra Trough.	Oil, some gas (not frequent)	Aquifer
Central 6	Warrego West 6		Poolowanna Formation	Upper Poolowanna	Precipice Sandstone	Transgression to highstand systems	Interbedded siltstone, sandstone and rare coal seams. Sandstone beds range from very fine to medium grained, and contain minor pebbles and granules of quartzite and reworked basement.		Maximum of 205 m in the Poolowanna Trough		Aquifer
				Lower Poolowanna		Lowstand (fluvial) and early transgressive system				Oil (not frequent)	
MAJOR UNCONFORMITY											
Central 7	Warrego West 7	Cooper Basin	Nappamerri Group	Tinchoo Formation	Gilpeppee Shale	Moolayember Formation		Interbedded siltstone and light grey sandstone	Triassic	Maximum of 109 m	Gas (not frequent)	Confining bed
					Doonmulla Member			Uniform dense siltstone, with minor coal seams (Gilpeppee Member) and intraclast conglomerate beds				
				Arrabury Formation	Wimma Sandstone Member	Clematis Sandstone		Fine to medium-grained quartzose sandstone with minor interbeds of siltstone and mudstone.		Maximum total thickness of 400 m in the Patchawarra Trough. Callamura Member: up to 150 m and more. Panning Member : up to 200 m and more. Wimma Sandstone : 115 m maximum	Gas (not frequent)	Aquifer
					Panning Member	Rewan Formation		Upward-fining cycles of fine to medium-grained sandstone grading into siliceous mudstone and siltstone units.			Oil (not frequent)	Confining bed
					Callamura Member			Siltstone and mudstone, minor sandstone interbeds (Early Triassic).Siderite and cements have formed in siltstone and sandstone beds.				Confining bed
			Gidgealpa Group	Toolachee Formation			Channels deposits	Interbedded fine to coarse-grained sandstone, siltstone and carbonaceous shale, sometimes with thin coal seams (<3 m thick), and conglomerates.	Permian	Up to 175 m	Gas	Aquifer
				Daralingie Formation				Siltstone and mudstone with interbedded fine to very fine-grained sandstone. Minor coal seams and carbonaceous partings and streaks occur.				Confining bed
				Roseneath Shale				Siltstone, mudstone and minor sandstone.		Up to 100 m or plus in some throughs		Confining bed
				Epsilon Formation				Thinly bedded, fine to medium-grained sandstone with carbonaceous siltstone and shale, and thin to occasionally thick (<2-20 m) coal seams.		Maximum thickness of 156 m in the Nappamerri Trough.	Gas	Aquifer
				Murteree Shale				Argillaceous siltstone and fine-grained sandstone.		Relatively uniform in thickness, averaging 50 m. Maximum thickness of 80 m in the Nappamerri Trough.		Confining bed
				Patchawarra Formation			Individual and stacked channels	Interbedded fine to medium-grained, locally coarse-grained and pebbly sandstone, siltstone, shale and coal .		Up to 680 m thick in the Nappamerri Trough	Gas	Aquifer
				Tirrawarra Sandstone			Braided channel deposits	Fine to coarse-grained, moderately well sorted sandstone with minor shale interbeds and rare, thin coal seams and stringers. Conglomerate beds are locally well-developed, notably in Gidgealpa and Big Lake Fields.		Maximum 75 m total thickness	Gas (not frequent)	Aquifer
				Merrimelia Formation			Glacial sediments deposits, deep glacio-lacustrine sediments	Conglomerate, sandstone, conglomeratic mudstone, siltstone and shale	Late Carboniferous to Early Permian			Water bearing

Data sources:
*: Petroleum Geology of South Australia, Volume 2 and 4, http://www.pir.sa.gov.au/petroleum/access_to_data/petroleum_publications/petroleum_geology_of_south_australia
**: GAB WRP, 2007
***: Australian Stratigraphy Database

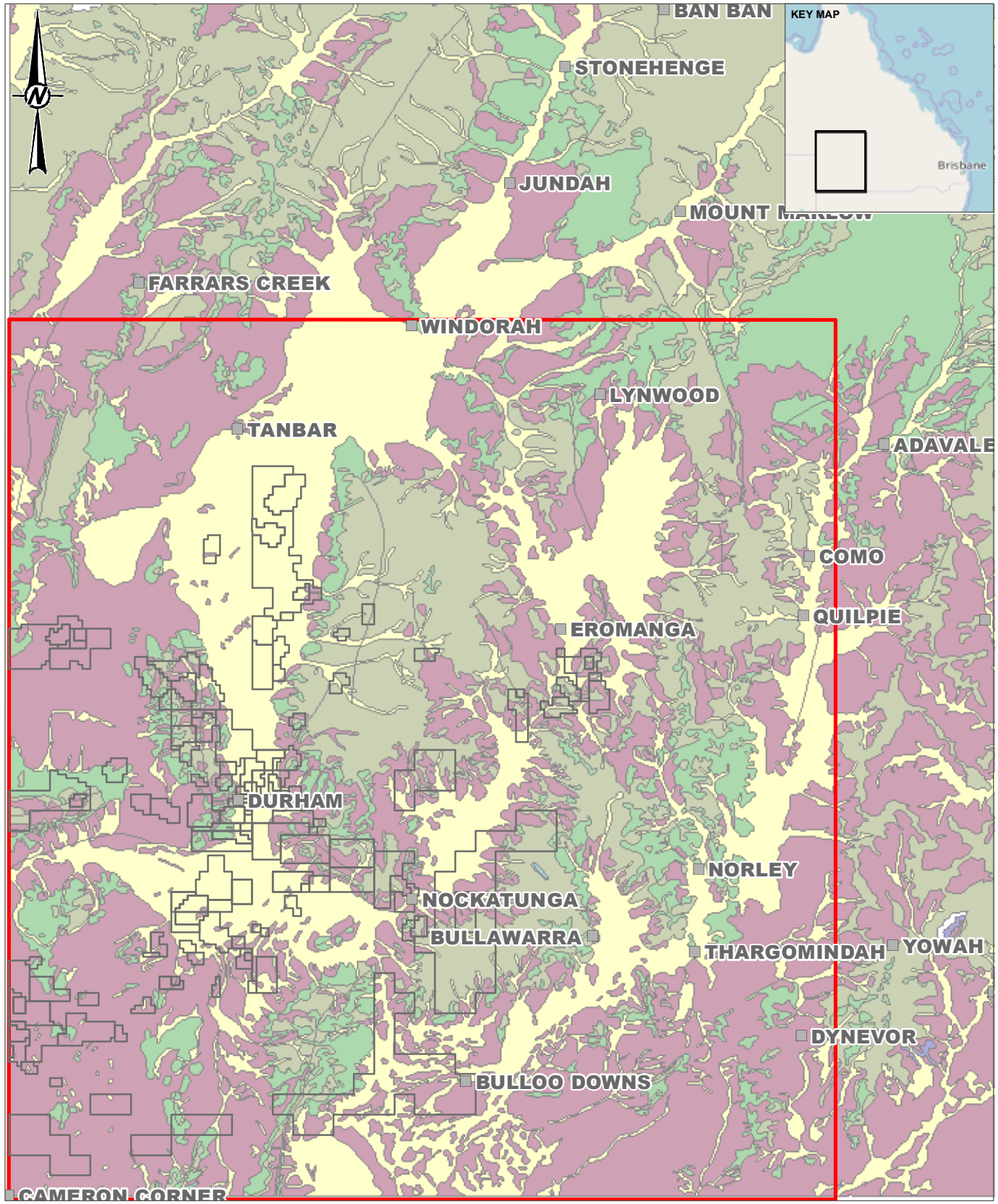
Figure 8: Chronology and Stratigraphy of the Cooper and Eromanga Basins (Queensland and South Australia)



Eromanga Basin Stratigraphy



Source: Draper, 2002



LEGEND

- Town/Locality
- Qa-CER
- Q-CER
- Glendower Formation
- Winton Formation
- Mackunda Formation
- Doncaster Member
- Santos Tenements
- Study Area

0 KILOMETERS 100

1:2,500,000 GCS GDA 1994

NOTE(S)

REFERENCE(S)

1. BASE INFORMATION COPYRIGHT MAPINFO AUSTRALIA PTY LTD
2. ATP/PL TENURE SUPPLIED BY SANTOS, NOVEMBER 2019
3. GEOLOGY SOURCED DEPARTMENT OF MINES AND ENERGY, QLD GOVERNMENT, 2007

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PROJECT
HYDRAULIC FRACTURING RISK ASSESSMENT – SANTOS SOUTHWEST QUEENSLAND TENEMENTS

TITLE
SURFACE GEOLOGY

CONSULTANT
GOLDER

DD-MM-YYYY	19-03-2020
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PREPARED	KB
REVIEWED	CB
APPROVED	CB

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2.4.3 Local Geological Setting and Petroleum Field Models

The following sections provide a summary of the Cooper Basin and Eromanga Basin geological settings. An overview of the stratigraphy and lithology for the study area is provided in Table 3. Figure 8 provides information on the continuity of the deposition process, and the discontinuities or major unconformities present in the stratigraphic sequence.

2.4.3.1 Cooper Basin Geological Setting and Model

The Cooper Basin comprises a thick late Carboniferous to middle or late Triassic non-marine sedimentary stratigraphic succession within a broad basin shaped setting in the interior of central Australia.

Structurally, the Cooper Basin is one of a number of remnant late Carboniferous to early Permian depositional centres which lay in the Australian interior of the Gondwana Supercontinent. The Cooper Basin differs from the smaller depositional centres by containing an additional sequence that ranges in age from late Permian to middle Triassic and spans the Permo-Triassic boundary without a break in deposition. It also differs as being the only such basin with major oil and gas production (Petroleum Geology of South Australia, Volume 4 - Cooper Basin, PIRSA, 1998). Three major troughs (Patchawarra, Nappamerri and Tanapperra) are identified within the basin, each separated by structurally high ridges.

The Cooper Basin depositional episode was terminated by a period of gentle regional compressional deformation resulting in landmass uplift and sustained erosion within the basin. Sedimentary basin development re-initiated subsequently with the formation of the Eromanga Basin (Section 2.4.3.2) during the Early Jurassic to Late Cretaceous times.

The Cooper Basin contains a succession of fluvio-lacustrine sandstone, shales and coals to a thickness of up to 1,800 m to the south and thinner in the north (up to 600 m thick). The target gas formations in the Cooper Basin lie at depths of 1,500 mbgl to greater than 2,000 mbgl.

The Cooper Basin is subdivided in two major geological groups: the late Carboniferous and Permian Gidgealpa Group and the Triassic Nappamerri Group. The earliest sediments within the Cooper Basin were of glacial origin. The subsequent formations generally consist of interbedded sandstone, coal and shale formations. The Tirrawarra Sandstone represents low sinuosity fluvial to glacial outwash deposits overlain by peat swamp, floodplain and high sinuosity fluvial facies of the Patchawarra Formation. Two lacustrine shale units (Murteree and Roseneath Shales) with intervening fluvio-deltaic sediments (Epsilon and Daralingie Formations) were deposited during a phase of continued subsidence. Early Permian uplift led to erosion of the Daralingie Formation and underlying units from basement highs (SA DPI, 1998).

The upper sequence of the Cooper Basin, the Gilpeppee Member of the Tinchoo Formation is dominated by siltstones and shales. Draper (2002) has mapped the thickness of shales of the Tinchoo Formation in SWQ. The mudstone (both shale and siltstone) thickness ranges from 80 to 160 m in the centre of the Cooper Basin with a maximum thickness of 182 m.

The Tirrawarra Sandstone, Patchawarra Formation, Epsilon Formation and Toolachee Formation (Table 3) are the main gas producers of the Cooper Basin. Minor gas reservoirs are also present in the Tirrawarra Sandstone, the Wimma Sandstone Member of the Arraburry Formation and the Tinchoo Formation. Some oil reservoirs are present in the Panning Member of the Arraburry Formation.

Geological contour maps illustrating the top and thickness of the following formations can be found in APPENDIX B (sourced from UWIR Report, Golder, 2012a). These maps include:

- Depth to the Toolachee Formation
- Depth to the Patchawarra Formation

- Thickness of the Patchawarra Formation
- Thickness of the Toolachee Formation
- Thickness of the shale within the Nappamerri Group.

2.4.3.2 Eromanga Basin Geological Setting and Model

The Jurassic to Cretaceous Eromanga Basin unconformably overlies the older Carboniferous to Permian Cooper Basin. The sedimentary sequences of the Eromanga Basin reach a thickness of up to 2,500 m and were deposited during a period of subsidence subsequent to that of the Cooper Basin. There are two main sub-basin centres in the Eromanga Basin: the *Central Eromanga Depositional centre* and the *Poolowanna Trough* to the west separated by the Birdsville Track Ridge (Figure 7). The top of the Eromanga Basin is also delimited by an unconformity.

The study area for this project is located in the *Central Eromanga Basin*.

The deposits of the Eromanga Basin follow three episodes (and three different origins) of deposition:

- Lower non-marine sediments from early Jurassic to Mid-Cretaceous corresponding to the Poolowanna Formation to the Cadna-Owie Formation. During that period the largest transgression over the Eromanga Basin was the “Birkhead Lake” transgression;
- Marine sediments from mid-cretaceous to late Cretaceous corresponding to the Wallumbilla Formation to the Mackunda Formation; and
- Upper non marine sediments (fluviolacustrine) of the Winton Formation.

The formations of the Eromanga Basin are a succession of well-defined sandstones, siltstones and mudstones with interbedded minor sandstones and occasional coal seams, as shown in Table 3. The formations of the Eromanga Basin often have an equivalent throughout the GAB. The nomenclature adopted in this section is the SWQ nomenclature as illustrated in Figure 8.

The target oil formations of the Eromanga Basin lie at depths ranging from 700 to 1,200 mbgl.

Geological contour maps for the following formations can be found in APPENDIX B (sourced from UWIR Report, Golder, 2012a):

- Depth to the Winton Formation;
- Depth to the Cadna-Owie Formation;
- Depth to the Hooray Sandstone;
- Depth to the Hutton Formation;
- Depth to the Poolowanna Formation;
- Thickness of the Cadna-Owie Formation ;
- Thickness of the Hooray Sandstone;
- Thickness of the Hutton Sandstone; and
- Thickness of the Poolowanna Formation.

2.4.3.3 Conceptual Geological Cross Sections

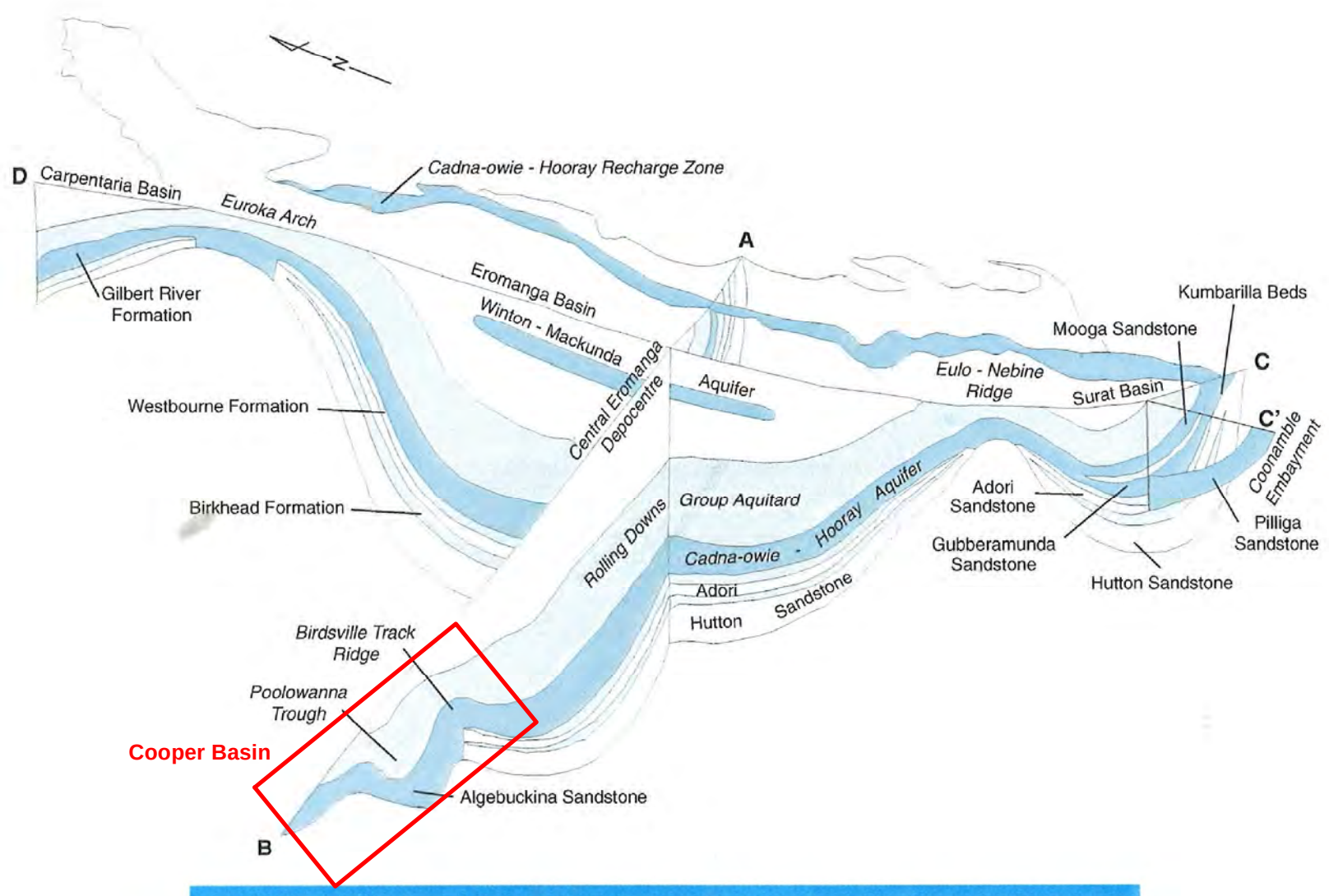
A schematic geological cross-section across the Eromanga Basin is presented in Figure 10. The “A-B” section cuts across the main depositional centre of the basin in SWQ. This corresponds to the general location of the study area. As displayed, the upper formations of the Eromanga Basin (from Cadna-Owie and Hooray Sandstone and younger) are continuous across the Basin. Older formations are restricted to areas within sub-basins (these formations or their equivalent may be present in several basins).

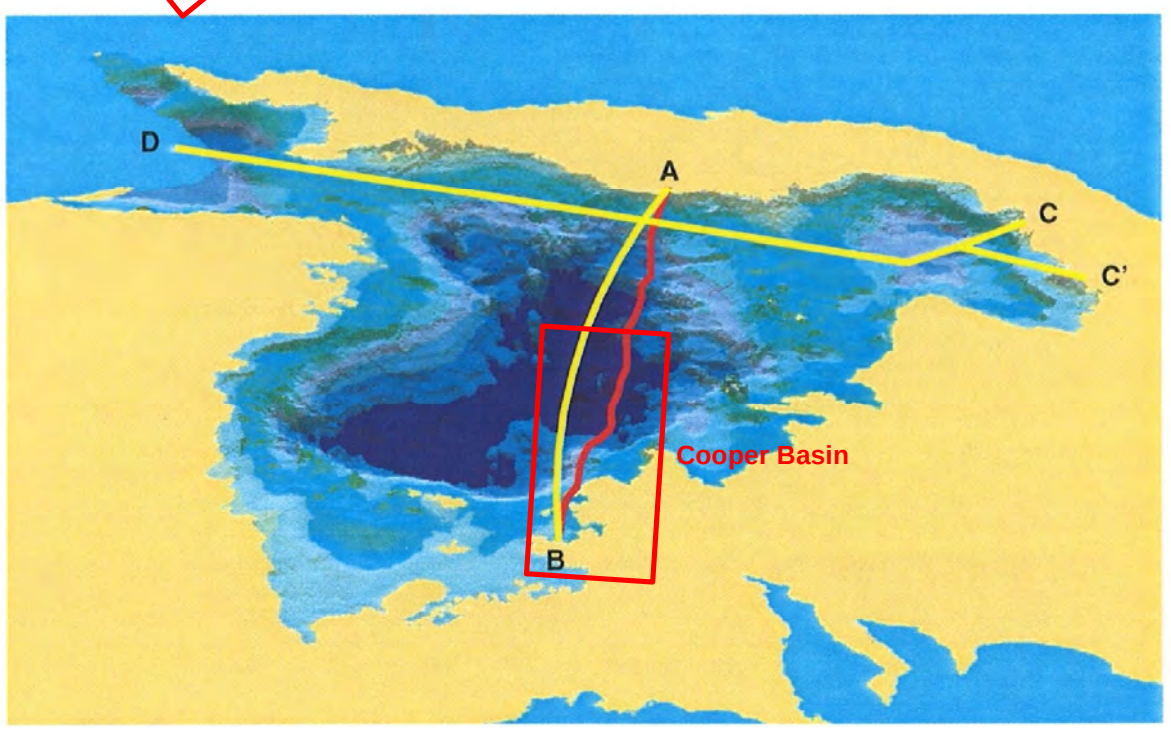
Abbreviations commonly used by Santos as stratigraphy markers or reservoir markers and used in some of the geological figures are summarised in Table 4.

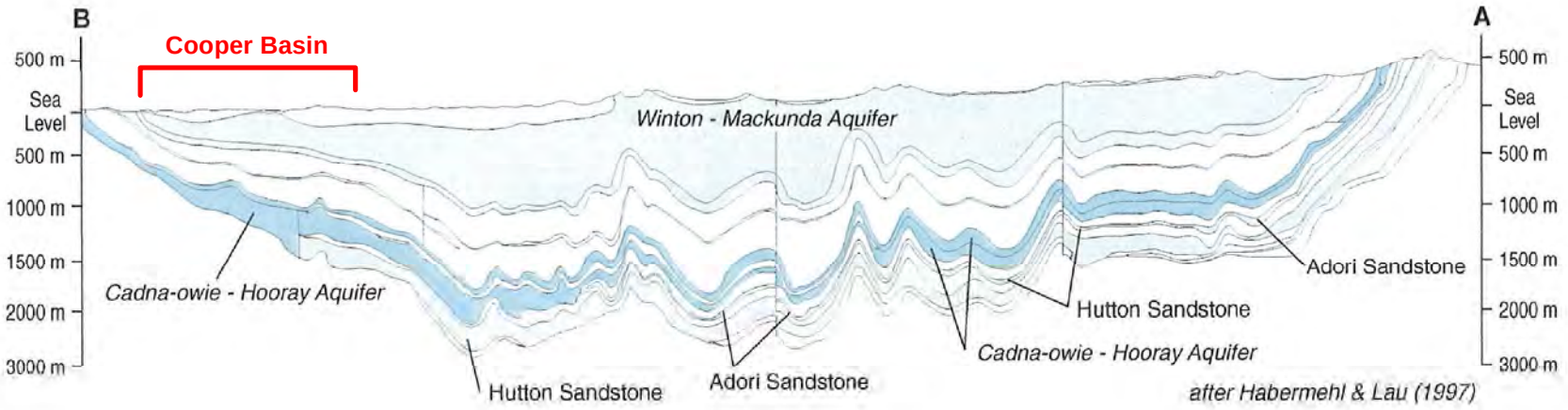
Table 4: Geological Abbreviations for Stratigraphical Markers

Name of Marker	Definition
'C' Horizon	Top Cadna-Owie
'E' Horizon	Top Birkhead Formation
'H' Horizon	Top Hutton Sandstone
'L*' Horizon	Basal Eromanga Unconformity
'PC00' Horizon	Top Toolachee Formation (chrono-marker)
'PU70' Horizon	Basal Toolachee Formation (chrono-marker and un-named Unconformity)
'VC00' Horizon	Top Patchawarra Formation (chrono-marker)
'VC50' Horizon	Lower Patchawarra Formation (chrono-marker)
'VCxx' - Horizon	Chrono-stratigraphic marker within the Patchawarra Formation
'ZU00' Horizon	Top Pre-Permian (Basement)

A geological conceptual cross section across both the Cooper and Eromanga Basins has been generated in a SW to NE axis across the study area passing through the Barrolka fields (Barrolka Trough). The conceptual geological cross-section is presented in Figure 11.







SWQ HYDRAULIC FRACTURING
RISK ASSESSMENT

SANTOS

GEOLOGICAL SCHEMATIC CROSS SECTION ACROSS THE GAB EROMANGA BASIN

PROJECT: **127666004**
DATE: **19/12/2012**
DRAWN: **FA**
CHECKED: **RS**

FIGURE 10

COPYRIGHT

1. Figure taken from Hydrochemistry and Implied Hydrodynamics of the Cadna-Owie-Hooray Aquifer Great Artesian Basin – BRS, 2000
2. Golder Associates 2012a Cooper Basin UWIR Report

GOLDER

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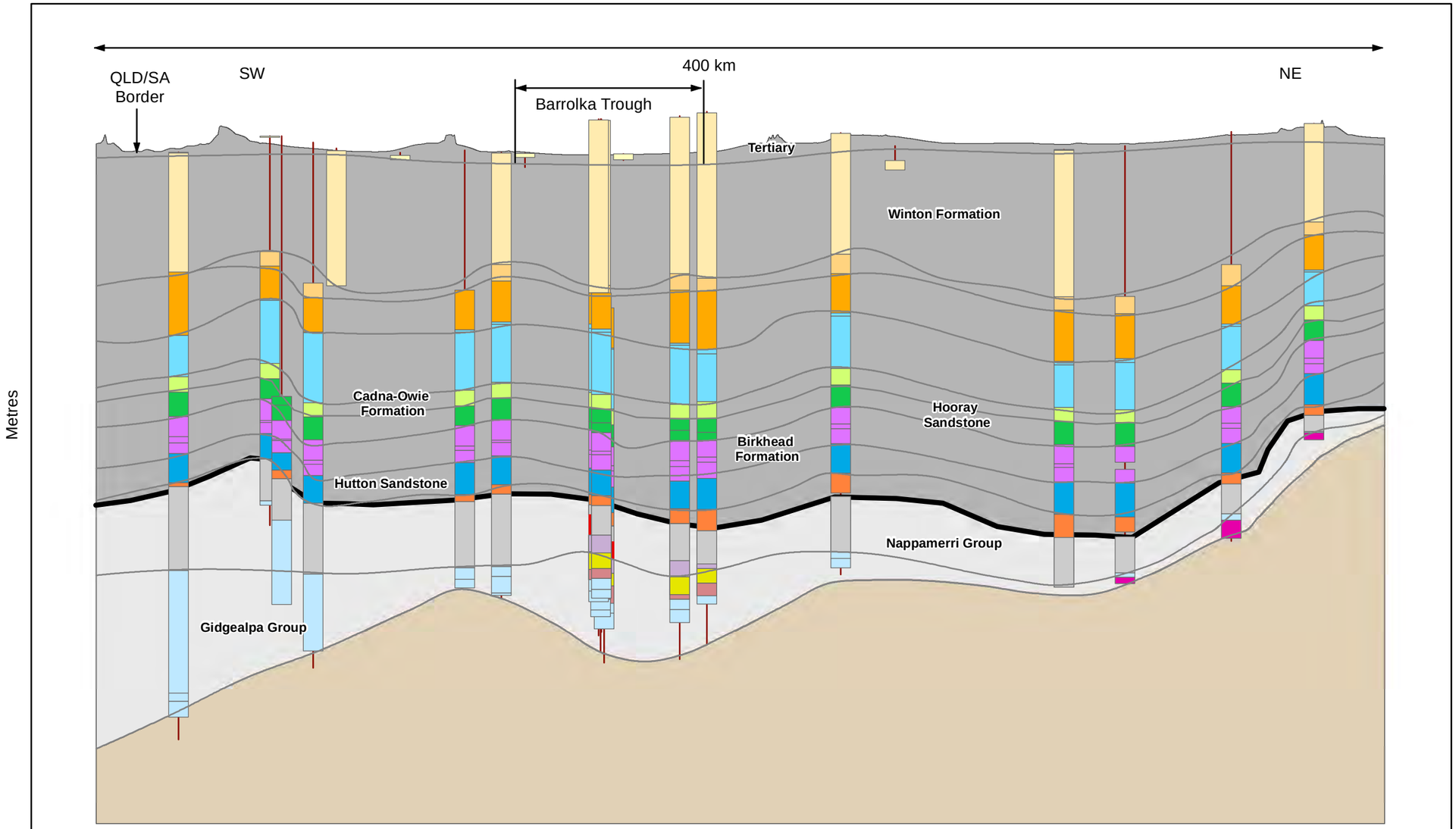
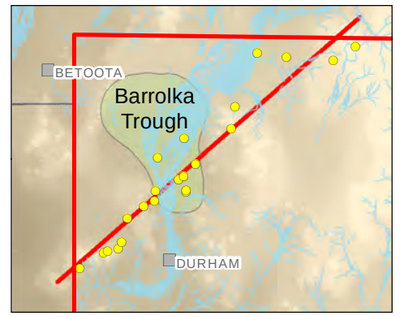


SWQ HYDRAULIC FRACTURING RISK ASSESSMENT

SANTOS

GEOLOGICAL CONCEPTUAL CROSS SECTION ACROSS THE STUDY AREA



LEGEND

	Litho-stratigraphy	
	Unit name	Sub-unit
Eromanga Basin	Tertiary sediments	
	Winton Formation	
	Mackunda Formation	
	Allaru Mudstone	
	Toolebuc Formation	
	Wallumbilla Formation	Coreena Member
		Doncaster Member
	Cadna-Owie Formation	Wyandra Sandstone member
		Lower Cadna-Owie
	Hooray Sandstone	Murta Formation
		McKinlay Member
		Namur Sandstone
	Westbourne Formation	
	Adori Sandstone	
	Birkhead Formation	Upper Birkhead
		Middle Birkhead
		Lower Birkhead
	Hutton Sandstone	
	Poolowanna Formation	Upper Poolowanna
		Lower Poolowanna
Cooper Basin — Nappamerri Group	Tinchoo Formation	Gilpepee Shale
		Doonmulla Member
	Arraburry Formation	Wimma Sandstone Member
		Panning Member
		Callamurra Member
Cooper Basin — Gidgealpa Group	Toolachee Formation	
	Daralingie Formation	
	Roseneath Shale	
	Epsilon Formation	
	Murteree Shale	
	Patchawarra Formation	
	Tirrawarra Sandstone	
	Merrimelia Formation	

Study Area
Geological Contact
Major Unconformity
Eromanga Basin
Cooper Basin
Basement

0 10 20 40 60 Kilometres

Vertical Exaggeration 1:50

PROJECT: **127666004**
DATE: **19/12/2012**
DRAWN: **FA**
CHECKED: **RS**

FIGURE 11

GOLDER

2.4.3.4 Primary Oil and Gas Producing Reservoirs

Oil and gas production in the study area targets sandstone reservoirs in both the Cooper and Eromanga Basins. Conventional gas reservoirs are predominantly present within the Cooper Basin sequence, whereas oil reservoirs present in the Eromanga Basin. The production of oil or gas is related to its deposition (sedimentological and lithological), hydrocarbon maturation (i.e. paleontological and age related) and charge.

Several types of reservoirs can form depending on the “trapping” mechanism for the hydrocarbons (Figure 12). The trapping mechanisms prevent further migration, and result in accumulation, of the hydrocarbon fluids in the sandstone reservoir. The hydrocarbon reservoir trapping mechanisms relevant to the Cooper and Eromanga Basins are shown in Figure 13.

Figure 12: Hydrocarbon ‘Traps’ Geological Settings

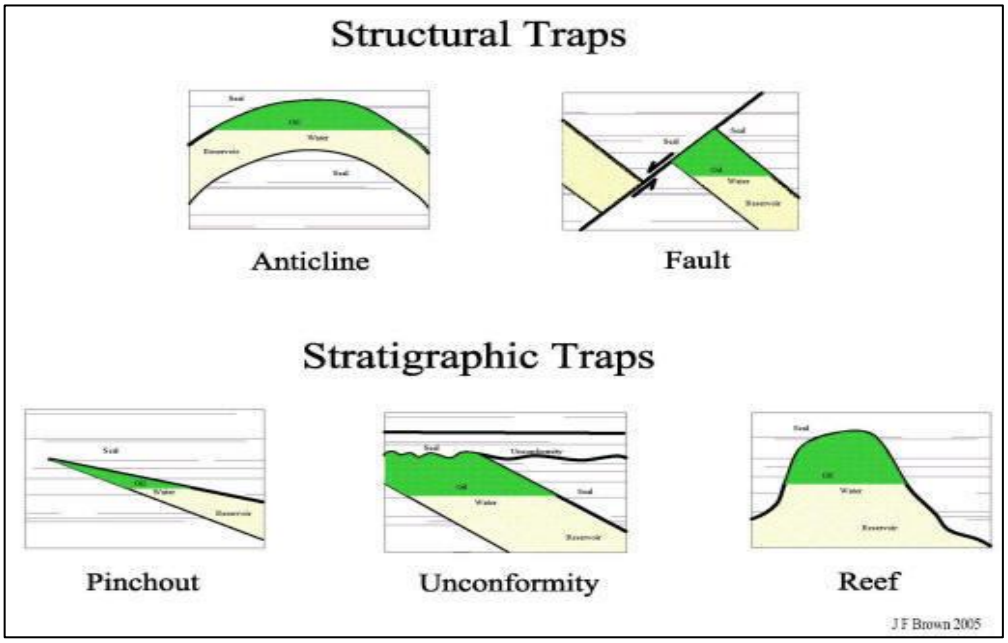
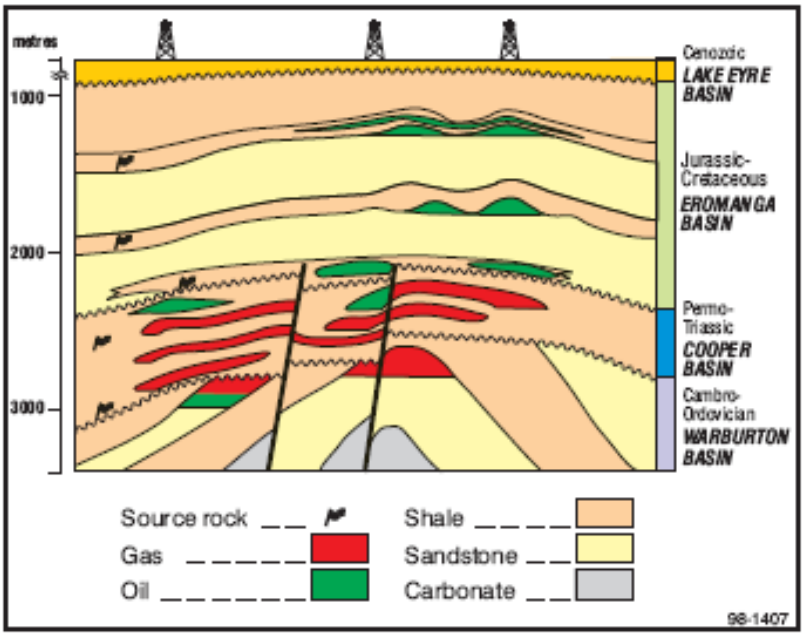


Figure 13: Petroleum Reservoirs Trapping Mechanisms of the Cooper and Eromanga Basins



Source: SA DPI, 1998

Cooper Basin

Anticlinal and faulted anticlinal traps have been identified as proven exploration targets in the Cooper Basin. The reservoir formations are capped by a series of fine-grained, laterally extensive seals. The predominantly fine-grained formations of the Nappamerri Group act as a regional seal to the Cooper Basin, providing several hundred metres of vertical separation between the primary gas reservoirs of the Cooper Basin and the overlying Eromanga Basin. Deeper in the basin, the Roseneath Shale acts as a regional top seal for the reservoir sands in the Epsilon Formation and the Murteree Shale seals hydrocarbon reservoirs in the Patchawarra Formation. These formations also provide effective barriers to prevent vertical migration of stimulation fluids during fracture stimulation treatments of Cooper Basin reservoir formations.

The reservoir formations of interest for Santos in the Cooper Basin (from deepest) include:

- The *Tirrawarra Sandstone* comprises fine to coarse-grained and pebbly sandstone with locally common interbeds of conglomerate and minor interbeds of carbonaceous siltstone, shale and coal. The Tirrawarra Sandstone is 30 to 40 m thick on average in the study area.
- The *Patchawarra Formation* comprises predominantly sandstone beds interbedded with siltstone, shale and coals. The Patchawarra Formation is thickest (up to 680 m) in the Nappamerri Trough, with an estimated maximum thickness of 550 m in the study area (Figure 7).
- The *Epsilon Formation* comprises a series of sandstones, siltstones and shales with minor coals. The maximum reported formation thickness (156 m) occurs in the Nappamerri Trough, however in the study area, the thickness typically ranges from 30 to 40 m.
- The *Toolachee Formation* consists of sandstones, siltstones and shale with thin coal seams and some conglomerates. In the study area the thickness is typically of the order of 25 to 50 m (Draper, 2002).
- Minor oil and gas reservoirs occur in sand units of the Nappamerri Group, but due to its predominantly fine-grained texture (mudstone and shale) it acts as a thick, regional seal to the reservoirs of the Cooper Basin (PIRSA, 1998).

Stimulation events related to gas production in the study area from 2012 to 2016 are planned for the deeper Patchawarra Formation, the Toolachee Formation, and to a lesser extent in formations within the Nappamerri Group.

Eromanga Basin

Trapping mechanisms in the Eromanga Basin are predominantly structural with a stratigraphic component (e.g. Hutton–Birkhead transition, Poolowanna facies, McKinlay Member and Murta Formation). Seals consist of intraformational siltstones and shales of the Poolowanna, Birkhead and Murta Formations. Where these units are absent, potential seals higher in the sequence include the Bulldog Shale and Wallumbilla Formation (SA DPI, 1998).

The reservoir formations of interest for Santos in the Eromanga Basin are (from deepest):

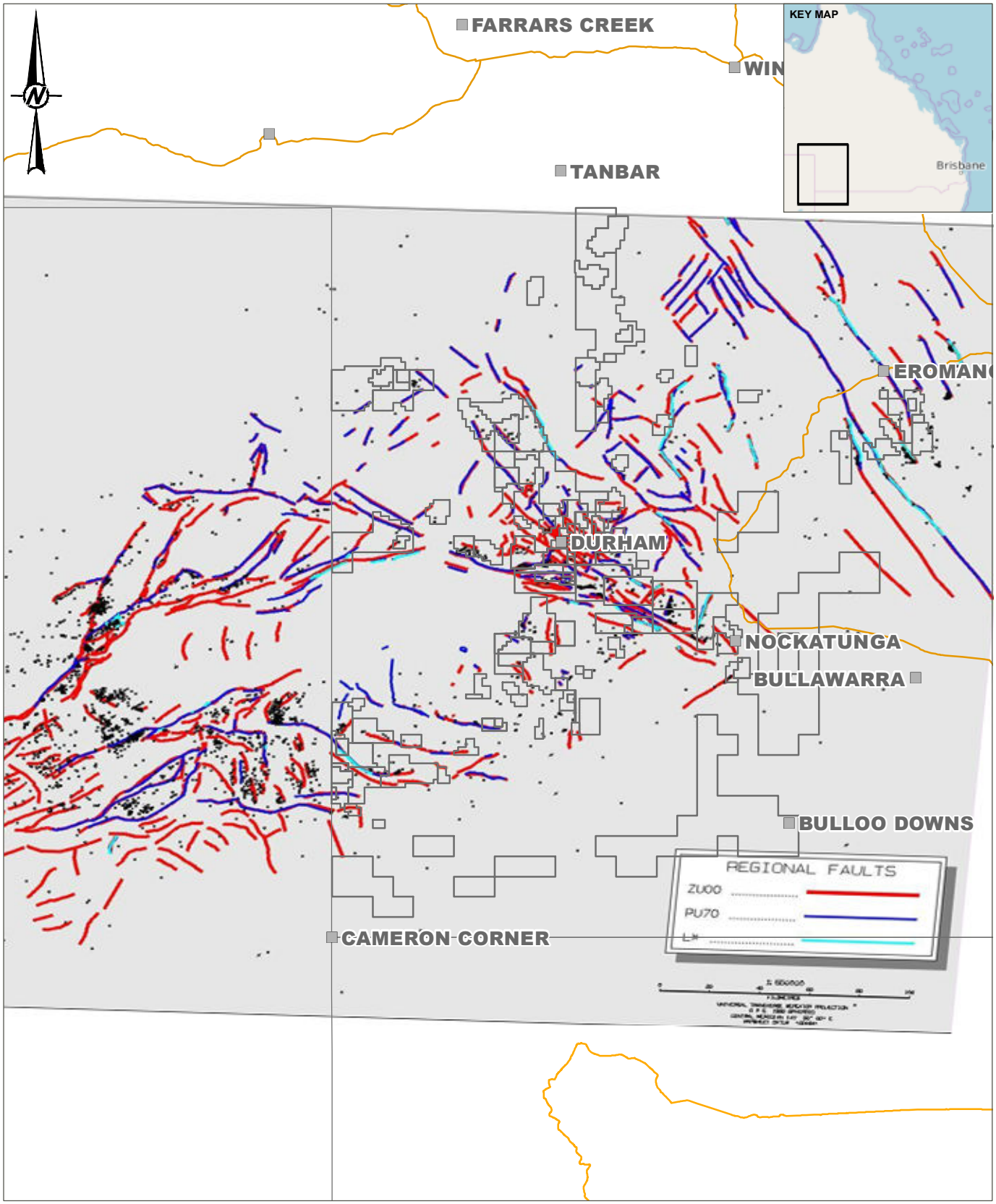
- The *Hutton* and *Poolowanna Formations* are major sandstone formations of the GAB. In the study area, the Hutton Formation is typically 90 to 210 m thick, and the Poolowanna Formation is up to 165 m thick;
- The *Westbourne Formation, Adori Sandstone* and *Birkhead Formation*: This group is dominated by shale and mudstone beds with thicknesses up to 140 m for the Westbourne Formation and 110 m for the Birkhead Formation in the study area. Interbedded sandstone layers within the Birkhead Formation comprise the primary oil targets. The Adori Sandstone contains the main sandstone beds of the group and is up to 55 m thick in the study area, and is reported to have a thick calcite-cemented zones (up to 45 m) developed in the base of the unit; and
- The *Cadna-Owie* and *Hooray Formations* consist of permeable sand units interbedded with siltstone, mudstone and shale that form intra-formational seals for hydrocarbon reservoirs. The basal unit of the Hooray Sandstone (the Namur Sandstone) is also strongly cemented.

2.4.3.5 Faults and Other Geological Controls

The structural framework of the Cooper Basin, particularly with regard to faulting is complex in the study area. Santos has undertaken an exercise of mapping (Figure 14; Santos, 2004) to simplify the tectonic features within the basins. The primary purpose of the mapping undertaken by Santos was to identify potential fault conduits (likely to enhance vertical migration of petroleum fluids), fault baffles (likely to prevent lateral migration of petroleum fluid) and identify potential gas targets.

Over the study area, the major episodic faults occurred in the top pre-Permian (basement), the basal Toolachee Formation and the basal Eromanga unconformity. The top pre-Permian faults provide the basin's overall fabric, whereas the younger faults from the basal Toolachee Formation and basal Eromanga unconformity are generally reactivated Permian faults.

In the Eromanga Basin formations, very few regional faults are observed as very little fault movement occurred during deposition of Eromanga Basin sediments. Major faulting events and structural uplifts have occurred within the eastern part of the Eromanga Basin; however, they did not structurally affect the part of the Eromanga Basin covered by Santos' SWQ tenements. Subsidence and compaction dominate the structural geology (PIRSA, 2006).



LEGEND

- Town/Locality
- Basal Toolachee Formation (PU70 Horizon)
- Top Pre-Permian (ZU00 Horizon)
- Basal Eromanga Unconformity
- Highway/Major Road
- Santos Tenements

0 KILOMETERS 100

1:2,500,000 GCS GDA 1994

NOTE(S)

REFERENCE(S)

1. BASE INFORMATION COPYRIGHT MAPINFO AUSTRALIA PTY LTD
2. ATP/PL TENURE SUPPLIED BY SANTOS, NOVEMBER 2019
3. FAULTS MAP SUPPLIED BY SANTOS (2004)

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TITLE
SURFACE GEOLOGY

CONSULTANT
GOLDER

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APPROVED	CB

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2.4.4 Stress Field Setting

2.4.4.1 Regional Setting

The origin and nature of near surface stress in Australia has been discussed in a number of publications, for example, Brown and Windsor (1990) and Enever and Lee (2000). The total stress at a point in the Earth's crust (including Australia) is generally considered to be made up of the following components:

- Gravity due to the weight of overburden. Gravity also contributes to the horizontal stress due to Poisson's effect;
- Tectonic component, which could be an active or a remnant tectonic stress, from movement of the earth's plates, and generally impacts the horizontal stress field; and
- Thermal and physio-chemical effects.

Analysis of stress in the SWQ study area has been undertaken through in-house services (discussed further under Section 2.4.5.3). The results of these studies are consistent with stress magnitude and orientation produced by broader plate tectonics as indicated on the publicly available Australasian Stress Map (Australasian Stress Map web site, University of Adelaide, Hillis et al., 1999; Hillis and Reynolds, 2003; and Reynolds et al., 2006).

Excerpts of the stress map are presented in Figure 15 and Figure 16 (from the web site, 2012) and illustrate the tectonic contribution to the regional stress field within continental Australia. Australia lies within the Indo-Australian tectonic plate and undergoes an absolute movement of approximately 7 cm per year to N-NNE. This is reflected in the N-NNE stress direction observed in SE Queensland (e.g. Bowen Basin, Figure 15). *However*, the Australian intra-plate stress field is highly variable and the maximum stress orientation at Cooper Basin, SWQ, is W-E and approximately perpendicular to the N-NE direction of the Indo-Australian plate. The stress field in Cooper basin appears to mark the apex of a horseshoe-shaped rotation in maximum horizontal stress direction across central eastern Australia (Reynolds, 2005). This is consistent with the project area that was mapped by Santos in 2004, which is discussed further in Section 2.4.5.2.

The minor horizontal stress will be approximately normal (90°) to this, i.e. N-S. The horizontal in situ stress is low but can be high and anisotropic and can *exceed* the vertical stress is some parts of the basin (Reynolds et al, 2006). The latter is an important consideration when stimulation pressures are calculated when designing and implementing a fracture event such that it is confidently contained entirely within the reservoir formations (Sections 3.2 and 3.3.5).

2.4.4.2 Basin Stress Regime

The primary stresses within the Cooper-Eromanga basin are vertical overburden stress σv, maximum horizontal stress σH, and minimum horizontal stress σh. The stress regime within the basins are characterised on the assumption that σv is a principal stress and therefore, σH and σh are also principal stresses, where σh is the least principal stress. This assumption is considered valid given the relatively flat topography across the basin.

The maximum horizontal stresses, σH, in the basin generally follow an east to west orientation, at approximately 101˚, as indicated by stress data from borehole breakout testing (Hills et al, 1998; Reynolds et al, 2004). The east-west trending nature of σH predominates in the Nappamerri trough, however, regional variations across the basin have been observed. In the Patchawarra Trough σH is oriented southeast to north-west; north-east of Gidgealpa σH was oriented west-northwest to east-southeast. This clockwise rotation of σH from the Nappamerri Trough to the Patchawarra Trough is accepted to be part of the larger stress rotation observed across the Australian continent. The orientation of σH does not exhibit significant variation with depth. (Reynolds et al, 2004).

The vertical overburden stress, σ_v is governed by overlying rock mass and the stress gradient does not exhibit significant variation with depth. The σ_v stress gradient is approx. 20.3 MPa/km at 1,000 m depth and approaches approximately 22.6 MPa/km at 3,000 m depth.

The magnitude of σ_h varies significantly across the basin; the σ_h stress gradient ranges from 13.6 MPa/km to 22.6 MPa/km across the basin, with σ_h approaching σ_v in some local areas (Reynolds et al, 2004). σ_h decreases with depth up to approximately 1 km below the surface and then stabilises. At 1 km to 4 km depth σh is between 0.6 σv to 0.7 σv, with σ_h generally approaching the higher end of this range (Hillis et al, 1998). At lower depths σ_h approaches, and may exceed, σ_v, resulting in σ_v becoming the minimum principal stress. (Reynolds et al, 2004).

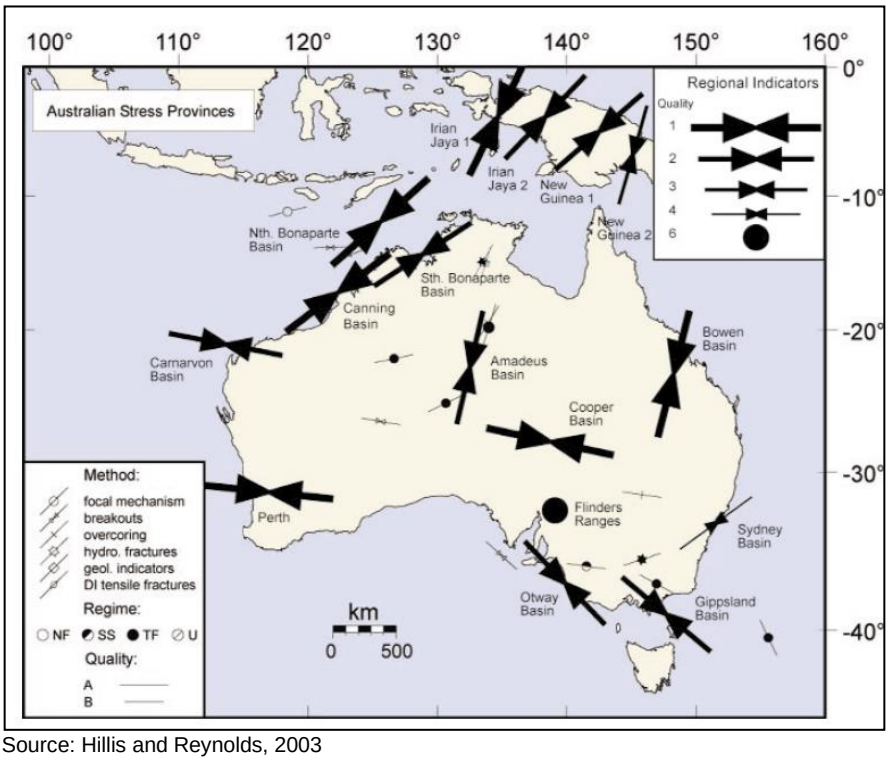
2.4.4.3 Stress Assumptions and Principal Stresses – General Faulting Regime

On the basis that σ_h is the minimum principal stress, the Cooper-Eromanga basin stress regime is primarily associated with strike-slip faulting ($\sigma_H > \sigma v > \sigma_h$), normal faulting ($\sigma_v > \sigma_H > \sigma_h$), and transitional strike-slip/reverse faulting ($\sigma_H > \sigma_h \approx \sigma_v$) at depth, where $\sigma_h \approx \sigma_v$. Reverse faulting ($\sigma_H > \sigma_h > \sigma_v$) is not associated with the stress regime in the basin however, at lower depths where $\sigma_h > \sigma_v$ may occur some reverse faulting may exist. (Reynolds et al, 2004).

2.4.4.4 Hydrostatic Stress

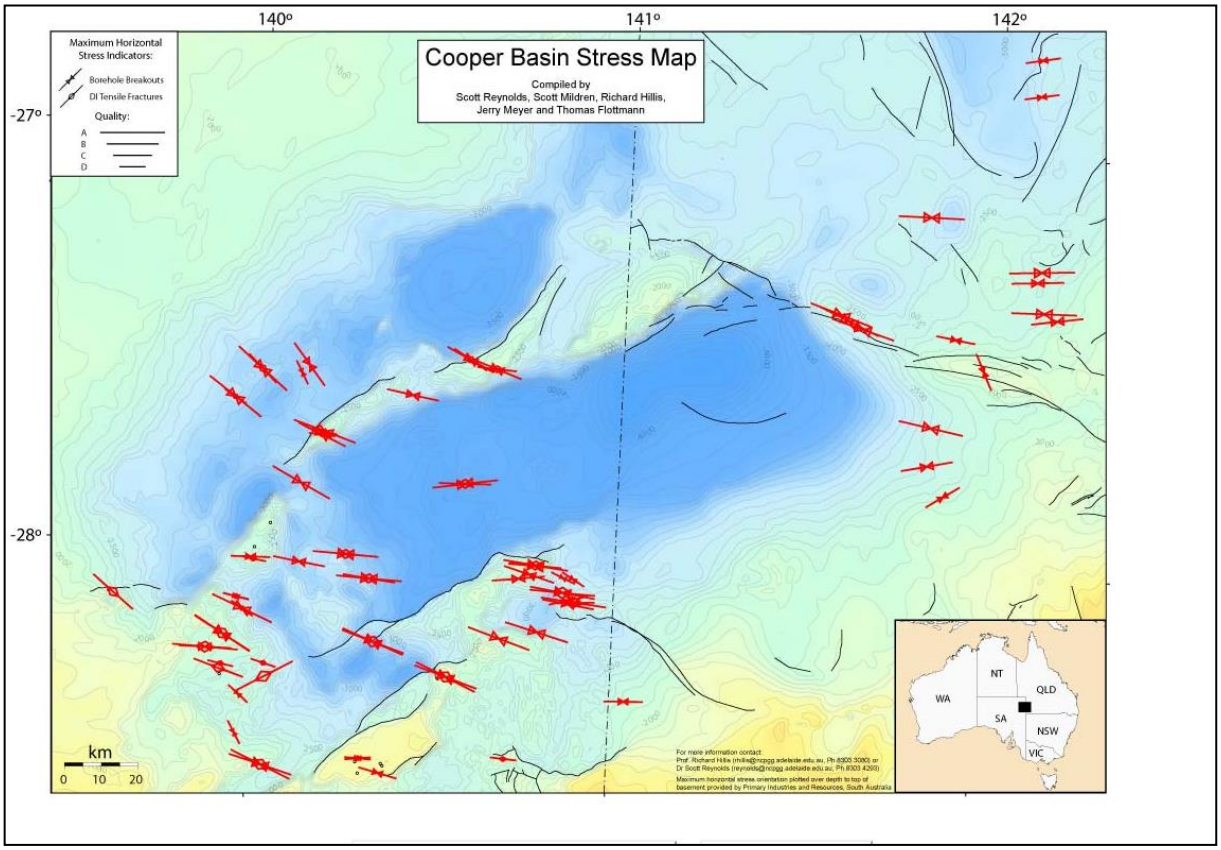
Pore pressures within the basin are generally hydrostatic. Overpressures are thought to occur in deeper shalier strata within the basin and have been observed in the Nappamerri Trough from depths of 2.7 km (Hillis et al, 1998). Local under-pressures have also been observed and are attributed to production within the basin (Reynolds et al, 2004). This is of particular importance when considering the impact of depressurising formations during oil and gas production. The implication is that impact translation though the depositional sequences are minimised or negated completely.

Figure 15: Continental Geomechanical Setting – Mean Stress Orientation within Australian Stress Provinces



Source: Hillis and Reynolds, 2003

Figure 16: Primary Stress Field Distribution for SWQ Queensland (Reynolds et.al, 2006)



2.4.5 Seismic History of the Project Region

2.4.5.1 Vulnerability

The continent of Australia does not demonstrate significant seismic activity, particularly compared to the western US, Japan, and New Zealand. Australia is on the Indo-Australian plate, relatively far from the plate boundaries, reducing the amount of seismic activity affecting the continent. Earthquakes in Australia are generally caused from the release of built-up stress in the interior of the Indo-Australian plate, which is being pushed north (NNE) and is colliding with the Eurasian, Philippine, and Pacific plates. Geosciences Australia (2012) reported that:

- On average 200 earthquakes of magnitude 3.0 or more occur in Australia each year;
- Earthquakes above magnitude 5.5 occur on average every two years; and
- About every five years there is a significant earthquake of magnitude 6.0 or more.

Santos' SWQ tenements are in one of the least seismically active areas on the Australian continent. The closest seismic activity area is the Adelaide region, SA, some 250 km southwest of Cameron's Corner. While more frequent and larger in magnitude earthquakes occur in the Adelaide area, very little impact is experienced within the SWQ tenement area. A study performed in the 1990's found that there is a 90% chance that the *unitless peak ground acceleration* (a term used in civil engineering to estimate forces on structures) will not exceed 0.05 in any 50-year period for this area. This indicates that regardless of the epicentre of any possible earthquake, little ground movement will occur in this region.

2.4.5.2 Local Historical Faults and Potential Seismic Activity

The Santos fault model is shown in Figure 17 (refer to Table 4 for stratigraphical marker abbreviations). This cross section illustrates the major fault and fold structures affecting the Cooper and Eromanga Basin sequences. Of particular note is the deep-seated nature of the basement structures, particularly faulting. The major episodic faults occurred in the top pre-Permian (basement), the basal Toolachee Formation and the basal Eromanga unconformity. These generally do not penetrate beyond the Eromanga Basin stratigraphy. The structures are predominantly compressional, and do not have large fault-throws within the Cooper Basin stratigraphy and negligible throws in the Eromanga Basin stratigraphy.

The episodic faults in the Santos fault model (Figure 17 (refer to Table 4 for stratigraphical marker abbreviations)) provide the basin's overall fabric. The basal Toolachee Formation (PU70) and basal Eromanga unconformity (L*) are generally affected by reactivated Top Pre-Permian (Basement; Zu00) faults. Figure 17 shows the Toolachee formation may be more elastic and does not fracture due to folding. The fault does not extend up through the Eromanga unconformity into the Eromanga Basin.

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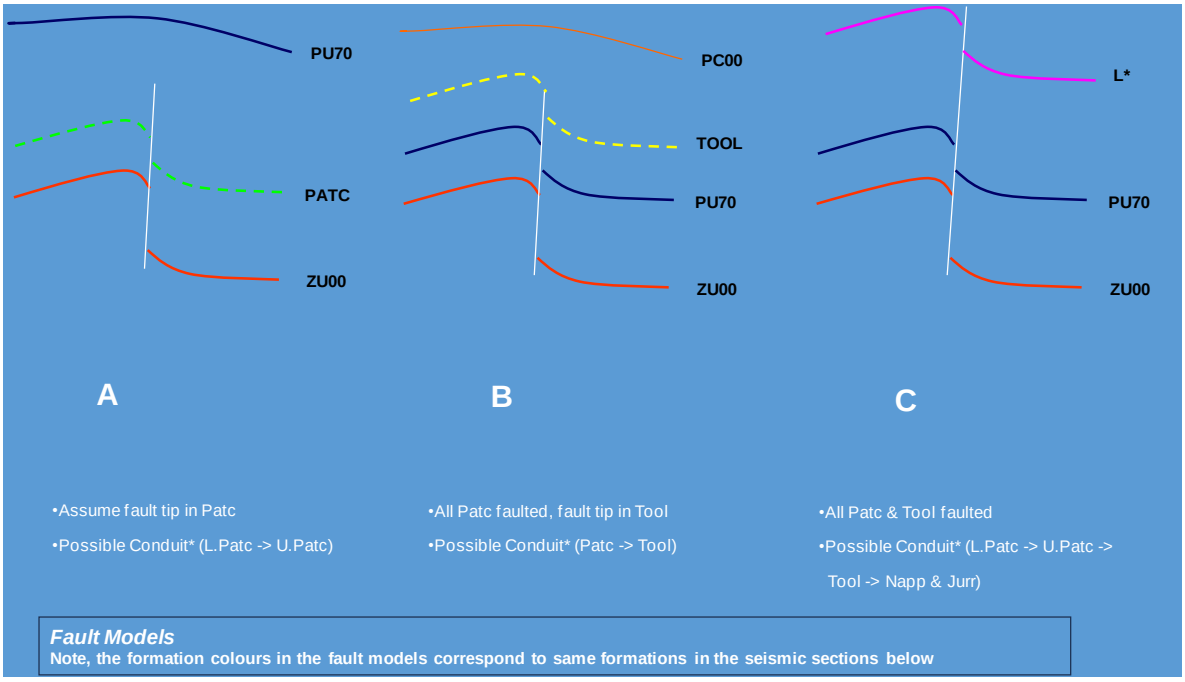
Figure 17: N-S Seismic Section for SWQ Project Area Showing Fault Models



2.4.5.3 Active Seismic Area and Faults

While no major currently or potentially active faults exist near the study area, there was possibly a minor fault within a former tenement area. The potential minor fault is 5 to 10 km and is considerably smaller in size than the majority of faults mapped within Australia (Geosciences Australia, 2012). The fault is located within a former tenement (ATP 766P, current in December 2012, but no longer a Santos tenement) at approximately latitude and longitude 26.4°S 143.1°E (the north-eastern most tenements in the study area). As of January 2020, the closest oil and gas fields to the minor fault were located at 50 to 60 km from the fault zone, and it was therefore considered highly unlikely that the fault zone would be influenced by stimulation activities

proposed for the fields. No significant seismic activity has occurred in the vicinity of this possible fault (ATP 766P; Figure 18) during the period 1950-2020.

2.4.5.4 Seismic History of the Cooper Basin Area

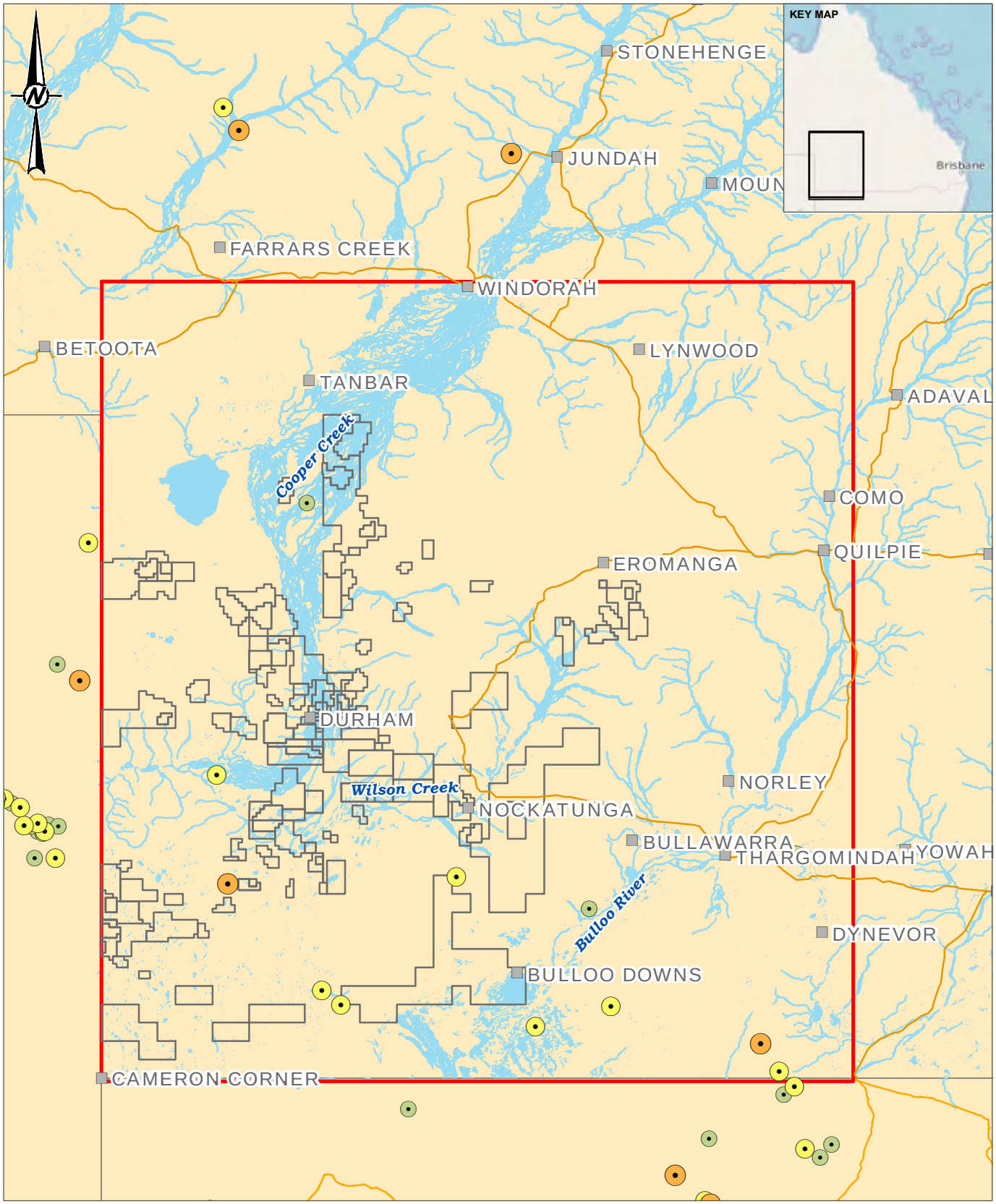
This region has experienced intermittent earthquakes of low to moderate magnitude since 1950 in the study area (Table 5). The location of the epicentre of these earthquakes is presented on Figure 18.

The majority of the earthquakes that have occurred since 1950 were approximately 8 to 11 km below the surface, with magnitudes ranging between 2.3 and 4.7 on the Richter scale. The earthquakes were generally located towards the south and western end of the study area.

Table 5: Earthquake Locations and Depths in the Study Area From 1950 - 2012

Magnitude	UTC	Latitude	Longitude	Depth (km)*
4.7	28/12/1961	-28.12	141.57	10
3.8	30/03/1963	-27.2	140.9	10
4	31/03/1963	-27.2	140.9	10
3.1	30/01/1985	-26.58	140.94	0
4	23/05/1989	-28.843	143.978	5
3.3	8/08/1989	-27.63	141.52	10
3.4	4/06/1996	-28.972	144.063	0
3.2	30/07/1997	-28.093	142.604	11
3.3	21/02/1999	-28.767	142.962	0
2.7	26/09/1999	-27.985	144.141	0
3.2	3/08/2000	-28.676	143.302	0
3.3	27/02/2001	-28.67	142.082	0
3.2	9/03/2001	-28.604	141.995	8
2.4	23/04/2001	-28.234	143.205	8
2.3	23/09/2002	-26.397	141.928	10

* Where depth is poorly constrained by available seismic data, a default depth of 0 or 10 km may be selected depending on the local earthquake activity in the area (Reference: Geoscience Australia www.ga.gov.au).



LEGEND

- Town/Locality
- Highway/Major Road
- River/Creek
- Santos Tenements
- Study Area

Epicentre - Magnitude Range

- <1
- 1-1.9
- 2-2.9
- 3-3.9
- 4-4.9
- 5-5.9
- 6-6.7

0 KILOMETERS 100

1:2,750,000 GCS GDA 1994

NOTE(S)

REFERENCE(S)

1. BASE INFORMATION COPYRIGHT MAPINFO AUSTRALIA PTY LTD
2. ATP/PL TENURE SUPPLIED BY SANTOS, NOVEMBER 2019

CLIENT
SANTOS

PROJECT
HYDRAULIC FRACTURING RISK ASSESSMENT – SANTOS SOUTHWEST QUEENSLAND TENEMENTS

TITLE
EPICENTRE AND MAGNITUDE OF EARTHQUAKES IN THE STUDY AREA

CONSULTANT
GOLDER

DD-MM-YYYY	19-03-2020
DESIGNED	KB
PREPARED	KB
REVIEWED	CB
APPROVED	CB

PROJECT NO.	CONTROL	REV.	FIGURE
127666004	011-R	2	18

2.5 Hydrogeology and the Groundwater Resource

2.5.1 Introduction and Setting

The Cooper and Eromanga Basins are two chronologically successive stacked basins, with the Cooper overlying the Eromanga. Based on strict geological interpretation, the Cooper Basin is considered to be distinct and separate from the GAB, however it has been an historical convention in Queensland to include the upper sedimentary units of the Cooper Basin in the administration of GAB groundwater resources (GAB Resource Operating Plan (ROP), DERM 2007: GAB Water Resources Plan (WRP), DERM 2006). The Eromanga Basin is the largest of the three major sedimentary basins comprising the GAB and covers the whole of the Cooper Basin. The connection between the two basins is geologically marked by a major unconformity.

Both the Cooper Basin and Eromanga Basin are multi-layered systems comprising alternating layers of sandstone, shale, mudstone and siltstone formations (Section 0). The sandstone formations of the Eromanga Basin correspond to water bearing formations and aquifer formations; they support a range of beneficial uses such as potable water and stock and domestic supply. In other areas of the Basin (remote from Santos' tenements), they also supply groundwater to springs.

The siltstone, shale and mudstone formations are low permeability rocks and act as aquitards separating aquifer formations (and also as seals for hydrocarbon reservoirs). In the study area, a number of thick, competent and laterally extensive fine-grained formations are present within both the Cooper and Eromanga Basins that are important in providing vertical separation of water and hydrocarbon-bearing formations. Minor sandstone units occasionally occur as interbedded layers within predominantly fine-grained formations and may be capable of providing limited groundwater supply (e.g. <5 L/s), however in the study area water supply development preferentially targets the upper formations of the Eromanga Basin (e.g. the Winton and Glendower Formations).

For management purposes, the GAB has been subdivided into 25 Groundwater Management Areas (GMA) as defined in the *GAB Hydrogeological Framework for the GAB WRP Area* (DERM, 2005); the GMAs relevant to the study area are presented in Figure 19. GMAs are subdivided into groundwater management units (GMU), as represented in Table 3, comprising one or more geological formations with similar hydrogeological properties.

2.5.2 Hydrostratigraphy

As previously described, the formations of the Cooper and Eromanga Basin within the study area comprise a stacked sedimentary sequence of sandstone formations that act as aquifers and hydrocarbon reservoirs, interbedded with fine-grained formations that act as competent and laterally extensive aquitards and seals for hydrocarbon traps. The main aquifer and aquitard units are presented in Table 6. The main aquifer groupings, in terms of production of groundwater, include:

- The aquifers of the Quaternary sediments and Tertiary formations (potential water supply for agricultural and potable water);
- The GAB aquifers of the Eromanga Basin (possible water supply for agricultural and potable water, and produced formation water); and
- The older and deeper aquifers of the Cooper Basin (produced formation water).

The Quaternary and Tertiary deposits are preferentially developed as groundwater resources because they are shallow, accessible and able to yield productive quantities of groundwater to support beneficial uses relevant to the study area (principally, domestic supply and stock watering). In contrast, groundwater resources associated with the deeper aquifers of the Eromanga Basin have had limited development. The deep aquifers of the Cooper Basin are only accessed during the production of gas.

A summary of the groundwater resources within the study area is presented in the following section. A more detailed discussion of the groundwater resources is contained in the UWIR (Golder 2020).

Table 6: Hydrostratigraphy of the Study Area

GMA Unit		Unit name		Sub-unit	Equivalent Formation other parts of the GAB
	Eromanga Basin	Glendower Formation			
		Winton Formation			
		Mackunda Formation			
		Alluru Mudstone			
Central 1 - Warrego West 1		Toolebuc Formation			Surat Siltstone
		Wallumbilla Formation		Coreena Member	Wallumbilla Formation
				Doncaster Member	
Central 2 - Warrego West 2		Cadna-Owie Formation		Wyandra Sandstone Member	Cadna-Owie Formation, Bungil formation, Gilbert River Formation
				Lower Cadna-Owie	
Central 3 - Warrego West 3		Hooray Sandstone		Murta Formation	Hooray Sandstone, Mooga Sandstone, Orally Formation and Gubberamunda Sandstone
				Namur Sandstone	
Central 4 - Warrego West 4		Westbourne Formation			Injune Creek Group
		Adori Sandstone			
		Birkhead Formation		Upper Birkhead	
				Middle Birkhead	
				Lower Birkhead	
Central 5 - Warrego West 5		Hutton Sandstone			
Central 6 - Warrego West 6		Poolowanna Formation		Upper Poolowanna	Precipice Sandstone
				Lower Poolowanna	
MAJOR UNCONFORMITY					
Central 7 - Warrego West 7	Cooper Basin	Nappamerri Group	Tinchoo Formation	Gilpeppee Member	Moolayember Formation
				Doonmulla Member	
			Arraburry Formation	Wimma Sandstone Member	Clematis Sandstone
				Panning Member	Rewan Formation
				Callamurra Member	

GMA Unit		Unit name		Sub-unit	Equivalent Formation other parts of the GAB
		Gidgealpa Group	Toolachee Formation		
			Daralingie Formation[1]		
			Roseneath Shale		
			Epsilon Formation		
			Murteree Shale		
			Patchawarra Formation		
			Tirrawarra Sandstone		
			Merrimelia Formation		
		Aquifer			
		Water Bearing in part			
		Confining Bed			

[1] The Daralingie Formation is considered to be water bearing in some areas of the Cooper Basin but has been classified as a confining bed within this study area.
Source: DERM, 2005

2.5.2.1 Eromanga Basin

The main GAB aquifers in the study area occur within the Eromanga Basin stratigraphy, and include the Winton Formation, Cadna-Owie Formation, Hooray Sandstone, Hutton Sandstone and Poolowanna Formation (Precipice Sandstone equivalent).

Hydrogeological contour maps are provided (where data was available) in APPENDIX C for the following hydrostratigraphic units. Note that the Quaternary and Tertiary sediment aquifers and the Winton Formation are not administered under the GAB ROP (DERM 2007).

Poolowanna Formation (Central 6 - Warrego West 6)

Also referred to as the Basal Jurassic Formation (older name in the nomenclature), the Poolowanna Formation is the equivalent of the Precipice Sandstone (in SE QLD). No further information is available.

Hutton Sandstone (Central 5 - Warrego West 5)

The Hutton Sandstone is a significant GAB aquifer however its depth in the study area (approximately 2,000 mbgl; refer to Figure 11) has precluded access for water supply development. Based on limited available data, the groundwater flow is expected to be to the southwest (i.e. consistent with the regional flow direction of the major GAB formations).

The water quality of the Hutton Sandstone in the study area cannot be commented upon as produced water quality data was not readily available, and no data was available in the DEHP database.

Westbourne Formation, Adori Sandstone and Birkhead Formation (Central 4 - Warrego West 4)

The Westbourne Formation is considered to be a confining layer of relatively homogeneous characteristics (lacustrine deposits associated with a large transgression). However, in the southeast section of the study area, it is possible that a number of private bores are completed in the Westbourne Formation, possibly accessing minor sandstone beds within the formation.

The Adori Sandstone is considered to be an aquifer (at least in part) in the study area, however insufficient information is available to characterise it further. The basal portion of the Adori Sandstone is noted as having a thick calcite cemented zone up to 45 m thick.

The Birkhead formation comprises a succession of non-continuous confining beds and water bearing sandstone units.

Water quality data for these formations are not available in the DEHP database and were not available in regard to Santos produced water extracted from this formation. Data collected during a Water Bore Baseline Assessment (WBBA) of the study area is limited and not conclusive.

Hooray Sandstone (Central 3 - Warrego West 3)

The Hooray Sandstone is a significant unit in GAB. In the study area it is considered to be a major aquifer. Oil reservoirs and minor gas reservoirs are also contained with this unit. Two sub-units are identified in the Hooray Sandstone:

- The Murta Formation (equivalent formations in other GAB basins include the Mooga and Gubberamunda Sandstones). In the study area it is considered to be a confining bed, the main confining unit being a siltstone bed located at the base of the Murta Formation and found widespread over the Cooper region. Minor oil and gas reservoirs are noted to be present as fine-grained sandstone units capped by intra-formational siltstone and shale seals.
- The Namur Sandstone consists predominantly of fine to coarse grained sand with minor fine-grained interbeds, and is the major water bearing unit of the Hooray Sandstone. Oil can also be present in this unit.

The water quality in the Hooray Sandstone is generally fresh to slightly brackish with electrical conductivity (EC) values (DEHP database) ranging from 675 to 3,930 µS/cm (or approximately 470 to 2,750 mg/L) with a median value of approximately 1,000 µS/cm (approximately 700 mg/L). This water quality is suitable for potable water supply, and the few available long-term records (i.e. 40 year monitoring period) indicate that water quality has remained consistent over time.

A number of bores within the Hooray Sandstone may be artesian. Groundwater bores for that unit seem to be concentrated to the southeast of the study area (APPENDIX C). No reliable water level and salinity data are available for this formation in the vicinity of Santos' tenements.

According to the available data the groundwater flow direction is towards the southeast (APPENDIX C).

The Hooray Sandstone is considered to yield productive quantities of groundwater, and a town water supply bore is potentially completed with the Hooray Sandstone (to be confirmed as part of continuing field works for the WBBA).

Cadna-Owie Formation (Central 2 - Warrego West 2)

The Cadna-Owie Formation is considered to be a major aquifer of the GAB, and in the study area comprises two sub-units: the upper the Wyandra Sandstone and the Lower Cadna-Owie. The Wyandra Sandstone is considered to be an aquifer however its thickness is limited in SWQ. The Lower Cadna-Owie comprises siltstone and very fine-grained sandstone and is considered to be an aquitard.

The few data points available in the DEHP groundwater database indicate fresh to slightly brackish water quality with the Wyandra Sandstone. Insufficient water level information is available to describe water flows and water levels.

Habermehl (1986 and 1997) defines this unit as non-artesian; however, the DEHP groundwater database does identify artesian bores in the Cadna-Owie Formation.

Winton Formation (Central 1 - Warrego West 1)

According to the DEHP database, the Winton Formation is a significant aquifer for the local community that supplies a number of stock and domestic bores. The depth and thickness of the Winton Formation are illustrated in the maps of APPENDIX B. The top of the Winton Formation is approximately 50 mbgl and thickness can reach up to 970 m.

Santos' geology team however dispute the role of the Winton Formation as a significant aquifer in SWQ and consider it to be water bearing at best. Although the Winton Formation is a significant aquifer in a large area of Queensland, the quality of the Winton Formation as an aquifer appears to diminish westward from central to southwest Queensland and into South Australia (Pers. Comm. N. Lemon, Santos, November 2011). The top and bottom of the Winton are so poorly defined in the subsurface that it is difficult to confirm whether water production currently assigned to the Winton Formation is coming from the overlying Tertiary (Eyre Formation in South Australia) or underlying Mackunda Formation. This situation is supported in SA by the findings of Gravestock and al. (1995).

The Winton Formation directly underlies the Tertiary sediments; some degree of hydraulic connectivity is expected however no data is available to confirm this.

The water quality in the Winton Formation is fresh to brackish with EC values ranging from 900 to 13,000 µS/cm (approximately 630 to 9,100 mg/L). Groundwater flow in this aquifer is generally to the southwest (APPENDIX C).

Quaternary and Tertiary Alluvium

Quaternary and Tertiary alluvial deposits cover a large proportion of the study area. They are often associated with the very flat structures of the flood plains and are absent where the Winton Formation outcrops.

Cendon et al. (2010) have described the groundwater resources associated with Quaternary sediments of the Cooper Creek basin as comprising predominantly saline water (reported total dissolved solids (TDS) values up to 38,000 mg/L) that occurs within fluvial and aeolian sand deposits that are extensively overlain by thick, low permeability mud deposits. The surficial fine-grained deposits limit recharge to the sand units, even below the waterholes that are present in the main creek channels during extended periods of low (or no) stream flow. Episodic flood events are thought to occasionally scour through the low permeability deposits within major creek channels and provide temporary recharge to the underlying sand beds, resulting in discrete and discontinuous freshwater lenses in the otherwise saline groundwater environment.

Evaluation of water level and water quality data (including major and minor ion chemistry and stable isotope analysis) suggests that the surface water features in the study area do not receive shallow groundwater recharge (Hamilton et al., 2005; Bunn et al., 2006; Costelloe et al., 2007, Cendon et al., 2010). However, they

may receive seepage through their basal mud layers to provide limited recharge to the underlying saline groundwater system. The lack of connectivity between surface water systems and shallow groundwater is an important consideration with respect to exposure pathway analysis (as is discussed in corresponding hydraulic stimulation service provider reports).

The Glendower Formation is the main Tertiary formation within the study area. The Glendower Formation consists of consolidated sediments comprising sandstones, sandy siltstones and minor conglomerate and mudstones (Australian Stratigraphic Database, Geosciences Australia). The Australian Stratigraphic Database identifies the Whitula Formation as overlying the Glendower Formation; however, the significance of the Whitula Formation in the study area is unknown.

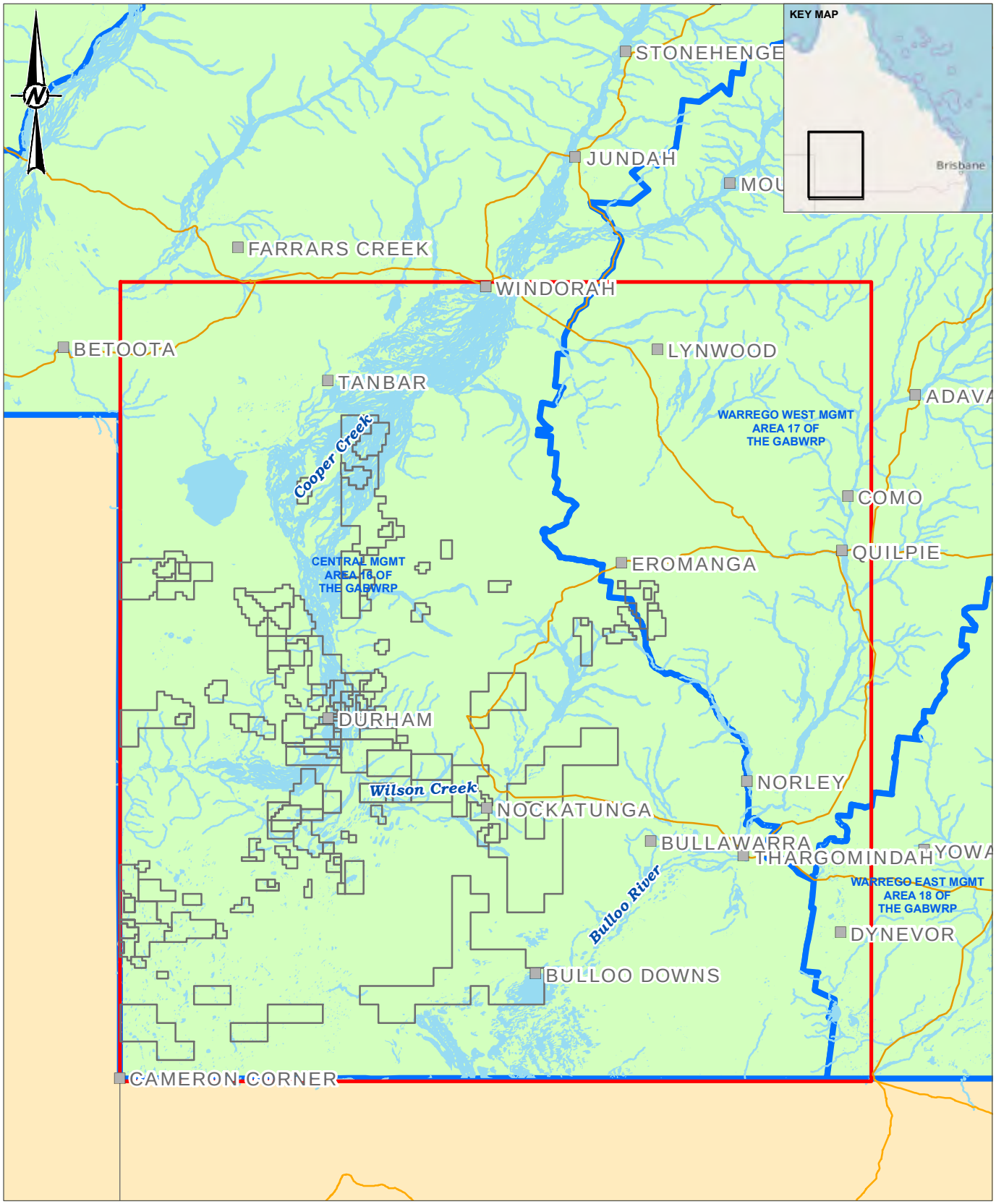
Groundwater flow in these formations follows topography in the study area and is influenced by outcrop areas of the underlying Winton Formation. As illustrated on the hydrogeological map (APPENDIX C), the hydraulic gradient is very small.

The quality of the Tertiary aquifers is brackish, with EC values ranging from 3,000 to 7,000 µS/cm (approximately 2,100 to 4,900 mg/L).

2.5.2.2 Cooper Basin

The upper formations of the Cooper Basin are included in the administration of GAB groundwater resources under QLD regulations. This includes the Panning and Wimma Sandstone Members of the Arraburry Formation, and the underlying Toolachee formation.

Insufficient information is available to provide a detailed description of the hydrostratigraphy of the Cooper Basin formations.



LEGEND

- Town/Locality
- Highway/Major Road
- River/Creek
- Groundwater Management Area
- Santos Tenements
- Study Area

0 KILOMETERS 100

1:2,750,000 GCS GDA 1994

NOTE(S)

REFERENCE(S)

1. BASE INFORMATION COPYRIGHT MAPINFO AUSTRALIA PTY LTD
2. ATP/PL TENURE SUPPLIED BY SANTOS, NOVEMBER 2019
3. GROUNDWATER MANAGEMENT AREA SOURCED DEPARTMENT OF NATURAL RESOURCES & WATER, QLD GOVERNMENT, 2008

CLIENT
SANTOS

PROJECT
HYDRAULIC FRACTURING RISK ASSESSMENT – SANTOS SOUTHWEST QUEENSLAND TENEMENTS

TITLE
GROUNDWATER MANAGEMENT AREAS FOR THE STUDY AREA

CONSULTANT
GOLDER

DD-MM-YYYY	19-03-2020
DESIGNED	KB
PREPARED	KB
REVIEWED	CB
APPROVED	CB

PROJECT NO.	CONTROL	REV.	FIGURE
127666004	011-R	2	19

2.5.2.3 Observed Reservoir Pressure Data

The hydrostatic pressure of water-bearing stratum is measured during drilling activities by:

- Drill stem test (DST);
- Repeat formation tester (RFT); or
- Formation micro tester (FMT).

Pressure testing is undertaken to assess the likely thickness of the oil or gas column found at any particular depth interval. This is calculated by comparing the pressure in the hydrocarbon-bearing zone with the expected water pressure as predicted by the water pressure-depth line (Figure 20).

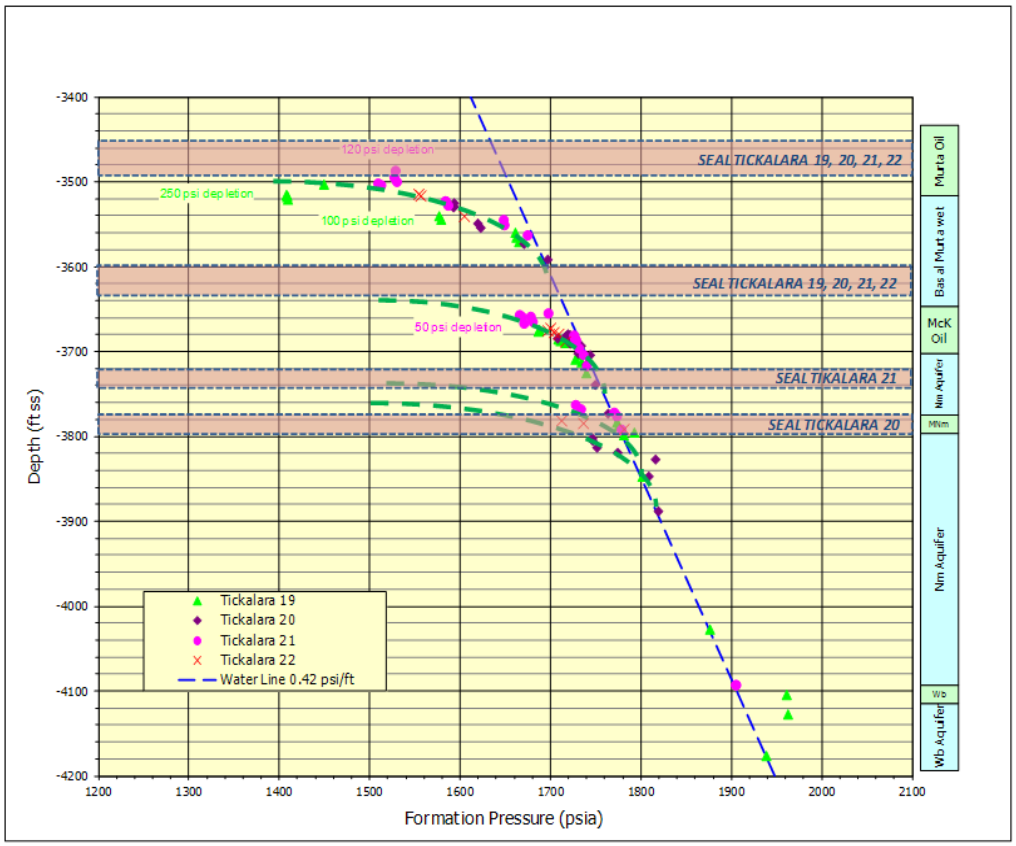
Models for predicting the influence of gas and oil, and associated water production at depth require input data on the pressure transmissibility of the strata that separates the target formations (referred to as seals). In the case of SWQ:

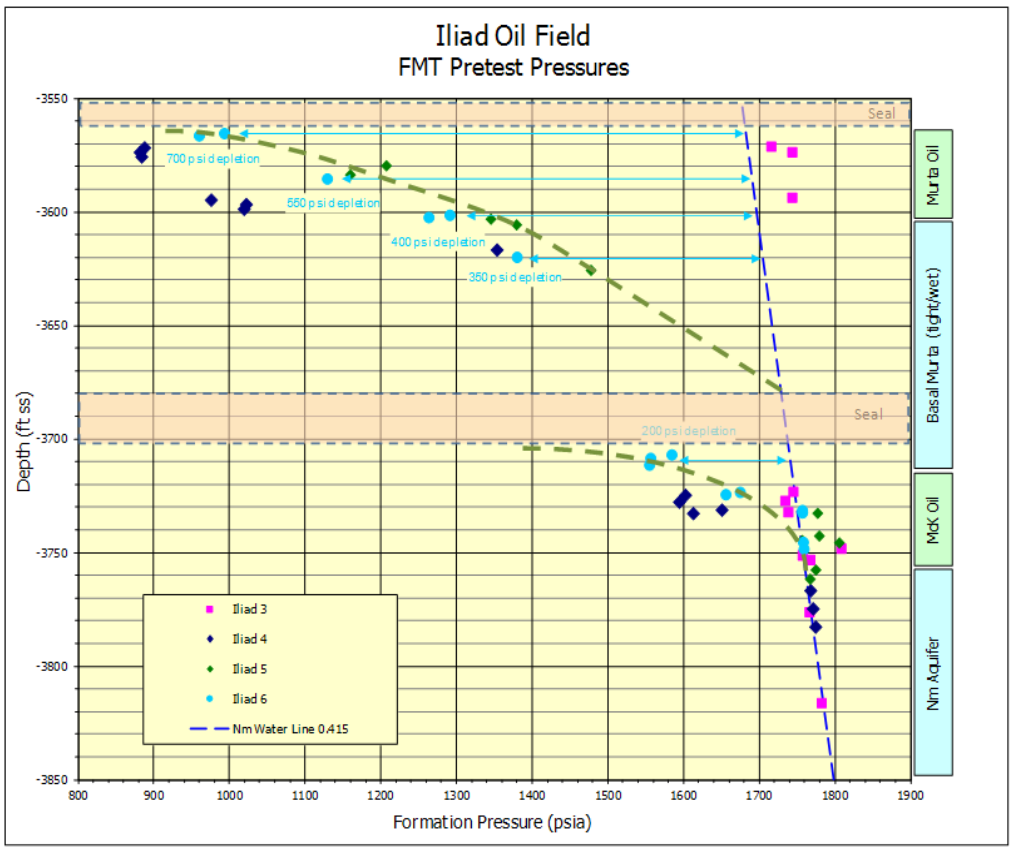
- Seals between the Glendower and Winton aquifers; and
- Seals between the Murta, Namur (Hooray) and Hutton Sandstone, from which oil is produced.

Numerous Santos wells have undergone pressure measurements in the Cadna-Owie Formation to establish water pressure-depth lines and this data can be re-assessed to see if depletion from underlying hydrocarbon production zones has influenced the aquifers utilised for water supply. If no depletion is observed in the Cadna-Owie Formation, then this provides evidence of the integrity of the cap rock separating the Cadna-Owie Formation from the underlying hydrocarbon reservoirs.

Figure 20 demonstrates how formation pressures are depleted below the predicted water pressure line (the blue dashed line increases in pressure with increasing depth) and are confined within each target formation (yellow layers) by the presence of an overlying aquitard (seal bed, orange layers). This data demonstrates the competence of the confining units in isolating hydrocarbon reservoirs from overlying and underlying aquifers.

Figure 20: Observed Tickalara (top) and Iliad Field Pressure with Depth Plots

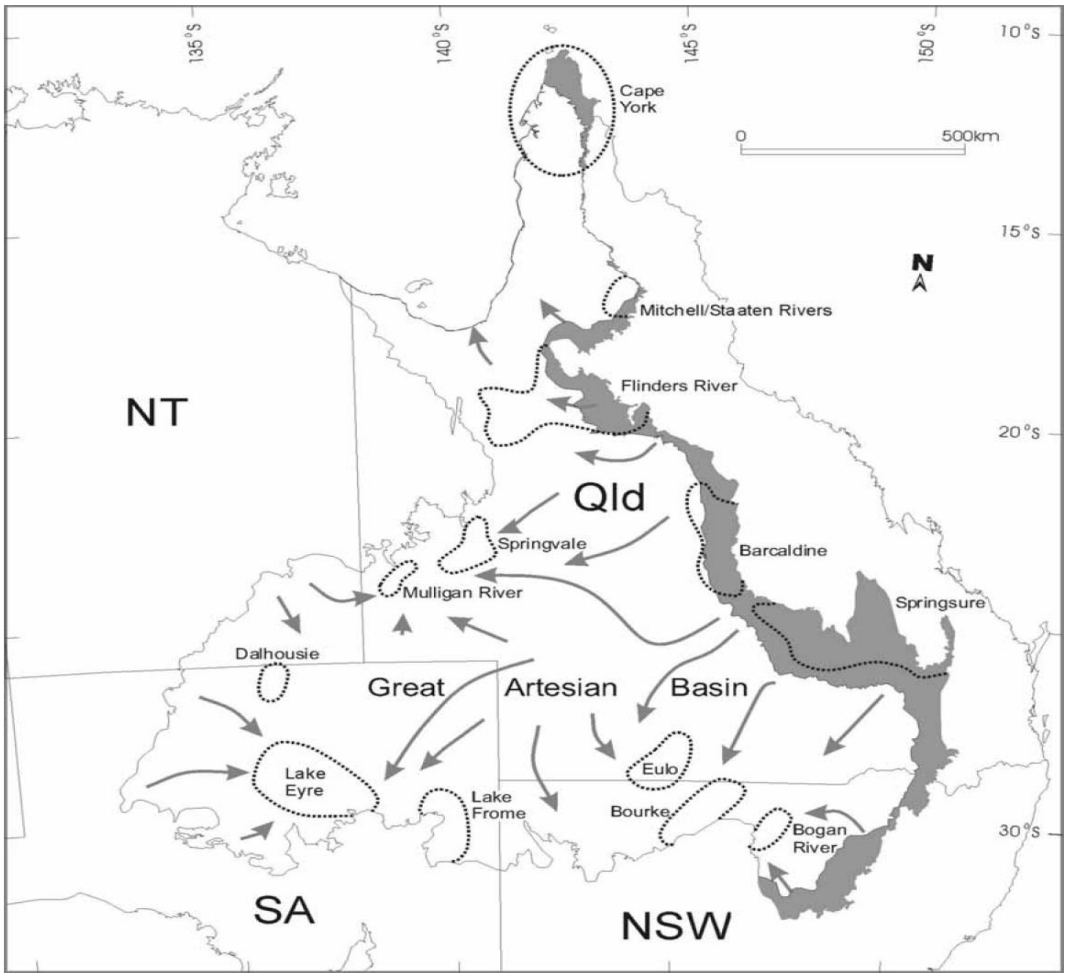




2.5.3 Groundwater Flow

In general, groundwater flow through the majority of the deeper units of the Eromanga Basin is to the south to southwest. This is consistent with the direction of flow in the major GAB units (Figure 21; BRS, 2000). Potentiometric surface contours for select Eromanga Basin aquifers are presented in APPENDIX C (sourced from the UWIR (Golder, 2012a) based on information available for the study area in the DEHP database). This data supports a southward flow direction but exhibits a high degree of variability which is attributable to the limited data available from the database. Shallower groundwater flow in the Tertiary Formation appears to be influenced by surface topography. The shaded patterns in Figure 21 broadly represent the recharge area; arrows represent modelled flow lines after Welsh (2000). Dashed lines represent spring clusters updated from Habermehl.

Figure 21: Map of GAB Extent, Regional Flow Paths, Recharge Beds, and Spring Clusters



Source: After Habermehl and Lau (1997)

Structural Influence on Groundwater Flow

Section 2.4.4 presents a summary of the tectonic setting and basin stress regime within the Cooper-Eromanga Basins. The stress regime is primarily associated with strike-slip faulting, normal faulting, and transitional strike-slip/reverse faulting at depth. When taking the observed (and sustained) overpressures into account, this stress regime is predominantly more conducive to tight compressive (non-tensional) fault creation, and as such largely self-sealing fault systems. This would infer the faults are not likely to form conduits for groundwater (or gas or oil) flow. This is supported by pressure profiles and sustained overpressures, such as presented in Figure 20.

2.5.4 Recharge/Discharge

The upper GAB aquifers are recharged by infiltration (rainfall), and leakage from streams into outcropping sandstone formations, mainly on the eastern margins of the GAB along the western slopes of the Great Dividing Range. Regional groundwater flow is from the topographically higher recharge areas around the basin margins towards the lowest parts of the basin in the southwest (Figure 21).

Outcropping areas of the major GAB units, which are considered as the recharge areas for the GAB, do not occur within 300 km of the study area.

Discharge areas in the GAB typically manifest as springs, supplied by leakage to alluvial aquifers (Tertiary-Recent), and discharge to inland lakes and water supply bores. In the study area there are no identified GDEs (Section 2.6.2.4); the only discharge of water is through water supply bores or as a by-product during oil and gas production.

2.5.5 Aquifer and Aquitard Hydraulic Properties

A review of hydraulic parameters was undertaken for the strata in the vicinity of the study area. The hydraulic parameters characterising the formations are presented in Table 7. The data presented in the table are based on field measurements and available published values.

Table 7: Hydraulic Parameters

Basin	Formation	Hydraulic Conductivity (m/d)		Porosity (fraction)
		Min	Max	
Eromanga Basin	Quaternary and Tertiary Alluvium	-	-	-
	Winton Formation	-	-	-
	Mackunda Formation Alluru Mudstone Toolebuc Formation Wallumbilla Formation	-	-	-
	Cadna-Owie Formation	-	-	-
	Hooray Sandstone	$4.3x10^{-4}$	$4.3x10^{-1}$	-
	Westbourne Formation, Adori Sandstone and Birkhead Formation	$8.0x10^{-7}$ [2]	$2.5x10^{-4}$ [2]	0.2 [2]
	Hutton Sandstone	$3.5x10^{-1}$	$9.8x10^{-3}$	
	Poolowanna Formation	$1x10^{-7}$ [2]	$3.7x10^{-3}$ [2]	0.18 [2]
Cooper Basin	Tinchoo / Arrabury Formations			
	Toolachee Formation	$2.0x10^{-3}$ [1]	$4.3x10^{-3}$	0.15 0.08 to 0.12[3]
	Daralingie, Roseneath Shale, Epsilon and Murteree Shale Formations	-	-	-
	Patchawarra Formation	$3.3x10^{-4}$ [1]	$3.5x10^{-3}$ [1]	0.13 0.08 to 0.12[3]

[1] Gov. of South Australia, Primary Industries and Resources, SA. Petroleum and Geothermal in South Australia – Cooper Basin, 2009.
[2] Alexander, E.M., Reservoirs and Seals of the Eromanga Basin (undated).
[3] Recent information provided by Santos (Santos, 2011a).

Note that insufficient data is available to provide transmissivity, which is a function of the thickness of an aquifer (T = Kb).

2.5.6 Groundwater Quality

Groundwater quality data was reported in a metadata table from the UWIR (Golder, 2012a; 2020). The metadata table includes both automated database enquiries and manually interpreted data for target formations using the available depth and construction information. Water quality data extracted from the DEHP database included a total of 772 samples collected from 437 groundwater bores located within the study area. However, only 494 of the samples collected were considered suitable for interpretive use, based on cation-anion balance, and could be assigned to a particular aquifer formation.

Groundwater quality data in the study area was available for the aquifers associated to the following formations[4]:

- Tertiary sediments (10 samples):
- Glendower Formation (31 samples):
- Winton Formation (160 samples):
- Mackunda Formation (16 samples):
- Alluru Mudstone (7 samples):
- Wallumbilla Formation (97 samples)[5];
- Cadna-Owie Formation (20 samples);
- Hooray Sandstone (147 samples);
- Adori Sandstone (1 sample); and
- Hutton Sandstone (5 samples).

Groundwater pH values in the study area ranged from 6.2 to 9.9. The slightly acidic pH (6.2) was associated with groundwater from the *Winton Formation* aquifer. The most alkaline sample was collected from the *Wallumbilla Formation.* For the majority of samples, the pH ranged between 7.5 and 8.5.

Total hardness was calculated from the chemical composition and refers to the sum of calcium and magnesium (expressed in mg/L of CaCO3). Approximately 49% of samples represent soft groundwater, 16% moderately hard, and approximately 15% of groundwater samples would cause scaling.

2.5.6.1 Water Types of the Study Area Formations

A piper diagram of all groundwater samples within the study area is presented as Figure 22, and piper diagrams for individual formations are presented in Figure 23. The red line represents conservative (non-reactive) mixing of fresh water and sea water. The position of the markers away from the conservative mixing line is an indication of a geochemical reaction. As presented in Figure 22 and Figure 23 the dominant ions are sodium, bicarbonate and chloride, and water types are either sodium-bicarbonate or sodium-bicarbonate-chloride types. Groundwater from the Winton Formation, Wallumbilla Formation, Hooray Sandstone and Tertiary Sediments/Glendower Formation appear to have higher proportion of sodium and magnesium.

2.5.6.2 Total Dissolved Solids

Based on TDS concentrations the majority of the groundwater samples (87%) are slightly brackish (TDS <3,000 mg/L). The rest of the samples from Winton Formation, Wallumbilla Formation, Glendower Formation

[4] Data current as of December 2012

[5] The Alluru Mudstone and Wallumbilla Formation are considered to be confining beds in the study area. Interpretation of water quality and completion formation is based on the target formation interpretations in the DEHP database. It is possible that samples may have been mis-identified.

and Hutton Sandstone are classified as brackish with TDS concentrations in the range of 3,000 to 10,000 mg/L. The most saline sample was collected from the *Winton Formation* aquifer.

A measure of salinity and sodium hazard is presented in a Wilcox plot in Figure 24. Both salinity hazard (C) and sodium hazard (S) are each divided into four classes based on EC values and sodium absorption ratio (SAR): S1 or C1 indicates low sodicity or salinity (respectively) and S4 or C4 indicates high results. Figure 22 indicates that groundwater from the study area plot within a wide range of both sodium and salinity hazard classes. The groundwater from all of the formations from SWQ aquifers fall into high sodicity (S2-S4) and very high salinity classes (C4).

Figure 22: Piper Diagram

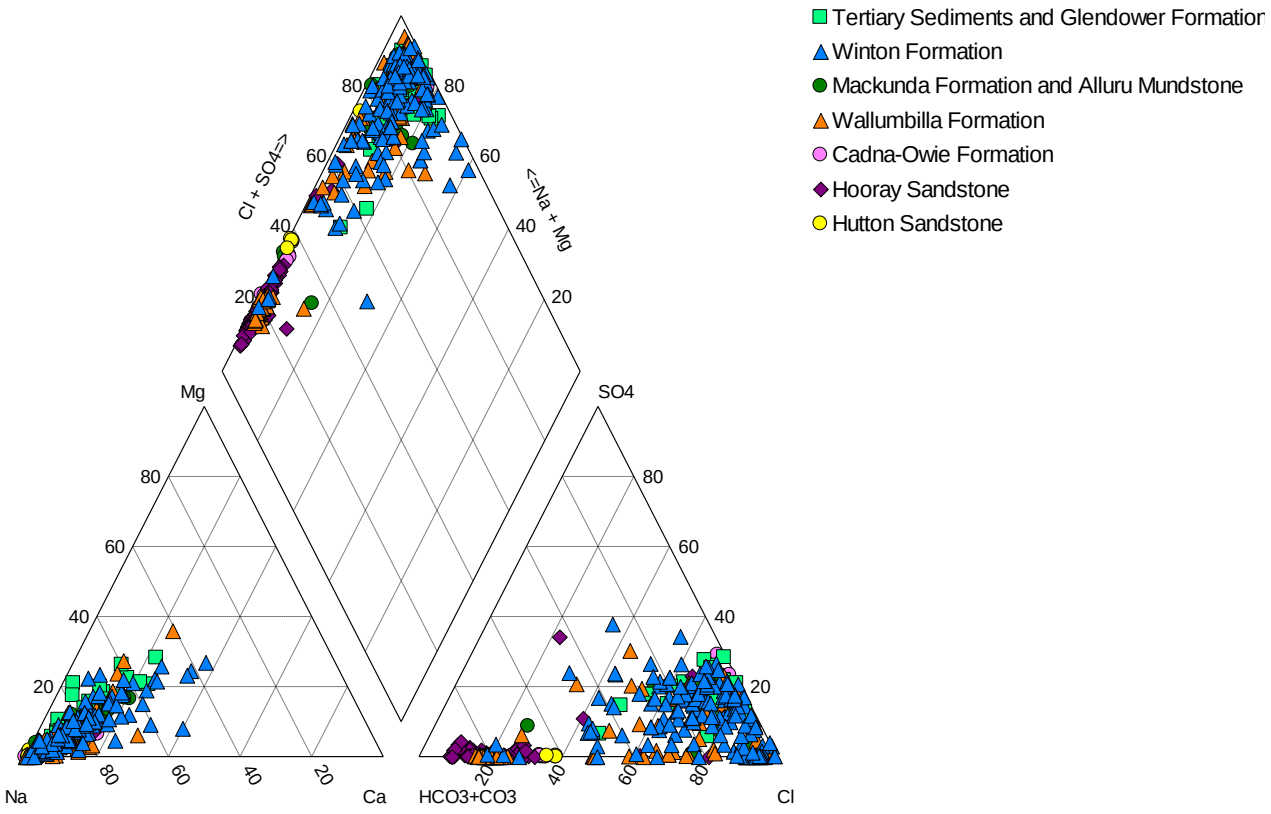
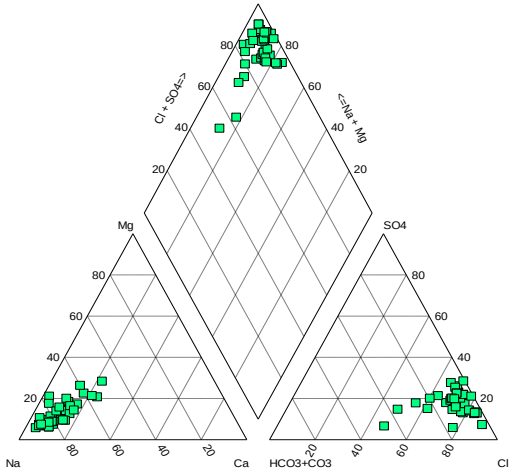
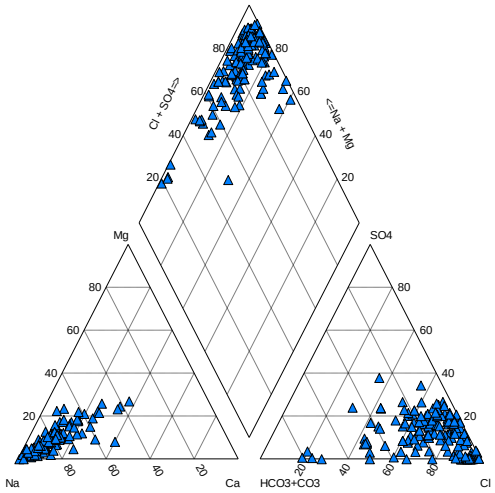


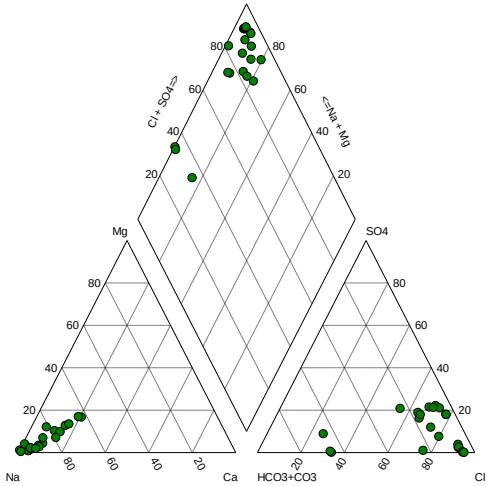
Figure 23: Piper Diagrams of Individual Formations



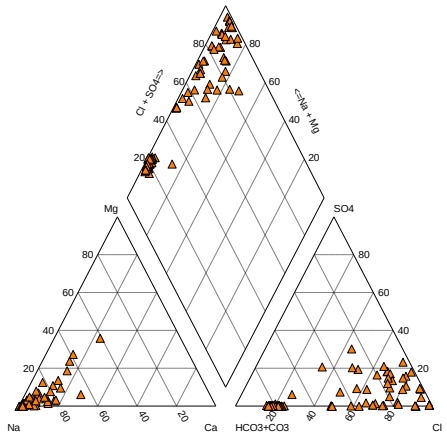
Tertiary Sediments and Glendower Formation



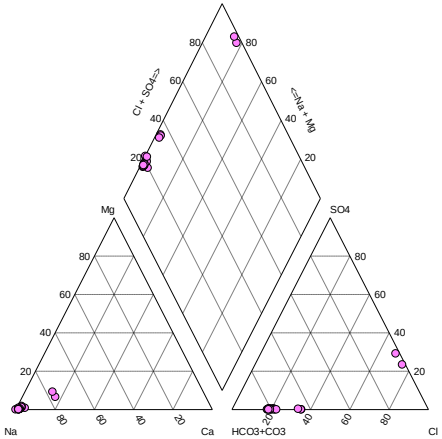
Winton Formation



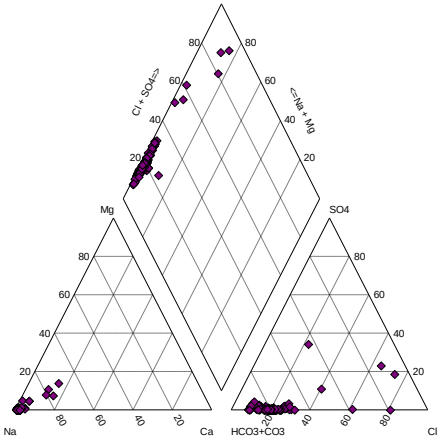
Mackunda Formation and Alluru Mudstone



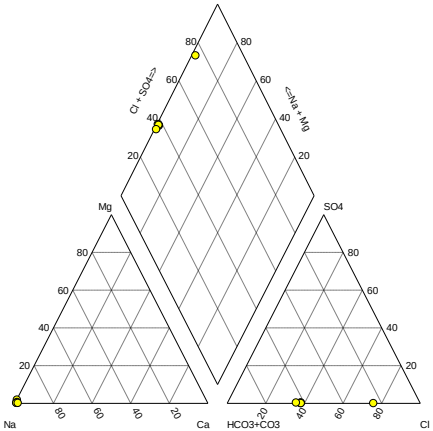
Wallumbilla Formation



Cadna-Owie Formation

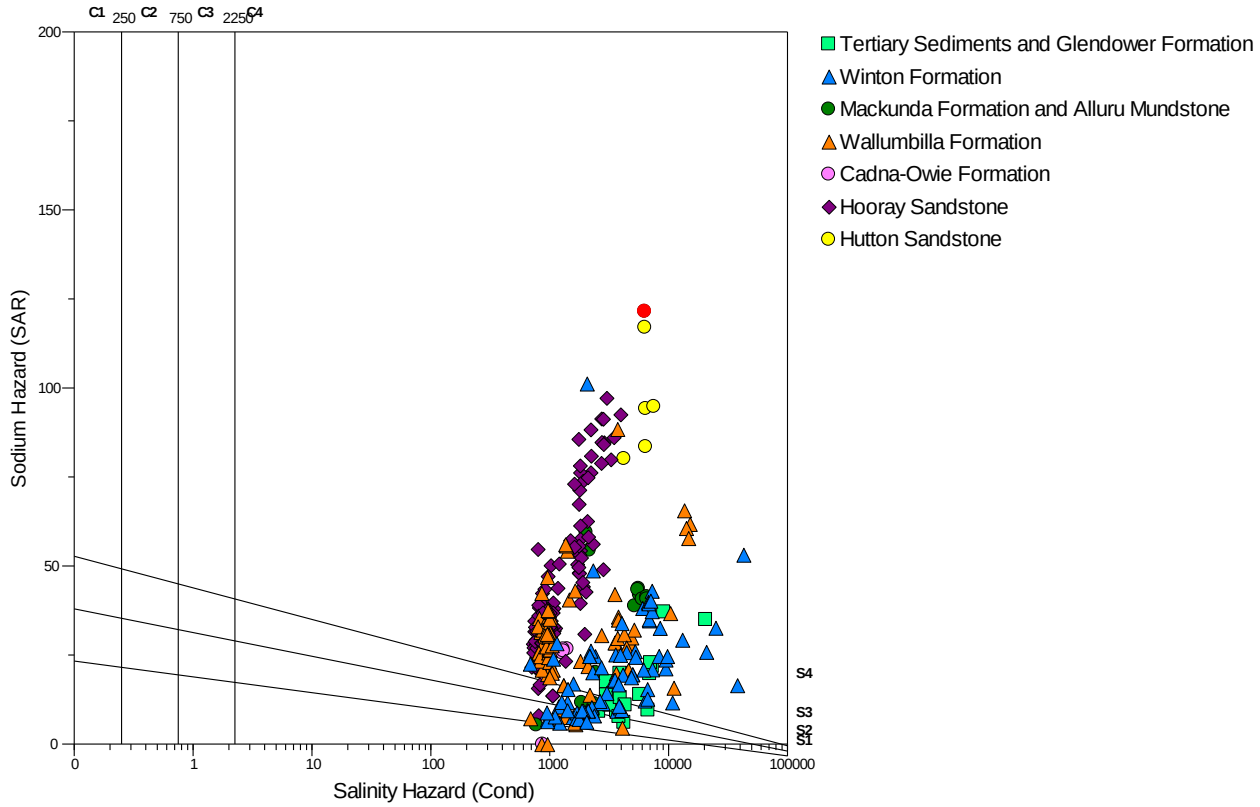


Hooray Sandstone



Hutton Sandston

Figure 24: Wilcox Plot Showing Salinity and Sodicity Hazard Classes



2.5.7 Groundwater Use (Excluding Produced Water)

Groundwater use is largely for stock and domestic purposes, with some town and camp water supply also sourced from groundwater (Figure 25).

There are no large groundwater users albeit for municipal supply in the study area, based on the available data in the DEHP Water Entitlements System (WES) database (previously WERD database). The bores for municipal supply licensed in the WES database are for Eromanga and Thargomindah.

There are 99 existing water production bores known to Santos within the Project Area. Of these, 55 are currently operated by Santos (SWQ EMP 2014).

Groundwater is primarily sourced from the Tertiary formations and the upper GAB formations of the Eromanga Basin. Figure 26 illustrates the distribution of groundwater sources for registered water supply bores within the study area[6]. The geographical distribution of private bores and Santos bores is presented in Figure 27.

[6] Data current as of December 2012

Figure 25: Groundwater Use within the Santos Study Area

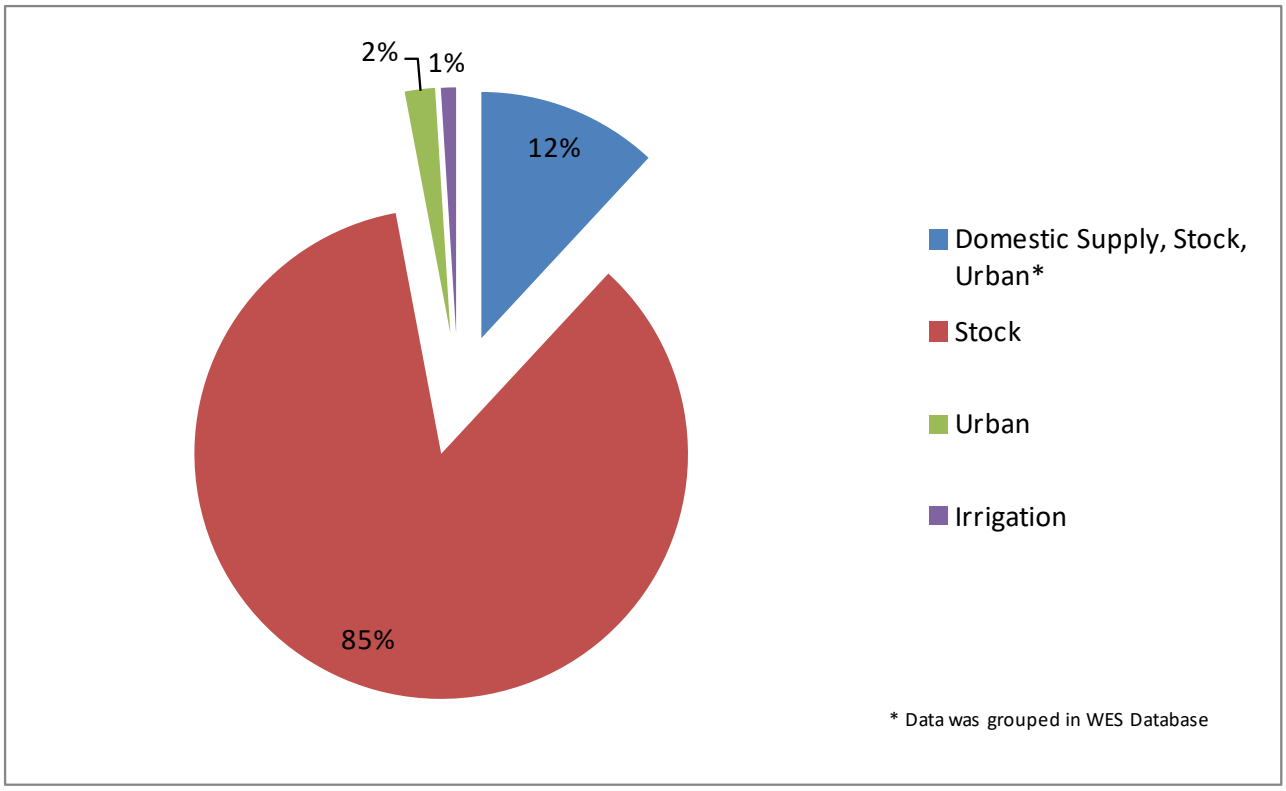
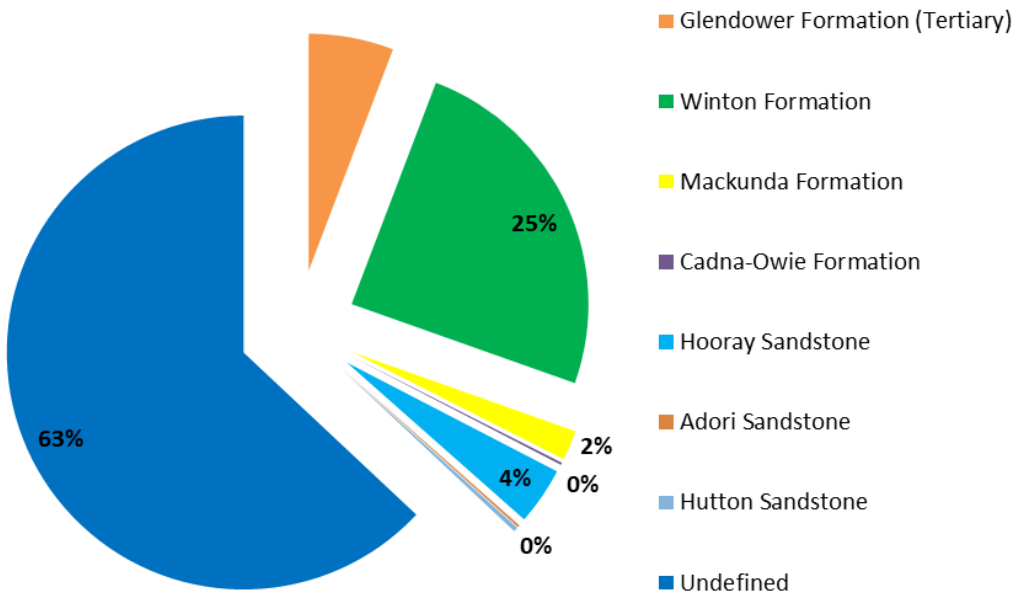


Figure 26: Target Groundwater Sources for Groundwater Usage in the Study Area



Note: Figure 26 was prepared using the data from the DERM groundwater database (Golder, 2020). A total of 138 bores have information on pump type or are indicated as artesian and have been assumed to be used for groundwater supply. Of these 138 licensed bores in the study area, 63% are assigned to the Hooray Sandstone aquifer.

Most private properties are expected to have access to their own water supply through stock and domestic entitlements as part of the basic landholder rights to access water. Groundwater use is limited to domestic consumption and cattle farming (not including industrial cattle operations). There is no volumetric groundwater entitlement associated to these licences however it is commonly assumed that those bores extract a maximum of 5 ML/year.

As of January 2020 (UWIR, 2020), the total volumetric water entitlements in the study area is 2,390 ML/yr for urban and town supply from seven bores; however, four of these licensed bores (totalling 900 ML) were listed as “Lapsed/Never Constructed” and/or expired. The total nominal allowance for stock and domestic bores is 635 ML/yr for 127 bores. The total extraction volume for the 135 licensed bores listed in the DEHP database is therefore 2,125 ML/yr (excluding lapsed/non-constructed bores entitlements).

Santos water production associated with oil and gas production (Golder, 2012a) is mostly from the Hutton Sandstone (82% of average annual production), the Birkhead Formation (7.8%) and the oil reservoirs of the Hooray Sandstone (8.6%).

2.5.8 Regional Bore Inventory

In parallel with the UWIR (Golder, 2012a) Santos engaged Golder to undertake a Water Bore Baseline Assessment (WBBA) in SWQ (Golder, 2012b; reference no. 117666006-019-R-Rev0). The purpose of the WBBA was to verify the existence and operation of water supply bores in the study area, and where possible to collect water extraction, level and quality data. In 2012, Santos identified 242 water bores within the study area which required assessment according to the following criteria:

- *Priority 1*: within leased areas and inside a 2 km radius of a production bore;
- *Priority 2*: within leased areas and outside a 2 km radius of a production bore;
- *Priority 3*: outside of the established leased areas but within Santos tenement boundaries.

The WBBA works undertaken were generally consistent with the DEHP requirements outlined in the *Baseline Assessment Guideline* (2011) (now DES Baseline Assessment Guidelines Version 3.02, effective 5th July 2017), and condition J13 of the draft CSG model conditions for Level 1 EAs, and included assessment of the following information:

- Capacity, quality, and water level of existing bores in the vicinity of oil and gas production areas;
- Details on bore construction, where available;
- Type of infrastructure used to pump water from the bore;
- Identifying bores with potential for inclusion in a regional groundwater monitoring network; and
- Providing an opportunity for bore owners to have direct communication with a field scientist and Santos Land Access Staff (LAS) and for developing positive relationships with these groundwater users.

As of December 2012, 89 bores were located within leased areas (*Priority 1* and *2* bores). Of these, only eight active water supply bores were confirmed within Santos tenements. Details are presented in Table 8 and Figure 27. Refer to the WBBA (Golder 2012b) for a detailed description of field observations.

Table 8: Summary of WBBA Priority 1 and 2 Bores Observed to be Used by Third Parties (Assumed Private Landowners)

Santos Priority	Bore Name	DEHP RN	Santos' Permit	Measured Water Depth (m btoc)	Bore Depth (mbgl) (source: DEHP database)	Target Aquifer (source: DEHP database)*
1	Palara Bore	6057	PL 59	-	243.80	(no data)
1	Mt Margaret No 14	9096	PL 170	-	129.60	Winton Formation
1	Walla Wallan Bore 5	6373	PL 295	15.40	156.70	(no data)
2	Mt Margaret No 20	10565	PL 295	-	89.00	(no data)
2	Cherry Cherry Bore	6369	PL 39	-	285.40	(no data)
2	Tarbat Job No 1947	12036	PL 295	30.40	209.80	Winton Formation
2	Grahams Bore	14955	PL 110	-	94.80	Glendower Formation
-	Moon Road Field Bore	0**	ATP 259P (now referred to as ATP 1189)	-	-	-

Notes:
* Data extracted from the DEHP database (bore depth and target aquifer) is considered to be indicative only, as the original data source is unknown and was not confirmed with field measurements.
** Bore not observed in database records. Referred to as "Moon Field Road Bore" in WBBA.

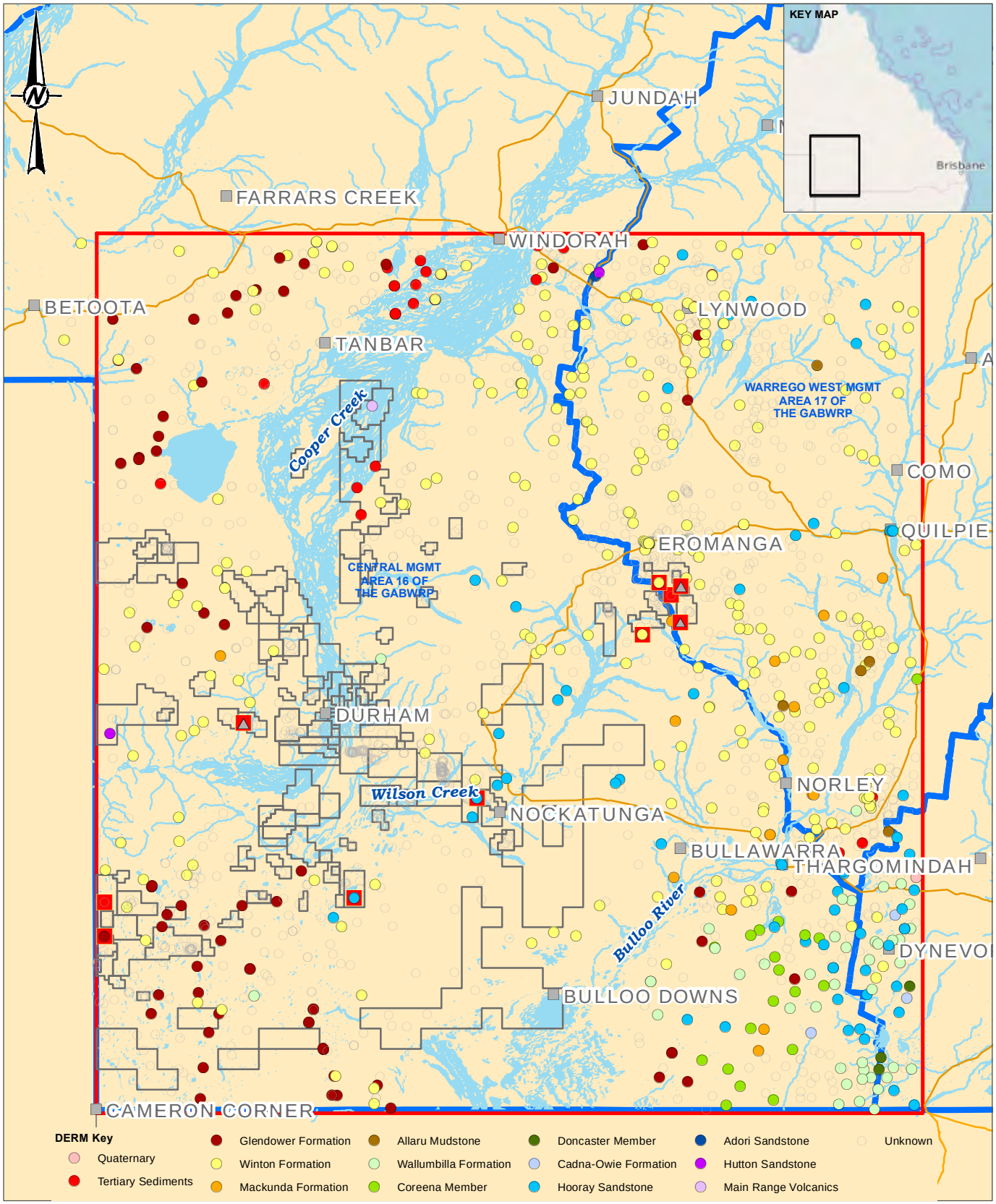
Significant data gaps have been identified between the DEHP database (used in preparing the UWIR), Santos records and the actual existence of bores (Refer to Section 4.8 of the WBBA). Active bores were also observed not to have corresponding DEHP registration numbers. In general, reliable historic and bore construction records were limited and records indicating the aquifer in which bores are screened were not available.

The Golder UWIR indicates that oil and gas production may produce groundwater drawdown in some locations within the study area. Two bores highlighted in the UWIR as being within potential impact zones (in addition to the eight identified private bores) were identified within the affected areas:

- **5032: Whim Well**
  Coordinate location visited in 2012; however, the bore was not observed and the DEHP records could not be verified. In 2016, the bore was located by Santos and was found to be non-operational (A. Stannard, pers. comm.).
- **5033: Coothero Water Bore**
  This bore is monitored by Santos as part of the UWIR Monitoring program (UWR 2020). It is located outside of the established leased areas but within Santos tenement boundaries (i.e., *Priority 3;* location shown on Figure 27*)*. This bore targets the Hooray Sandstone at 1,415 m depth, which is vertically within several hundred metres of hydrocarbon reservoirs in which hydraulic stimulation may occur. Bore uses may include road maintenance and stock watering (based on observations at the site). This bore was investigated by DES and found not to be an authorized bore (does not have a license that permits the

owner to extract groundwater). It therefore does not qualify for protection and management in accordance with s363 of the Water Act (as advised by DEHP on 29 July 2014) (UWIR 2020). Water level measurements between 1988 and 2009 show a 40 m decline in this well, potentially as a result of water extraction due to oil and gas field activities, this however has not been confirmed and could be a result of climatic factors (long-term drought cycles) (UWIR 2020).

The locations of the eight identified private bores and the additional identified bores (Whim Well and Coothero Bore)are shown within the Santos tenements on Figure 27. The locations of these bores in proximity to the stimulation activities are discussed further in Section 3.5.



LEGEND

Santos Bores
- Unknown
- WBBA Bores
- Town/Locality

Highway/Major Road

River/Creek

Groundwater Management Area

Santos Tenements

Study Area

0 KILOMETERS 100

1:2,500,000 GCS GDA 1994

NOTE(S)

REFERENCE(S)

1. BASE INFORMATION COPYRIGHT MAPINFO AUSTRALIA PTY LTD
2. ATP/PL TENURE SUPPLIED BY SANTOS, NOVEMBER 2019
3. GROUNDWATER MANAGEMENT AREA SOURCED DEPARTMENT OF NATURAL RESOURCES & WATER, QLD GOVERNMENT, 2008

CLIENT
SANTOS

PROJECT
HYDRAULIC FRACTURING RISK ASSESSMENT – SANTOS SOUTHWEST QUEENSLAND TENEMENTS

TITLE
GEOGRAPHICAL DISTRIBUTION OF GROUNDWATER USE

CONSULTANT
GOLDER

DD-MM-YYYY	19-03-2020
DESIGNED	KB
PREPARED	KB
REVIEWED	CB
APPROVED	CB

PROJECT NO.	CONTROL	REV.	FIGURE
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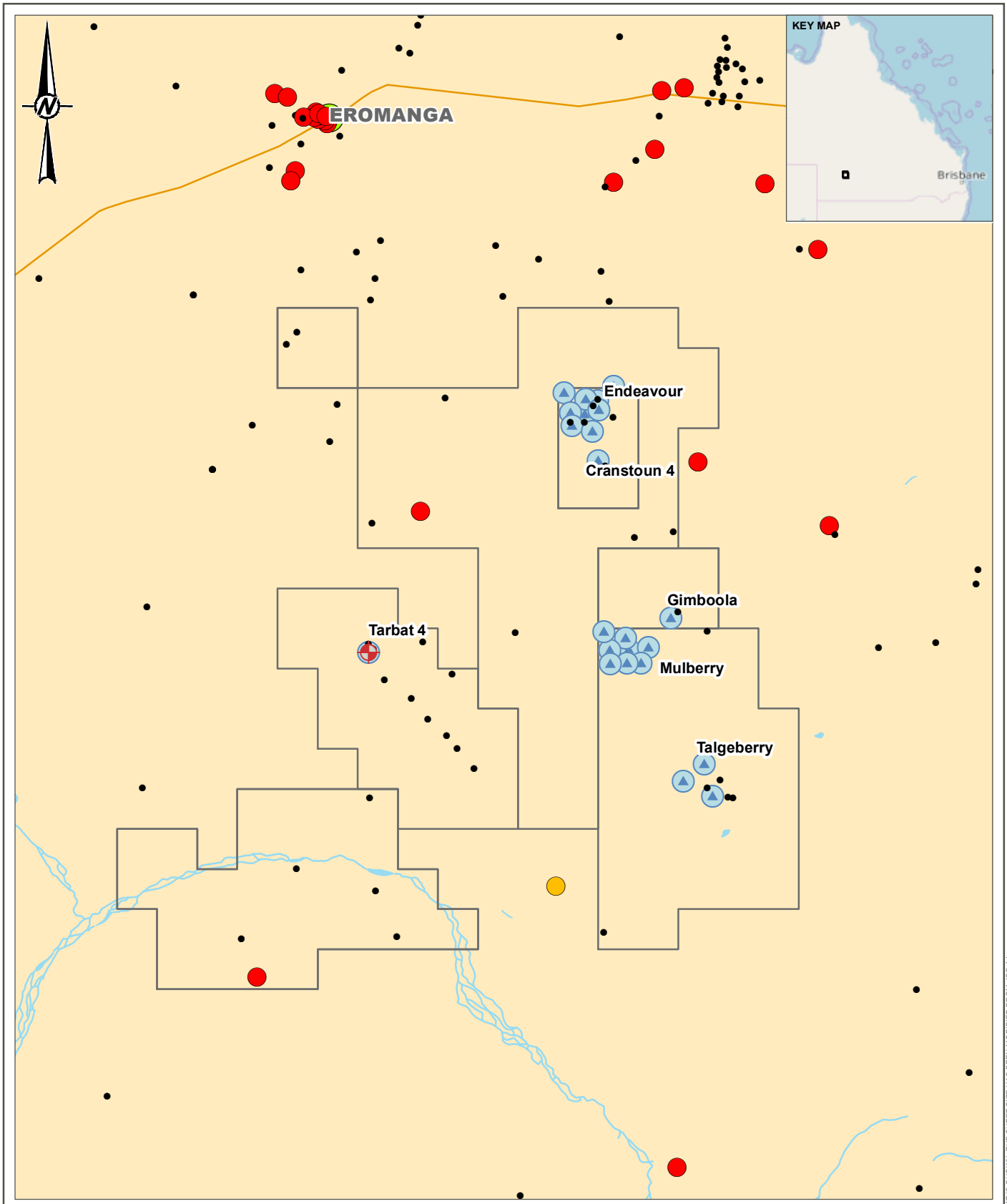

LEGEND

Private Bores - Target Aquifer

- Hooray Sandstone
- Winton Formation
- Mackunda Formation
- Unknown
- Water Source Well
- Water Injection Wells
- Town/Locality
- Highway/Major Road
- River/Creek
- Santos Tenements
- Study Area

0 KILOMETERS 10

1:250,000 GCS GDA 1994

REFERENCE(S)

1. BASE INFORMATION COPYRIGHT MAPINFO AUSTRALIA PTY LTD
2. ATP/PL TENURE SUPPLIED BY SANTOS, NOVEMBER 2019
3. GROUNDWATER MANAGEMENT AREA SOURCED DEPARTMENT OF NATURAL RESOURCES & WATER, QLD GOVERNMENT, 2008

CLIENT
SANTOS

PROJECT
HYDRAULIC FRACTURING RISK ASSESSMENT – SANTOS SOUTHWEST QUEENSLAND TENEMENTS

TITLE
WATER FLOODING ACTIVITIES

CONSULTANT
GOLDER

DD-MM-YYYY	19-03-2020
DESIGNED	KB
PREPARED	KB
REVIEWED	CB
APPROVED	CB

PROJECT NO.	CONTROL	REV.	FIGURE
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2.6 Environmental Values in the Study Area

2.6.1 Introduction

For the purpose of this study, environmental values (EVs) relate to surface water or groundwater resources within the study area and are defined as “those qualities of the waterway that make it suitable to support particular aquatic ecosystems or human use” (*Environmental Protection (Water) Policy, 2009*, referred to as EPP Water, 2009). The EPP 2009 provides guidelines on determining the environmental value that should be considered for a particular project site or area, which follow the framework set out in *Appendix H* of the *Queensland Water Quality Guidelines 2006* (QWQG 2006).

Terrestrial environmental values of the study area, defined as the terrestrial ecosystems (flora and fauna) present within the study area, have also been considered, with information obtained from the Department of Environment and Energy (DoEE) formerly the Department of Sustainability, Environment, Water, Population and Communities (SEWPaC) Interim Biogeographic Regionalisation of Australia (IBRA), and the Environment Protection and Biodiversity Protection (EPBC) Act Protected Matters Search Tool.

With the exception of updated tenements, this section of the SRA is largely unchanged from the Rev0 (December 2012) version of this report.

2.6.2 Environmental Values of Groundwater

The EVs relevant to groundwater resources in the study area include:

- Town water supply;
- Stock and domestic water supply;
- Sandstone aquifers of the GAB; and
- Groundwater Dependant Ecosystems (GDEs).

2.6.2.1 Town Water Supply

Groundwater is a common potable water source for many inland arid to semi-arid areas of Australia, especially where productive, good quality aquifers are present at reasonably shallow depths. Use of groundwater in the region is further encouraged by the low average rainfall, which is significantly exceeded by the pan evaporation potential (Section 2.1).

Municipal water supply accounts for most of the larger licensed groundwater allocations across the study area. Municipal water supply bores identified in the WES database are licensed to extract from the Hooray Sandstone.

2.6.2.2 Stock and Domestic Water Supply

Groundwater is an important resource for stock and domestic water supply for many inland areas of Australia, especially where productive, good quality aquifers are present at reasonably shallow depths.

Groundwater supply development by the local communities predominantly targets the Glendower and Winton Formations (according to the DEHP database), and to a lesser extent the deeper formations of the Eromanga Basin. The WBBA undertaken by Golder (2012b; 2020) identified eight private water supply bores in use from a total list of 242 *Priority 1* and *2* bores within the Santos tenements (Section 2.5.8).

Groundwater for stock and domestic supply is considered to be an important environmental value in the study area.

2.6.2.3 Sandstone Aquifers of the Great Artesian Basin

The main GAB aquifers present within the study area (Section 2.5.2.1) are the Winton Formation, Cadna-Owie Formation, Hooray Sandstone, Hutton Sandstone and Poolowanna Formation (Precipice Sandstone equivalent). The sandstone formations of the Cooper Basin are not considered by the regulator to fall within the definition of "*sandstone aquifers of the GAB*".

In the study area, only the upper aquifers within the stratigraphic sequence are of interest to the local community (Section 2.5.7). The deeper aquifers are not economically viable for use as domestic supply due to the drilling costs to access them. As such, the Hutton and Poolowanna Sandstone aquifers are not used by the community with the possible exception of a couple of oil and gas exploration bores converted to private bores.

Any activity interfering with recharge to the aquifer may impact on the greater GAB. However, outcropping areas considered as the recharge regions of the major GAB units do not occur within 300 km of the study area.

2.6.2.4 Groundwater Dependant Ecosystems

GDEs can be defined as those ecosystems whose ecological processes and biodiversity are wholly or partially reliant on groundwater. There is currently no national GDE database, however, the *Environmental Water Requirements of Groundwater Dependent Ecosystems* report prepared by Sinclair Knight Merz Pty Ltd (SKM; 2001) provides an overview of key threatened GDEs in Australia and the framework for assessing environmental water provisions for GDEs. The extent of GDE dependency on groundwater can range from being marginally or episodically dependent to being entirely dependent on groundwater.

Examples of GDEs include:

- Springs and associated aquatic ecosystems in spring pools;
- Aquatic ecosystems in rivers and streams that receive groundwater baseflow;
- Terrestrial vegetation supported by shallow groundwater;
- Wetlands, which are often established in areas of groundwater discharge; and
- Aquifers and caves, where stygofauna (groundwater-inhabiting organisms) reside.

The potential presence of GDEs in the study area was assessed from literature sources (DERM, 2005 and 2007; Fensham and Fairfax, 2005) and public databases (e.g. Queensland wetlands project, Queensland spring database, EPBC Act Protected Matters database). The results of the GDE evaluation in the study area are presented in Figure 29 and are summarised below:

- No discharge springs (according to the GAB registers) are located within the vicinity of proposed stimulation activities. The nearest GAB discharge spring is located 95 km southeast of Santos tenements, and 150 km east of the nearest tenement proposed for stimulation (Figure 29);
- No GAB recharge springs, or watercourse springs have been registered within the study area;
- The *Cooper Creek Basin Wild River Area Summary: Natural Values Assessment* (DERM, 2010) concludes that "the persistence of waterholes in the Cooper Creek is largely influenced by surface water flows and evaporation, with little inputs from groundwater". This is supported by published peer-reviewed research into the surface water – groundwater connectivity of Cooper Creek waterholes, as discussed in Section 2.3 and 2.5.2.1. As a consequence, the Cooper Creek drainage system, including the associated watercourses and waterholes, is *not* classified as a GDE;
- Within the study area, one listed wetland of international significance and 11 wetlands of national significance were identified (Table 10). The Ramsar-listed Currawinya Lakes is located in the south-eastern corner of the study area, more than 170 km from the closest Santos lease and is not considered further in this report. Of the nationally important wetlands, three are located (partially) within Santos

tenement boundaries, two are within 25 km of a Santos tenement boundary, and the rest are 40 km or more from tenement boundaries. Similar to the discussion of the groundwater dependency of waterholes above, it is considered that the wetlands in this region are likely to be sustained by episodic flood events or surface water from the semi-permanent waterholes, as the relatively deep and saline water table aquifer characteristic of the study area is unlikely to sustain the wetlands. Further discussion of the wetlands is provided in Section 2.6.3.1; and

- Nearby national parks include the Lake Bindegolly National Park, west of the town of Thargomindah and the large Innamincka Recreation Reserve in SA, which do not have registered GDEs.

In summary, according to the GDE databases and literature referenced above, the only registered GDEs within the study area are discharge springs located more than 95 km from Santos tenements. These have not been considered further in this report.

2.6.2.5 Proximity of Oil and Gas Targets to Overlying and Underlying Aquifers

The key aquifers identified in the study area are considered to be the following: the Tirrawarra Formation, Patchawarra Formation, Epsilon Formation, Toolachee Formation and Wimma Sandstone of the Cooper Basin; and the Poolowanna Formation (Precipice Sandstone equivalent), Hutton Sandstone, Hooray Sandstone, Cadna-Owie Formation, Winton Formation in the Eromanga Basin (refer to Section 2.5.2).

The general ranges of stratigraphic thickness that separate the aquifers from the nearest hydrocarbon reservoirs are also presented in Table 9.

The average offset between the base of the Hutton Sandstone and the top of the Permian gas reservoirs is between 200 to 300 m, with most of the intervening stratigraphy consisting of very low permeability mudstones and shales. For economic reasons landholder bores will generally access the shallowest beneficial use aquifer, typically being the Glendower and Winton Formations in the study area. The vertical offset between these aquifers and the top of the gas-bearing Permian interval is of the order of 1,400 m to 1,800 m for the Glendower Formation and between 1,000 m to 1,500 m for the Winton Formation.

Across the study area, the typical depth range between the Glendower Formation and the Cadna-Owie Formation in which the shallowest oil reservoirs are present is of the order of 500 m to 1,400 m, and between 400 m to 800 m for the Winton Formation.

Table 9: Stratigraphic Thickness between Hydrocarbon-Bearing Formations and Aquifers

Basin	Stratigraphic Unit	Relative to Nearest Potential Oil/Gas Target Formation	Vertical Distance
Eromanga	*Winton Formation (GAB)*	Wyandra Oil (Upper Cadna-Owie)	400 – 800 m
	Cadna-Owie Formation (GAB)		0 – 90* m
	Hooray Sandstone (GAB)	Murta Oil (Upper Hooray)	0 – 85* m
	Hutton Sandstone (GAB)	Middle Birkhead Oil (Birkhead Formation)	40 - 80 m
	Poolowanna Formation (GAB)		140 – 220 m
		Wimma Gas (Nappamerri Grp)	140 – 200 m
Cooper	*Wimma Sandstone (GAB)*		0 – 115* m
	Toolachee Formation (CB)	Toolachee Gas (Gidgealpa Group)	0 – 190* m
	Epsilon Formation (CB)		<180**

Basin	Stratigraphic Unit	Relative to Nearest Potential Oil/Gas Target Formation	Vertical Distance
		Patchawarra Gas (Gidgealpa Group)	<50**
	Patchawarra formation (CB)		0 – 150 *
	Tirrawarra Formation(CB)		0 - 40 m

GAB = Great Artesian Basin (Eromanga Sub-basin, Triassic-Cretaceous), CB = Cooper Basin (Permian-Triassic),
* maximum thickness of unit (where the nearest gas or oil unit is a sub-unit of the aquifer).
** Maximum (uncertain due to lack of information)

In Table 9, where aquifer formations also contain hydrocarbon reservoirs the vertical range between the aquifer and reservoir formation is indicated as zero up to the maximum thickness of the formation. The water-bearing zones are separated from hydrocarbon reservoirs by intra-formational seals; however, there is not enough information available to discretise the internal stratigraphy of these formations. Where petroleum activities (including stimulation) occur within a formation that hosts both aquifers and hydrocarbon reservoirs, the lateral distance of the water supply bores accessing the aquifer to Santos' tenements was considered.

According to the DEHP database and the interim results of the WBBA program, groundwater supply development in the vicinity of Santos' tenements is limited to the Glendower and Winton Formations, and to a lesser extent the Hooray Sandstone. The minimum vertical offset between these aquifers and the shallowest hydrocarbon reservoirs (oil reservoirs of the Cadna-Owie Formation) is 400 to 800 m, which includes the low permeability formations of the Wallumbilla Formation and Allaru Mudstone, which form a thick, competent and regionally extensive seal between the Cadna-Owie Formation and the shallower aquifers.

The closest beneficial use bore to the Santos tenements targeting the Hooray Sandstone in the DEHP database records is the Coothero Bore, which has a DEHP database recorded depth of 1,165 m, is at least 25 km from the closest tenement proposed for hydraulic stimulation and more than 80 km from the closest tenement with activities proposed at a similar depth (i.e. oil production from the Hooray Sandstone). Santos monitors the Coothero Bore as part of the UWIR monitoring program.

2.6.3 Environmental Values of Surface Water

Specific EVs for the watercourses within the study area are not defined within the EPP (Water) 2009 and there are no detailed local plans relating to environmental values for the catchments.

Based on the land uses present within the catchment area the EVs which would apply to watercourses within the Cooper Creek Catchment are:

- Protection of aquatic ecosystems;
- Recreation and aesthetics: primary recreation with direct contact, and visual appreciation with no contact; and
- Cultural and spiritual values.

The Santos EMPs (March 2014) discuss the cultural and spiritual values of the study area. These are summarised in the UWIR (Golder 2020). The EMPs identify ten sites of Aboriginal cultural heritage significance related to surface water within or in close proximity to the study area. These are presented in the UWIR (2020) and are listed in the Register of the National Estate (RNE) and or the Queensland Heritage Register.

2.6.3.1 Aquatic Ecosystems

The EVs associated with aquatic ecosystems comprise two inter-related aspects:

- The intrinsic value of aquatic ecosystems, habitat and wildlife in waterways and riparian areas – for example, biodiversity, ecological interactions, plants, animals, key species (such as waterfowl or frogs) and their habitat, food and potable water; and
- Waterways that include perennial and intermittent surface waters, groundwater, tidal and non-tidal waters, lakes, storages, reservoirs, dams, wetlands, swamps, marshes, lagoons, canals, natural and artificial channels and the bed and banks of waterways.

As discussed in Section 2.3, water flows in the Cooper Creek vary greatly over time. The Cooper Creek drainage channel system is predominantly ephemeral. Every three to four years a major flood event occurs (Figure 6) and during extended periods of no flow, the Cooper contracts to a series of semi-permanent waterholes, which provide drought refuges for a variety of flora and fauna.

The Cooper Creek Basin is the largest catchment in the Lake Eyre region. This area resides within the Channel Country Strategic Environmental Area and may include threatened plants, birds and marine and estuarine species. Hence, the aquatic ecosystems associated with the waterholes and billabongs that form between flood events are considered to be of high ecological value.

2.6.3.1.1 Wetlands

For the purpose of this study, wetlands are defined as areas of permanent or periodic/intermittent inundation, with water that is static or flowing fresh, brackish or salt (Wetlandinfo, 2012). Wetlands must have one or more of the following attributes:

- at least periodically, the land supports plants or animals that are adapted to and dependent on living in wet conditions for at least part of their life cycle; or
- the substratum is predominantly undrained soils that are saturated, flooded or ponded long enough to develop anaerobic conditions in the upper layers; or
- the substratum is not soil and is saturated with water or covered by water at some time.

The Queensland Wetland Program identifies eleven wetlands of ecological importance and one Ramsar Wetland (Commonwealth of Australia, 2010) within the study area. These wetlands and their proximity to Santos' tenements are summarised in Table 10.

Table 10: Identified Wetlands of National and International Significance in the Study Area

Wetland Name	Reference Number	Area (ha)	Approximate Distance to Santos SWQ Tenement
International Importance [1]			
Currawinya Lakes[1]	43	151,300	130 km E of ATP 1063P
National Importance [2]			
Cooper Creek – Wilson River Junction	QLD027	63,925	Within ATP 1189, PL25 PL133, PL150, PL177, PL208, PL1051 and PL1060
Bulloo Lake	QLD024	83,227	Within ATP 1063P
Cooper Creek Swamps – Nappa Merrie	QLD026	106,311	Within ATP 1189, PL131 and PL146
Lake Yamma Yamma	QLD037	86,548	17 km NE of ATP752 and 25 km W of PL38
Lake Bullawarra	QLD031	1,287	50 km E of ATP765

Wetland Name	Reference Number	Area (ha)	Approximate Distance to Santos SWQ Tenement
Nooyeah Downs Swamps Aggregation	QLD041	6,241	40 km E of ATP765
Lake Cuddapan	QLD033	1,704	61 km NW of ATP1189
Cooper Creek Overflow Swamps – Windorah	QLD025	124,853	20 km N of ATP1189
Lakes Bindegolly and Toomaroo	QLD125	9,677	113 km E of ATP765
Quilpie (Bulloo River FP) water holes	QLD167	30	87 km NE of PL295
Mitchell Swamp	QLD170	500	140 km NE of PL295

1. List of Wetlands of International Importance of the Ramsar Convention
2. A Directory of Nationally Important Wetlands in Australia (Environment Australia, 2001)

2.6.3.1.2 Ecological Investigation of the Study Area

The unpredictable flow regime and spatially complex environment has created a distinctive ecology, with the Cooper Creek Catchment (Section 2.3) providing important habitats for a range of species, especially in times of flood.

Most species of aquatic fauna are well adapted to the extreme flood-drought regime prevailing in the region. Life cycles are completed rapidly during favourable conditions, and temperature, salinity and oxygen tolerances are often high. Several species are highly dependent upon the refuge habitat provided by permanent waterholes for survival during the long droughts that regularly occur in the region.

A brief overview of the biology of the study area, as evidenced from the field surveys undertaken to better understand the implications of the Commonwealth EPBC Act 1999 (Carpenter and Armstrong, 2001 and 2002; Santos 2003), is summarised below:

- Aquatic Flora: No rare or threatened species of aquatic flora have been recorded from the waterways in the oil and gas fields;
- Aquatic Macroinvertebrate Communities: Several species of crustaceans inhabit the creeks and waterholes of the Cooper Basin. They are dependent upon permanent water for survival, and generally retreat to permanent waterholes during droughts. Some species, however, can survive for prolonged periods, buried in the dry bed of creeks and waterholes. Species include freshwater crabs, the common yabby, shield shrimps, freshwater shrimps and freshwater mussel;
- Fish Communities: Most of the fish species within the study area can tolerate a large range of water quality conditions. Golden perch, mosquito fish, western carp-gudgeon and central Australian catfish are tolerant species that can live in water characterized by low DO levels, high salinity and relatively high turbidity;
- Waterfowl: Sixteen species of waterbird were surveyed near water holes along the flood plain. These include the pink eared duck, glossy ibis and brolga. Brolga is a large silvery-grey waterbird with a red face and nape and is listed as vulnerable. It inhabits shallow lakes, swamps, wet grasslands and dry land adjacent to these areas.

2.6.3.2 Recreational Values

The Cooper Creek Catchment is a popular recreational fishing destination. Fishing for golden perch and catching common yabby are popular within the study area in:

- the waterholes of the Bulloo River at Thargomindah;
- the Wilson River at Nockatunga; and
- Cooper Creek, in the channel country (Bulloo Shire Council, 2012).

The portion of the Cooper Creek system in South Australia, downstream of Cooper Basin, is a popular destination for tourists from all over the world. With only a few permanent waterholes in South Australia section of the Cooper Creek system, fish must survive droughts by colonising as many temporary waterholes as possible during the Cooper Creek catchment flood events (Section 2.3).

2.6.3.3 Proximity of Santos Tenements to Surface Water with Environmental Values

The proximity of Santos tenements and proposed petroleum activities to surface water EVs are described below:

- *Aquatic Ecosystems* – The proximity of aquatic ecosystems to Santos' tenements are described in detail in Section 2.6.3.1 and illustrated in Figure 29. Cooper Creek, is largely influenced by surface water flows and evaporation, with negligible contribution from groundwater. Waterholes and billabongs occur throughout the Cooper Creek floodplain and channel complex, some of which coincide directly with Santos tenements;
- *Wetlands* – As indicated in Table 10 reveals that three of the identified wetlands (Cooper Creek – Wilson River Junction, Bulloo Lake and Cooper Creek Swamps – Nappa Merri) are within boundaries of Santos' tenements. It should be noted that stimulation activities may be completed within any tenement boundary over the life of the Project;
- *Recreational Values* – The Cooper Creek catchment and downstream Lake Eyre are popular recreational fishing destinations. The proximity to popular fishing spots from Santos activities are listed below:
  - Bulloo River at Thargomindah is 55 km from the Santos tenement boundaries, and 90 km to the closest active lease area; and
  - Cooper Creek flows (episodically) through some of the western tenements.

These wetlands, waterholes and rivers with ecological and recreational values are identified and spatially managed in a DEHP GIS database of Environmentally Sensitive Areas (ESAs), a copy of which was provided to Santos for all of their tenements. The ESAs form a routine part of the constraints analysis in the planning of all Santos well leases and associated disturbance proposals in SWQ. Prior to any greenfield disturbance, or subsequent re-disturbance, a Santos Environmental Advisor or external ecologist inspects the site for potential environmental impact. The resultant assessment, and any recommendations for mitigation, is managed via the Santos *Environmental Approval Request Tracking Form* (EART). Approval conditions must be accepted by the relevant project proponent prior to any physical works occurring.

2.6.4 Terrestrial Environmental Values

For the purpose of this assessment, terrestrial environmental values are considered to comprise the native flora and fauna of the study area. Based on information obtained from the SEWPaC (now referred to as DoEE) IBRA (online at: http://www.environment.gov.au/parks/nrs/science/bioregion-framework/ibra/index.html), three biogeographical regions cover the study area, as follows:

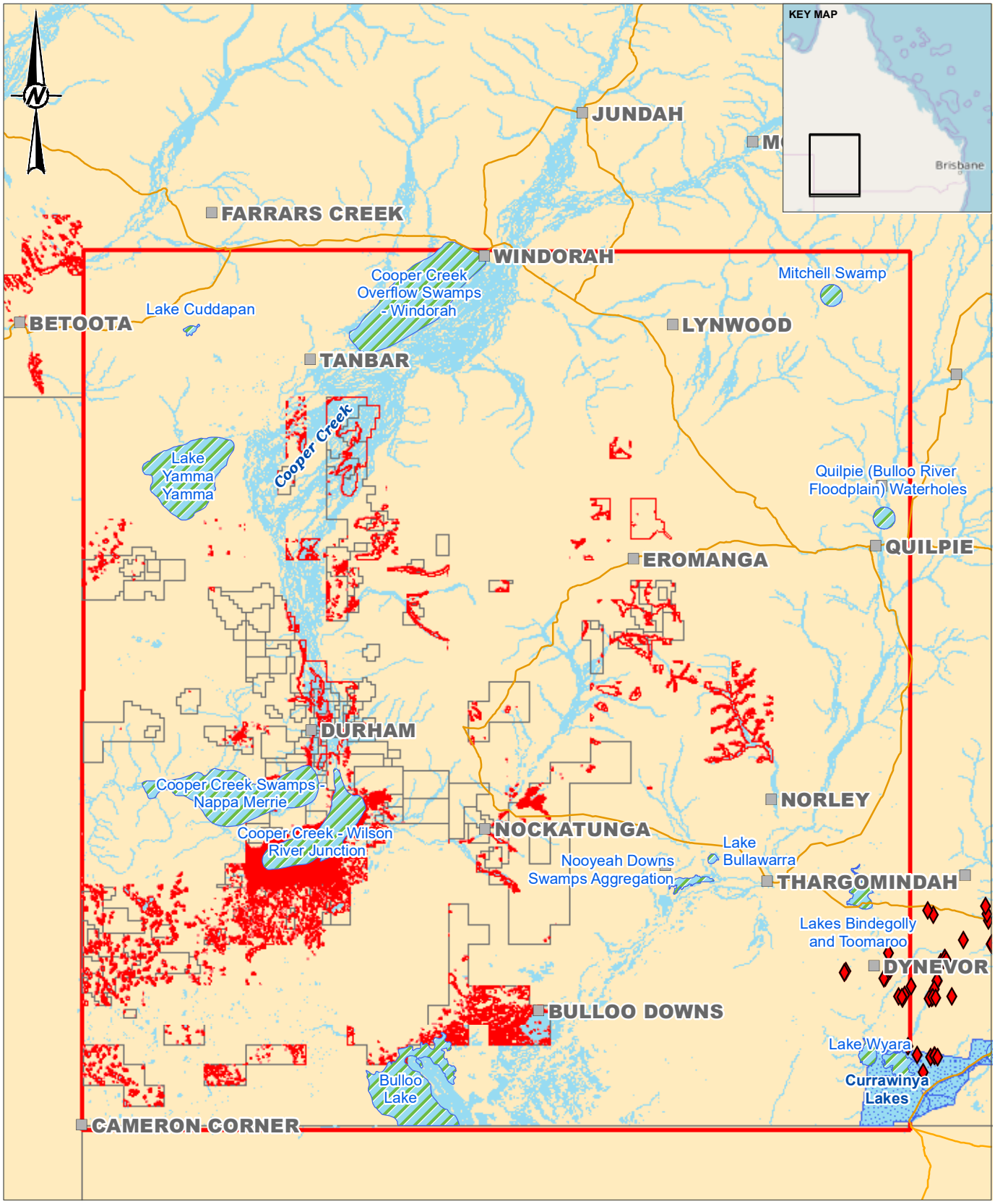
- Channel Country, which covers the central portion of the study area and is characterised by vast braided, flood and alluvial plains surrounded by gibber plains, dunefields and low ranges. Native vegetation is predominantly Mitchell grass, gidgee and spinifex, and various weeds are known to exist in the area. The region is predominantly used for stock grazing (approximately 91%) and is home to several invasive animals. Native species are abundant and include red, eastern, and western grey kangaroos, with various marsupials and reptiles adapted to the variable ecosystems ;
- Mulga Lands, which covers the eastern portion of the study area and is characterised by flat to undulating plains with outcrops of low ranges and tablelands. The dominant native vegetation types are mulga and eucalypt woodland, with some weed species well established particularly where grazing occurs. The region is predominantly used for stock grazing (approximately 94%) and is home to several invasive animals, but also supports an assemblance of diverse native species; and

- Simpson Strzelecki Dunfields, which covers the southwest corner of the study area and comprises long parallel sand dunes, fringing dunefields, extensive sand plains, ephemeral watercourses and saltpans. Vegetation is predominantly spinifex hummock grasslands with sparse acacia shrublands and some narrow river red gum and coolibah riverine woodlands. The region is partially used for stock grazing (approximately 49%) and is home to several invasive animals, as well as highly adapted native species.

A study area specific report generated from the interactive EPBC Act Protected Matters Search Tool (http://www.environment.gov.au/epbc/pmst/index.html, assessed 2012) indicated matters of national environmental significance, as follows:

- Threatened species including 5 birds, 1 fish, 6 small and medium sized mammals, 1 reptile and 8 plants;
- Migratory species including 3 marine birds, 2 terrestrial birds and 6 wetland birds;
- Listed species including 9 birds;
- Indicative and registered indigenous and historic areas;
- Reserves and wetlands; and
- Invasive plant and animals.

It is considered that some of these terrestrial environmental values could be in close proximity to Santos stimulation activities. Consistent with before mentioned procedures, prior to greenfield disturbance, or subsequent re-disturbance, a Santos Environmental Advisor or external ecologist inspects the site for potential environmental impact. The resultant assessment, and any recommendations for mitigation, is managed via the Santos Environmental Approval Request Tracking Form (EART). Approval conditions must be accepted by the relevant project proponent prior to any physical works occurring.



LEGEND

- GAB ROP Discharge Spring
- GAB ROP Recharge Spring
- Town/Locality
- Highway/Major Road
- River/Creek
- Nationally Important Wetland
- Ramsar Site
- Constraint Areas
- ESA (Primary)
- ESA (Secondary)
- Santos Tenements
- Study Area

0 KILOMETERS 100

1:2,500,000 GCS GDA 1994

REFERENCE(S)

1. BASE INFORMATION COPYRIGHT MAPINFO AUSTRALIA PTY LTD
2. ATP/PL TENURE SUPPLIED BY SANTOS, NOVEMBER 2019

CLIENT
SANTOS

PROJECT
HYDRAULIC FRACTURING RISK ASSESSMENT – SANTOS SOUTHWEST QUEENSLAND TENEMENTS

TITLE
ENVIRONMENTALLY SENSITIVE AREAS IN TENEMENTS WITHIN THE SANTOS STUDY AREA

CONSULTANT
GOLDER

DD-MM-YYYY	19-03-2020
DESIGNED	KB
PREPARED	KB
REVIEWED	CB
APPROVED	CB

PROJECT NO.	CONTROL	REV.	FIGURE
127666004	011-R	2	29

3.0 STIMULATION PROCESS

3.1 Introduction

The description of the stimulation process is covered under the following headings:

- Description of the oil-bearing units and the oil they contain;
- Description of the gas-bearing units and the gas they contain;
- Purpose of the stimulation process;
- Description of the stimulation process;
- How is stimulation carried out;
- Infrastructure and equipment used;
- Stages of stimulation;
- Assessment techniques for determining extent of stimulation activities;
- Practices and procedures used to ensure fracture remains in target zone;
- Program for wells to be stimulated;
- Frequency of stimulation;
- Distribution of wells stimulated to date and to be stimulated;
- Location of landholders' active bores; and
- Chemical constituents in acid and stimulation package.

3.2 Well Design and Stimulation - General Considerations

Prior to considering the practice of stimulation to enhance conventional oil and gas well production, two important matters require addressing in accordance with the requirements anticipated of the EA conditions that will apply to new areas proposed for production, namely:

- Comparison to *international best practice* –the procedures employed by Santos' and its contractors follow a design philosophy predicated on the guidance, specifications and recommended practices of the American Petroleum Institute (API), considered to represent international best practice;
- *Well mechanical integrity and surveillance* – the procedures employed by Santos' and its contractors for mechanical integrity and surveillance follow a design philosophy with international best practice. Practices for ensuring well mechanical integrity consist of a robust surveillance plan, which includes;
  - *Well integrity checks including casing pressure surveys, downhole isolation checks (where applicable), casing top-ups with inhibited fluid and casing pressure tests.*
  - *Operator surveillance involving quarterly casing pressure surveys and visual inspections.*
  - *Wellhead maintenance requiring valve function testing and maintenance.*
  - *Cement integrity involving acoustic logging and casing pressure tests.*

3.2.1 Comparison to International Best Practice

Within Australia and the world, the oil and gas industry is reliant on a number of experienced stimulation contractors.

These contractors, along with operating companies, have developed and defined industry best practices in the field of stimulation. These practices have been transferred to applicable operations in Australia.

These practices have been developed over 60 years using experience and technological innovation. These experiences and practices are communicated and shared via academic training, professional and trade

associations, extensive literature and documents and, importantly, industry standards and recommended practices.

The industry best practice guidelines, arising from this body of knowledge, experience and leading edge research, are distilled in a series of guidance documents published by the API. It should be noted that API Technical Reports (TRs) and Recommended Practices (RPs) are not legal requirements and the use of these documents is voluntary. The key guidance documents relevant to the contractor's operations in the SWQ oil and gas fields of the Cooper Basin include:

- API Guidance Document HF1, *Hydraulic Fracturing Operations – Well Construction and Integrity Guidelines*
- API Guidance Document HF2, *Water Management Associated with Hydraulic Fracturing*
- API Guidance Document HF3, *Practices for Mitigating Surface Impacts Associated with Hydraulic Fracturing*
- API Specification 5CT/ISO 11960, *Specification for Casing and Tubing*
- API Specification 6A/ISO 10423, *Specification for Wellhead and Christmas Tree Equipment*
- API Specification 10A/ISO 10426-1, *Specification for Cements and Materials for Well Cementing*
- API Recommended Practice 10B-2/ISO 10426-2, *Recommended Practice for Testing Well Cements*
- API Recommended Practice 10B-3/ISO 10426-3*, Recommended Practice on Testing of Deepwater Well Cement Formulations*
- API Recommended Practice 10B-4/ISO 10426-4, *Recommended Practice on Preparation and Testing of Foamed Cement Slurries at Atmospheric Pressure*
- API Recommended Practice 10B-5/ISO 10426-5, *Recommended Practice on Determination of Shrinkage and Expansion of Well Cement Formulations at Atmospheric Pressure*
- API Recommended Practice 10B-6/ISO 10426-6, *Recommended Practice on Determining the Static Gel Strength of Cement Formulations*
- API Specification 10D/ISO 10427-1, *Specification for Bow-Spring Casing Centralizers*
- API Specification 10D-2/ISO 10427-2, *Recommended Practice for Centralizer Placement and Stop Collar Testing*
- API Recommended Practice 10F/ISO 10427-3, *Recommended Practice for Performance Testing of Cementing Float Equipment*
- API Technical Report 10TR1, *Cement Sheath Evaluation*
- API Technical Report 10TR2, *Shrinkage and Expansion in Oil Well Cements*
- API Technical Report 10TR3, *Temperatures for API Cement Operating Thickening Time Tests*
- API Technical Report 10TR4, *Technical Report on Considerations Regarding Selection of Centralizers for Primary Cementing Operations*
- API Technical Report 10TR5, *Technical Report on Methods for Testing of Solid and Rigid Centralizers*
- API Specification 13A /ISO 13500, *Specification for Drilling Fluid Materials*
- API Recommended Practice 13B-1/ISO 10414-1, *Recommended Practice for Field Testing Water-Based Drilling Fluids*
- API Recommended Practice 13B-2/ISO 10414-2, *Recommended Practice for Field Testing Oil-based Drilling Fluids*
- API Recommended Practice 45, *Recommended Practice for Analysis of Oilfield Waters*
- API Recommended Practice 53, *Blowout Prevention Equipment Systems for Drilling Operations*
- API Recommended Practice 65, *Cementing Shallow Water Flow Zones in Deep Water Wells*
- API Recommended Practice 65-2, *Isolating Potential Flow Zones During Well Construction*
- API Recommended Practice 90, *Annular Casing Pressure Management for Offshore Wells*

The stimulation contractors operating in Australia and used by Santos currently follow the intent and detail of these guidance documents as they apply to the site-specific conditions for each hydrocarbon bearing field. In conjunction with these activities, other stimulation technologies are also being used, such as use of pneumatic techniques (gases, such as CO_2) to fracture the sandstone hydrocarbon reservoirs. The process of researching alternate methods is an ongoing process, and descriptions and results of trialled alternative methods will be provided as the findings become available and are considered field-ready.

3.2.2 Well Mechanical Integrity and Integrity Testing

3.2.2.1 Background

One of the major controls in providing a high degree of protection to the Cooper and Eromanga aquifers is through robust well design, well construction, and scheduled integrity checks throughout the lifecycle of the well i.e. from production to abandonment. Quality control procedures are implemented through the material selection, sourcing process, installation as well as maintenance and checks to ensure the casing and seals are adequate barriers for hydraulic isolation.

A properly designed production well provides full containment of hydrocarbons within its internal casing and/or completion conduit from the subsurface to the surface and affords:

- Protection of groundwater resources;
- Protection to the environment; and
- A safe working and operable environment.

Full containment is achieved by cementing in place multiple strings of steel casing and installing mechanical plugs or packers after a well is drilled to depth. The primarily objective of the well design is to prevent communication with aquifer systems and cross flow of fluids (gas, oil and water) between sedimentary layers. Of particular note is that important casing design parameters are factored to ensure that the well's integrity is maintained during the high treatment pressures imparted during fracture stimulation. Examples of specified casing parameters include pipe weight, metallurgy, burst and yield pressures.

In addition to the subsurface well construction, the surface well head integrity is of equal importance to ensure hydrocarbon containment. A properly designed wellhead ensures that the control measures (or barriers) are in place for well production, but more critically, that the well can be secured and isolated in events such as an uncontrolled release of hydrocarbons to atmosphere. Santos has embedded Standards and Procedures (EHSMS 11.5, AIMS and PESP 9.1, Santos 2009) to ensure that integrity controls and measures have been performed prior to stimulation. Typically, this would involve running a cement bond log to check the quality of the cement and/or pressure testing of the internal and annular sides of the well.

The hydrocarbon reservoirs are accessed through perforations in the steel casing and cement sheaths opposite the respective reservoir zones, with the produced oil and gas contained within the well casing all the way to the surface. This *containment* and barrier philosophy along with continued zonal isolation is what is meant by the term “well integrity.” Should an issue with casing be identified, fracture stimulation is postponed until the well is remediated. If remediation of the well is physically or economically unfeasible, the well is completed without fracture stimulation or plugged and abandoned to regulatory specifications.

Routine integrity checks are scheduled while the well is on production in accordance with the well design, well plan, and permit requirements, until such time that the well is abandoned.

NOTE: The discussion of well integrity has been drawn from discussions and information provided by Santos and supplemented by information directly sourced from API HF1 (API, 2009). The reader is urged to consult this document for a detailed description of the well completion process.

3.2.2.2 Drilling and Well Completion

Drilling a typical oil or gas well consists of several cycles of drilling, running casing (steel casing for well construction), and cementing the casing in place to ensure isolation. In each cycle, steel casing is installed in sequentially smaller sizes inside the previous installed casing string. The last cycle of the well construction is well completion, which can include perforating (creating holes in the steel casing) and stimulation or other techniques depending on the well type and formation characteristics.

The main stages of drilling and completing a well comprise:

- Lease preparation;
- Rigging up of major drilling equipment (e.g. tanks, pumps, rig, draw works, hydraulic and power packs);
- Drilling the surface hole;
- Cementing in place the surface casing;
- Installation of the Bradenhead and Blow Out Preventor (BOP);
- Running in to continue drilling in the production hole to depth;
- Petrophysical logging of the open borehole section;
- Cementing in place the production casing;
- Securing the well and rig release;
- Cased hole logging (for well integrity);
- Installation of wellhead or Frac Tree;
- Perforation of the first zone in preparation for stimulation;
- Fracture stimulation and initial flowback of well;
- Installation of artificial lift (if necessary);
- Installation of the final completion design;
- Installation of production well head, flowlines and telemetry;
- Well on production;
- Monitoring of well's production and integrity checks; and
- Rehabilitation of surrounding well's lease.

3.2.2.3 Selection and Sourcing of Casing Materials

To ensure long term casing integrity, Santos has developed detailed specifications for all well casings and well completion materials. The casing materials are specifically rated to handle stimulation treatments at Permian depths and pressures. Parameters such as yield and burst pressures are specified and triaxial load modelling are sometimes performed to ensure that the well's integrity is maintained during the high treatment pressures applied during fracture stimulation and for the lifecycle of the well.

All materials are inspected by Santos and the contractors prior to installation to ensure compliance with the Santos specifications. A similar process of inspections and testing are utilised throughout the drilling and casing installation program. This testing and inspection is discussed in the sections below.

3.2.2.4 Logging the Borehole

All of Santos oil and gas wells are routinely logged with tools to obtain specific information on the hydrocarbon bearing reservoirs. The results of these logs are used as important indicators that aid in fracture target selection.

Open-Hole Logging

Once the production hole/reservoir section is drilled to final depth, open-hole logging tools are run on wireline to obtain petrophysical information. A typical suite of electric logging tools would include the following:

- *Gamma Ray*: a receiver tool that detects natural radiation from rock. The main isotopes of thorium, potassium, and uranium can indicate the presence of clay mineralogy;
- *Laterolog*: tools which measure the resistivity of the fluids contained in the rock. This is used as an indication of water bearing zones. Higher resistivity values can be an indication of hydrocarbon bearing zones;
- *Spontaneous Potential (SP log)*: measures the salinity contrast between mud filtrate and formation water. This data can be used to assess permeability and potentially some information on lithology;
- *Density Tool*: measures the bulk density of the rock and indicates the presence of porosity;
- *Neutron Tool:* a source/receiver tool which measures rock porosity;
- *Calliper Tool*: measures hole diameter and can provide an indication of borehole geometry. Useful in terms of planning for casing running and cementing design; and
- *Sonic Tool*: a source/receiver tool measuring the transit time of acoustic waves passing through the rock. This data can be used as an indicator of porosity but is primarily used for geomechanical calculations, including minimum horizontal stress. This is a key value required in hydraulic fracture stimulation design.

Logging produces detailed information on the rock formations drilled and the water and hydrocarbons they might contain. This assists with installation of casing strings to the correct depth in order to achieve the well design objectives and to properly achieve the isolation benefits of the casing and cement sheath.

Many other types of logging tools are available and may be run on a case specific basis such as cased hole evaluation logs in place of open hole logs.

Cement Integrity (Cased-Hole) Logging

After cementing the casing in place (refer to Section 3.2.2.5), “cased-hole” logs can be run inside the casing to validate the quality and integrity of the cement sheath bond to the casing. Typically, these logs include the following:

- gamma ray (described previously);
- casing collar locator (CCL; a magnetic device that detects the casing collars); and
- cement bond log (CBL), segmented bond tool (SBT) and variable density log (VDL) that measures the acoustic properties of the cement sheath and the quality of the cement bond or seal between the casing and the formation.

The CBL-VDL or SBT is an acoustic device that can detect cemented or non-cemented casing. These acoustic devices work by transmitting a sound or vibration signal, and then recording the amplitude of the arrival signal. Casing that has no cement surrounding it (i.e. free pipe) will have large amplitude acoustic signal because the energy remains in the pipe. Casing pipe that has a good cement sheath (fills the annular space between the casing and the formation) will have a much smaller amplitude signal since the casing is “acoustically coupled” with the cement and the formation causing the acoustic energy to be absorbed.

Santos uses experienced contractors to identify the key features of the cement operation to ensure the integrity of the cement seal for each casing pipe sheath. The cased-hole logs are also useful when the well is perforated to position the perforating guns with respect to the formations (by comparing with the gamma-ray response of the open-hole log and the CBL).

Santos most commonly uses the CBL-VDL or SBT cement evaluation logs to evaluate cement integrity, however other types of cement evaluation tools are available and, depending on the situation, are considered as a part of the cement evaluation program.

A key result of the cased-hole logging program is to know the exact location of the casing, casing collars, and quality of the cement relative to each other and relative to the subsurface formation locations. This ensures that the well drilling and construction is adequate and achieves the desired design integrity and longevity objectives. It is also used to provide information in subsequent surveys of well integrity and seals over the production life of the production well.

3.2.2.5 Casing Design

A casing completion design is prepared by the engineering team based on rock cuttings and/or borehole core retrieved from the drilling of the well hole; information gained from geophysical logging of the borehole; the regional geological model; reservoir analysis; and the history of nearby wells. Historical problems encountered in the area (lost returns, irregular hole erosion, poor hole cleaning, poor cement displacement, etc.) are considered during the design process. A typical casing design is illustrated in Figure 30.

The basis of the site-specific design for the casing construction emphasises barrier performance and zonal isolation (including aquifer, low quality groundwater and poor ground isolation), as well as gas and oil production efficiency. It includes wellbore preparation, mud removal, casing pipe running (Section 3.2.2.6), and cement placement (Section 3.2.2.7) to provide barriers that prevent fluid and gas migration and well leakage. The well design process also includes contingency planning to mitigate the risk of failure due to unforeseen events.

The casing design process also accommodates analysis of those factors which determine the stimulation outcomes. These include defining the optimal location and orientation of perforations such that the zone of stimulation is contained entirely within the target hydrocarbon-bearing formations. The latter involves the assessment of borehole core, porosity analysis, fracture orientation and density testing, joint orientation, bedding plane analysis and stress field analysis.

3.2.2.6 Casing Completion

The first borehole drilled is for installing the conductor pipe (Figure 30). This is followed by drilling a series of sequentially deeper boreholes for installation of the various casing pipes as follows: surface casing, intermediate casing (if necessary), and the production casing. Specific considerations for each of these casing strings are presented below. It is important to note that the shallow portions of the well have multiple concentric strings of steel casing installed.

- The *conductor casing* stabilises the surficial sediments from the drilling action of subsequent drilling phases (prevents the loose soils from caving into the borehole) and is cemented into place to ensure an appropriately robust seal (up to ground level). Is also serves to isolate the surface water table and perched aquifers, if present;
- The *surface casing* is typically installed to protect the shallow formations (weathered or unconsolidated rock layers) and to stabilise the well from the later drilling phases of deeper sections of the borehole. This portion of the well completion can extend from 30 m to 60 m depth. This casing pipe is also cemented into place to ensure an appropriately robust seal, with cementing taking place from bottom to top to ensure an effective seal. The surface casing is designed to achieve all regulatory requirements for isolating groundwater and also to contain pressures that might occur during the subsequent drilling process;
- The *intermediate casing* pipe may be installed to isolate deeper aquifer systems (if present), for example, the Wallumbilla Formation may be cased off to reduce the risk of impact to this layer. As with the shallower casing strings, this casing pipe is also cemented into place to ensure an appropriately robust seal, again with cementing taking place from bottom to top to ensure an effective seal. A formation pressure integrity test is performed immediately after drilling out of the intermediate casing;
- After the production hole is drilled and logged, *production casing* pipe is lowered to the total depth of the borehole and cemented in place (total depth is typically 10 m to 20 m below the base of the lowermost hydrocarbon-bearing unit, but not penetrating the underlying aquifer systems, if present). The purpose of

the production casing is to provide the final isolation between the hydrocarbon reservoirs and all other overlying formations, and for containing and pumping the various fluids used to stimulate the target zones from the surface into the producing formation without affecting the shallower layers penetrated by the well. It also houses the downhole production pumping equipment (oil wells) when the well becomes operational. During the operational phase of the well, its most important function is internally containing the hydrocarbons produced from the oil and gas units.

The production casing pipe is pressure cemented, from bottom to top, to achieve robust and effective isolation of the well from the various subsurface layers (aquifers and aquitards alike):

- Prior to perforating and stimulation operations, the production well casing is pressure tested. This test should be conducted at a pressure that is greater than what is expected during stimulating and operations, to ensure that the casing integrity is adequate. A CBL, VDL and/or other diagnostic tools are run to establish that the cement integrity is satisfactory for the completion and operational conditions designed for the wells life (see Section 3.2.2). Remedial cementing operations are implemented if there is evidence of inadequate cement integrity: and
- Santos is increasingly moving to *deviated* and potentially *horizontal* production wells to reduce the oil and gas fields' footprint (multiple horizontal wells from a single surface location, thereby, reducing the cumulative surface impact of the production operation). Selection and use of these techniques are in its infancy and trials are currently underway.

Casing pressure tests are carried out at each stage to ensure integrity of the casing pipe for further drilling or operational conditions. These tests are conducted at pressures that will determine whether the casing integrity is adequate to meet the well design and construction objectives.

3.2.2.7 Cementing

Cement types, additives and mixes are higher quality materials produced specifically for oil and gas operations. Materials are selected and designed to address site-specific conditions relevant to a particular well. Cement mixtures and installation techniques are employed to provide a robust seal that isolates the well from the surrounding formations and protects the well materials from potentially aggressive groundwater or formation conditions. The cements are not typical building/construction cements, but are tailored cements designed for use in well construction and the subsurface conditions encountered.

Cement is placed using appropriate centralising equipment to completely surround the casing pipe to create a hydraulic seal against the rock face of the borehole, thereby achieving pipe integrity. Effective isolation of the well pipe from the various subsurface formations requires complete and even annular filling and tight cement interfaces with the formation and casing.

Following the casing design, these materials selection and cement procedures are typically implemented at Santos well casing completion sites:

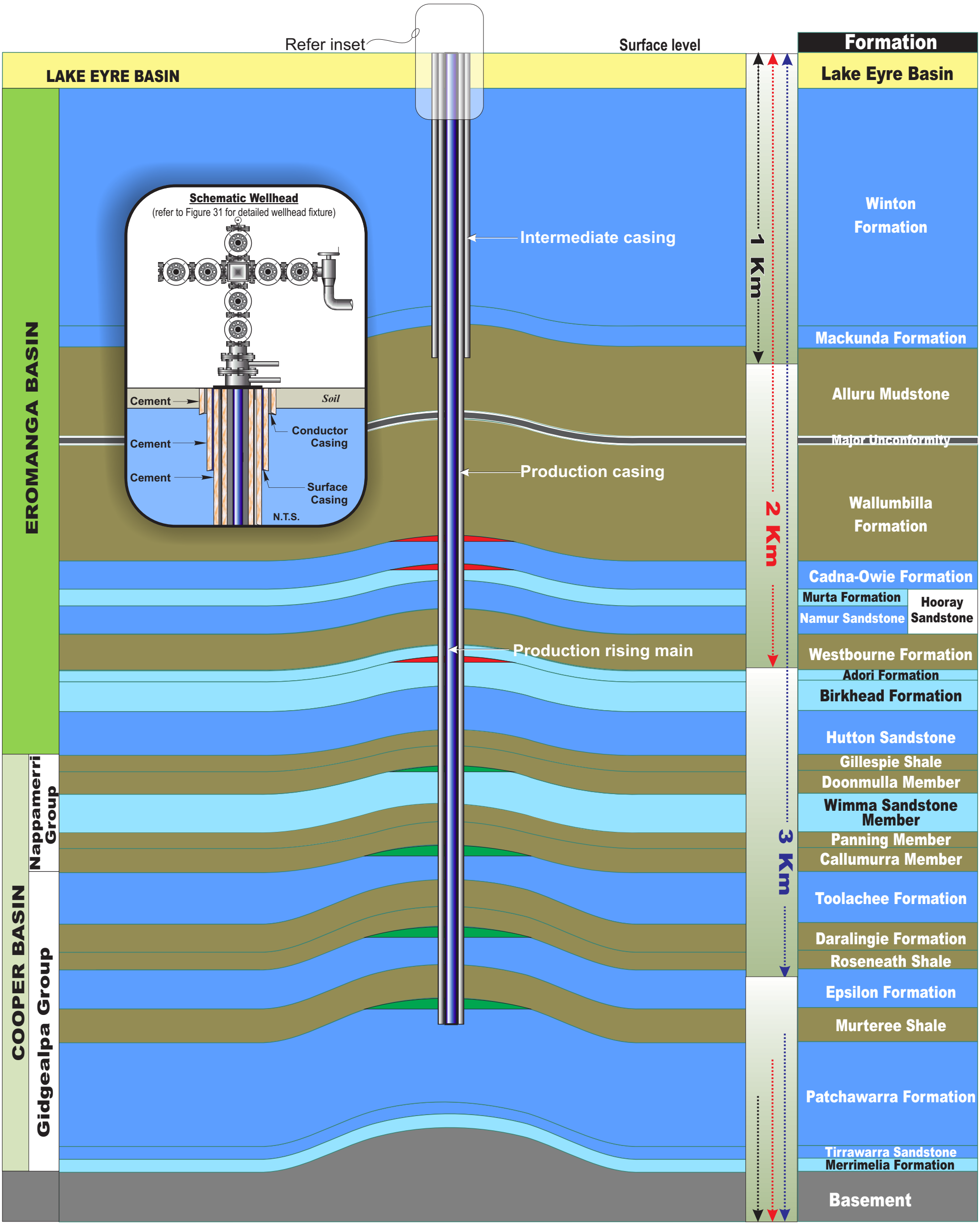
- Computer simulation and completion planning is carried out to optimise cement placement procedures;
- Santos drilling contractors are selected based on their reputation, and their adherence to industry best practice methods and regulatory requirements. Importantly, as it affects cementing, they are required to use established, effective drilling practices to achieve a uniform, stable well borehole with the desired hole geometry. Additionally, they are required to satisfy Santos health-safety-environmental (HSE) requirements with regard to their personnel and equipment. They are required to ensure that their cementing equipment provides adequate mixing, blending, and pumping of the cement in the field;
- Santos drilling contractors are required to ensure that the drilling fluid selection is appropriate for the designed well and the geologic conditions likely to be encountered, and present a low risk to the environment;
- Site drilling and cementing equipment are selected to adequately achieve the well design that will meet the well design objective and ensure effective isolation;

- Santos drilling contractors are required to employ casing pipe centralisers to help centre the casing pipe within the borehole and provide for good mud removal and cement placement, especially in critical areas, such as hydrocarbon-bearing zones, and groundwater aquifers;
- Santos cementing contractors are required to use appropriate cement testing procedures to ensure cement slurry quality and designs are adequate. These include implementation of appropriate cement slurry quality controls - with testing to measure the following parameters depending on site-specific geological and groundwater quality conditions:
  - slurry density;
  - thickening time;
  - fluid loss control;
  - free fluid;
  - compressive strength development;
  - fluid compatibility (cement, mix fluid, mud).
  - sedimentation control;
  - expansion or shrinkage characteristics of the set cement;
  - static gel strength development;
  - mechanical properties (e.g. Young's Modulus, Poisson's Ratio, elastic/compressibility characteristics); and
- Cement design may include placement in two stages, using a "lead" cement of lower density and a "tail" cement of higher density and compressive strength.

Appropriate setting times are adhered to ensure that the cement seals are optimal prior to further drilling, stimulation and/or operational testing. The cement is tested using specific quality assessment and quality control (QA/QC) procedures such as circulation testing and logging as outlined in Section 3.2.2.4.

3.2.2.8 Well Completion Design

The final well completion is not typically run until after fracture stimulation, although there are situations where it is run before the well is stimulated. Completions design is the process of running in of a separate piece of pipe or conduit in the already cased well. This pipe is secured with mechanical packers above the producing zones and is usually performed with a separate Completions/ Work Over Rig. The purpose of the final completion string is to allow the hydrocarbons to produce from it, but on a well integrity perspective, it acts as the secondary barrier control such that if the primary barrier (being the casing) fails, there is not an uncontrolled release of hydrocarbon to surface.



Key

- Aquifer
- Water Bearing
- Confining Bed
- Gas Accumulation
- Oil Accumulation

Source: Stratigraphy and scale based on DMITRE, 2012. Road map for unconventional Gas Projects in South Australia. Energy Resources Division, April 2012.

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CLIENT: SANTOS			PROJECT: SWQ HYDRAULIC FRACTURING RISK ASSESSMENT					
DRAWN: HC	DATE: 16.11.2012		TITLE: CONCEPTUAL CONVENTIONAL OIL OR GAS WELL CONSTRUCTION DETAIL					
CHECKED: RS	DATE: 19.12.2012							
SCALE: VERTICAL SCALE: AS SHOWN HORIZONTAL SCALE: N.T.S.		A3	PROJECT No.: 127666004	DOC No.: 011	DOC TYPE: R	FIGURE No.: F030	REV No.: 0	FIGURE 30

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3.3 Description of the Stimulation Process

3.3.1 Introduction

This section describes the process of hydraulically fracturing/stimulating a conventional oil or gas well, including:

- Description of the reservoir formations and the hydrocarbons they contain;
- Purpose of the stimulation process;
- Description of the stimulation process;
- Infrastructure and equipment used;
- Stages of stimulation;
- Assessment techniques for determining extent of stimulation activities;
- Practices and Procedures used to ensure fracture remains in target zone;
- Program for wells to be stimulated;
- Frequency of stimulation;
- Distribution of wells stimulated to date and to be stimulated; and
- Chemical constituents in stimulation fluid systems.

3.3.2 Description of Hydrocarbon Reservoir Formations in the Study Area

3.3.2.1 Conventional Gas

Conventional gas is mostly methane and is produced predominantly from stacked sands of the Toolachee and Patchawarra Formations (Gidgealpa Group), which lie within the Cooper Basin. The fluvial sandstone reservoirs are separated by shales and coals, which act as intra-formational seals (refer to detailed stratigraphy in Section 2.4). Minor gas production also occurs from other sediments within the Gidgealpa Group (e.g. the Epsilon Formation), from various localised sediments within the overlying Nappamerri Group (also part of the Cooper Basin) and from the Hutton Sandstone (within the Eromanga Basin). Generally, however, the Nappamerri Group shales act as a regional top-seal for gas.

The gas is predominantly stored as free gas within pore spaces in the sandstone reservoirs. Much of the porosity found in sandstone reservoirs is preserved primary intergranular porosity. The sandstone reservoirs often have low permeabilities (usually of the order of 1 to 10 milliDarcies, equivalent to a hydraulic conductivity range of 10^{-2} to 10^{-3} m/d), such that fracture stimulation is essential in order to achieve economic flow-rates and production volumes. Under the natural confining pressure of a typical reservoir the gas exists in a near liquid state.

A key element that distinguishes conventional gas production from CSG production is that conventional sandstone reservoirs do not require the depressurisation of the target beds (with respect to groundwater). When a conventional gas well is completed with its final production string, pressure drawdown (i.e. differential pressure between the reservoir and wellbore) is created by opening up the well to the gathering system. Gas is then able to flow by virtue of the conductive path to the well via the formation's permeability. In general, most gas reservoirs naturally deplete through a gas expansion drive mechanism. In contrast to the drive mechanisms associated with oil reservoirs and unconventional coal bed methane reservoirs, the drive mechanism in conventional gas reservoirs are such that gas will move from high pressure in the reservoir to low pressure at surface without the aid of mechanical lifting devices.

3.3.2.2 Conventional Oil

The conventional oil reservoirs in the study area are associated with sandstone formations of the Eromanga Basin. The oil is present in discontinuous oil reservoirs within interbedded sandstones beds or larger sandstone formations (in the sandstone units of the Cadna-Owie, Hooray Sandstone and Birkhead formations); with reservoirs typically comprising structural and sedimentary traps (Section 2.4.3.4).

The sandstone reservoirs are generally interbedded with shales, mudstones, siltstones and coals, which act as intra-formational seals. The primary oil reservoir formations are separated by low permeability formations comprising shale-mudstones-siltstones-sandstone assemblages of the Eromanga Basin, themselves situated at depth within a thick sequence of highly variable sedimentary rock types (Table 3).

The porosity found in oil sandstone reservoirs is preserved primary intergranular porosity. Water and oil commonly occur together, having a film of water separating the pore boundaries from the oil. Oil reservoirs that lack a film of connate water at pore boundaries can occur but are rare.

Oil production wells generally do not free flow, so gas lift is typically used to aid oil or condensate production. The produced water is separated from the oil and treated and is typically used in water flooding activities to restore and maintain reservoir pressure and enhance production (Figure 28; Golder, 2012a).

3.3.3 Purpose of the Stimulation Process

Hydraulic stimulation is employed in the petroleum industry to improve the production efficiency of many gas and oil producing wells. This is achieved by creating an area of increased conductivity within the reservoir. This increased reservoir contact, through a highly permeable fracture, creates an efficient pathway for the flow of gas and oil. In the majority of cases, the low permeability nature of the hydrocarbon bearing reservoirs are too tight to produce from at economic rates and without this increased flow potential many of the gas wells within the Cooper Basin could not sustain economic flow rates.

Santos include conventional fracture stimulation as part of the final completion process. Once the production casing is cemented, cement evaluation has occurred, and a frac tree is installed at the surface; the stimulation operation can begin. Perforations are placed across the required interval of the reservoir formation and the surface fracturing equipment is rigged up and tied-in to the well.

Production wells may be subject to multiple stimulation events during the completion process. In order to produce from all of the reservoirs intersected by a well, Santos uses methods to selectively isolate and individually stimulate each hydrocarbon-bearing zone. As a result, a typical gas well will have more than one stimulation treatment and the current average is about six treatments per well. The typical Santos oil well will rarely have more than one stimulation treatment due to the limited number of oil reservoirs and the fact that oil-bearing formations are not as dependent on stimulation to be commercially viable.

The subsequent sections describe stimulation design and the stimulation process.

3.3.4 Stimulation Treatment Design Considerations

As discussed in detail in Section 3.2, drilling, open hole and cased hole logging of the reservoir section provides information useful in the stimulation design process. Data is acquired providing information on reservoir parameters, as well as lithology variations and stress contrast from layer to layer. All of this data is used within an industry accredited stimulation software to develop an optimal design.

The basis of well specific design is to exploit the reservoirs through an optimal number of stimulation stages, fracture length, fracture conductivity, and fracture height within the targeted reservoir formation. A number of considerations influence the final design for each fracture design:

- Depth and thickness of the target zone;
- Lithology of target and bounding layers;
- Minimum horizontal stress across all layers (target and bounding);
- Thickness of the 'seals' (aquitard layers) above and below the target reservoir formation;
- Porosity and permeability;
- Pore fluid saturations (percentage of pore volume occupied by each fluid e.g. oil, gas or water);
- Pore fluid properties (e.g. density, water salinity);
- Well performance data, including flow rates, formation pressure and produced fluid properties;
- Formation boundaries (as identified from seismic data);
- Bulk density, elastic properties and compressibility;
- Bedding planes, jointing and mineralisation;
- Thickness of underlying formations and rock strength; and
- Stress field analysis to determine the maximum principle stress direction and the minimum principle stress direction.

The completion design process accommodates detailed analysis of these parameters to specify a stimulation design that provides containment within the target formation. The stimulation design models can model the fracture geometry; including fracture length and fracture height based on the geomechanical rock properties input into the model. The models do not predict the fracture orientation; however, Santos has regional stress information that is used to predict the fracture orientation across the basins. There is an increased use of micro-seismic sensing within the industry to monitor fracture orientation. Santos has experience with this technology and may consider additional projects in the future.

Stimulation fractures are designed to provide an optimal geometry within the formation of interest. A complete layer description, including lithology, stress contrasts between layers, and reservoir parameters is input into the fracturing simulator. Various pumping schedules are input to evaluate the simulated fracture geometry. Economics are optimised by designing a treatment that maintains the fracture height within the target formation. Fracture propagation into non-reservoir units will result in sub-optimal economics. Growth into non-reservoir units can have two outcomes: Firstly, the fluids and proppant are wasted and the hydrocarbon production may be reduced due to poor placement of proppant; secondly, there is a risk of fracturing into a water bearing interval which could lower production due to liquid loading. This would lead to an expensive workover to shut off the water production.

As discussed in Section 2.4.4, at the local scale, the regional stress field (magnitude and orientation) will be affected by discontinuities in the rock mass such as faults. The magnitude of horizontal stress will also be influenced by the geotechnical properties of the layered sedimentary rocks. The stiffer, more brittle rock layers, such as sandstone, have a low apparent fracture toughness (i.e. requires relatively little energy to fracture) compared to shale which is considered ductile (high apparent fracture toughness) and requires relatively large quantities of energy to fracture. Sandstones are porous and permeable in nature and have a significantly higher permeability compared with the overlying shale.

Stimulation is initiated with hydraulic pressure applied to the rock, through the perforations, such that the rock fails in tension against the minimum horizontal stress. With continued fluid injection, the fracture will continue to propagate in the direction of maximum horizontal stress. The fracture will also grow in height until a higher stress boundary is encountered. This stress contrast will prevent the fracture height growth to continue until the pressure in the fracture exceeds the barrier stress. Bottom hole fracturing pressures, at the depth of Cooper Basin reservoirs, can be of the order of 50 MPa to 80 MPa depending on depth of the reservoir rock

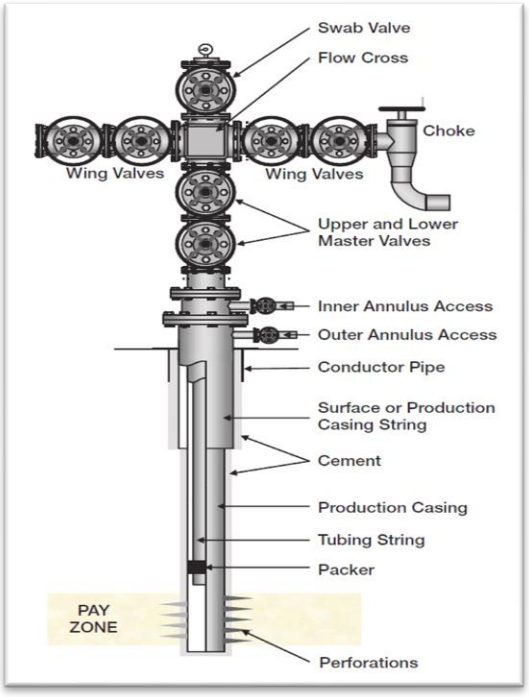
being fractured/stimulated and its geomechanical properties. Fractures within the basin, at the depths of the reservoir sands, are expected to be near vertical and orientated parallel to the major horizontal in-situ stress direction. Fracture height growth is likely to truncate along a low shear strength plane such as the top of the sedimentary layer. Alternatively, if a fracture propagates from a brittle (sandstone) layer into a formation that is ductile (shale often exhibits plastic properties), extra energy would be required to continue the fracture propagation. Consequently, contrasts in apparent fracture toughness form effective fracture height barriers.

In multi-target production wells, casing isolations are used to isolate the fracture pressures to the targeted reservoir rock and to limit the potential for fracturing of sequences above and below the target intervals. Two techniques are commonly used by Santos within the Cooper Basin. The first technique referred to as “plug and perf”, uses composite bridge plugs to mechanically isolate stages prior to perforating the next sand above. The second technique uses coiled tubing with the ability to mechanically isolate a stage below and jet perforate the next stage above, prior to fracturing.

3.3.5 Stimulation Process Description

Stimulation uses specially designed fluids, primarily consisting of water and sand or ceramic proppant, mixed on the surface. The fluids are injected into the well and through the perforations into the reservoir formation (‘pay zone’ in Figure 31), to create the hydraulic fracture. A typical well head used to inject into and control the well, during fracturing operations, is illustrated in Figure 31.

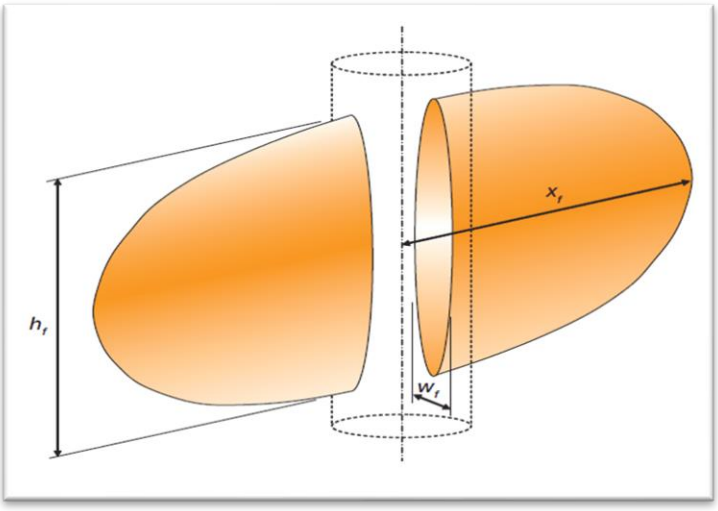
Figure 31: Typical Stimulation Wellhead Fixture



Source: Economides and Martin, 2007

As discussed above, the stimulation process occurs under high hydraulic pressures in order to physically fracture the reservoir rock. The stimulation fluids are injected through perforations (10 to 20 mm diameter holes created with jet perforating) in the well casing pipe. The stimulation fluids are injected from the surface via the wellhead or frac tree (Figure 31). A simplified schematic of the created fracture geometry is indicated in Figure 32. A hydraulic fracture in deep reservoirs, similar to the Cooper Basin, will propagate laterally from the well in a vertical plane, based on the in-situ stresses. Common dimensional terminology for hydraulic fractures includes fracture half length (x_f) and fracture height (h_f) and propped width (w_f).

Figure 32: Conceptualised Shape of Stimulation Zone of Influence



Source: Economides and Martin, 2007

The intent of stimulation is to place a highly conductive channel into the reservoir, to increase the flow capacity. Typically used in low permeability reservoirs, that cannot sustain economic production, it can be analogous to increasing the effective wellbore radius. This increase in flow area will increase the production rates and, in some cases, can contact additional reserves. A number of steps make up the stimulation process:

1) Perforate the interval to be fracture stimulated. The perforations are through jet perforating or abrasive jetting with coiled tubing and sand to jet holes through the casing and cement;
2) Pre-frac injection test with shut-down and decline to evaluate near wellbore entry friction, fracture gradient, fluid leakoff, and minimum horizontal stress. This stage is not always included;
3) Main fracture treatment; consisting of pad volume, slurry stages with increasing proppant concentrations, and flush stage to displace last slurry stage to the perforations. On occasion a pre-pad stage including weak hydrochloric acid to assist with remediating near wellbore entry friction may be pumped ahead of the pad stage;
4) Prepare to mechanically isolate the fracture stage completed, if a multi-stage well completion;
5) Perforate the next stage to be fracture stimulated and repeat the process in 2 to 4 above until final stage is completed; and
6) Flowback well to clean up injected fluids and monitor hydrocarbon production.

The following sections describe some of the specialised equipment required for stimulation and a further description on some of the various stages of the treatment.

3.3.6 Infrastructure and Equipment Used

Within SWQ stimulation is used on both oil and gas reservoirs. For the most part the process is the same. The differences may involve slight fluid formulation changes due to temperature variations with depth and some variation on the equipment used. Smaller oil reservoir stimulation treatments usually use less pumping horsepower and less stimulation fluid and proppant, and therefore require a smaller set-up than gas reservoir treatments (refer to .

Figure 33 and APPENDIX D for a typical equipment set up). Deeper gas reservoirs usually require variations in the fracturing fluid due to higher bottom-hole temperatures and higher in-situ stresses. The higher stresses mean that higher horsepower is usually required.

Santos uses two methods to pump and isolate fracture stages within multiple target gas wells within the Cooper Basin. The first method, referred to as “plug and perf”, uses wireline-conveyed jet perforating across each reservoir target. Sands are stimulated sequentially, one at a time, from the bottom of the well upwards. Between each pumping sequence a mechanical bridge plug is set above the sand completed to isolate the sand while fracturing the next sand above.

Another technique is to use coiled tubing assisted annular fracturing which can be used to provide a conduit for “pin-point fracturing”. Coiled tubing is run into the well to the deepest target. The bottom-hole assembly incorporates a jetting assembly which allows for low concentration sand slurry to be pumped into the coil and exit this assembly with high velocity. The jet created, along with the abrasive properties, will cut holes or slots into the casing and cement. These provide access to the reservoir similar to what jet perforating accomplishes. The stimulation treatment is then pumped into the coiled tubing / casing annulus to initiate and propagate the fracture. The other function of the coiled tubing is to include a packer as part of the bottom-hole assembly that can be used to isolate the fractured formation while fracturing the next formation/target above.

Figure 33 and APPENDIX D indicates the coiled tubing equipment, which may or may not be required on the actual treatment. Some further descriptions of equipment are provided below:

- **'Clean Fluids' Pit or Turkeys nest** – on site, a pre-dug lined pit (turkey's nest) provides temporary clean water storage for use in the stimulation process. Source water is generally trucked from a nearby water supply bore or recycled water from a nearby production facility. Small dosages of biocide are added to control algal growth particularly under warm and stagnant conditions. Often in smaller fracture treatments (e.g. oil wells), the volume of source water is small enough that the use of turkey's nests is not required, and the source water is stored and treated in tanks instead.
- **Sand Trailer Unit** – a large, multi-compartment trailer that holds proppant (sand or ceramic material) required for the treatment. When proppant is required, a conveyor system distributes proppant from the compartments to the downhole blender.
- **Blender Units** – In general, two different blending units are use: A pre-gel blender; and a downhole blender. The pre-gel blender combines the source water with additives required for the base stimulation fluid (also known as "linear gel") and proportions all required additives to provide the final stimulation fluid. The downhole blender unit then proportions proppant to the stimulation fluid to provide the proppant concentrations specified in the fracture design. The final stimulation fluid, without proppant, is referred to as the "clean fluid". The final stimulation fluid, with proppant added, is referred to as "slurry". Most of the stimulation fluids used within the Cooper Basin for the main stimulation treatment are cross-linked fluids to assist with fracture geometry and proppant transport. In small stimulation jobs for oil wells, the linear gel is "batched mixed" in tanks and negates the use of the pre-gel blender, thus reducing the overall equipment footprint on site. Chemicals are precisely, measured controlled and recorded by the blender throughout the stimulation treatment.
- **Hydration Units** – The hydration unit is generally situated between the pre-gel and downhole blenders and serves to prepare the linear gel for crosslinking. Water from the pond or tank is pumped to the hydration unit where a polymer, such as guar gum, is proportioned into the water. A sufficient residence time is available for the polymer to hydrate and provide sufficient viscosity for the fluid designed. The final result is the base gel, or linear gel, for the final stimulation fluid.
- **High Pressure Pumps** – reciprocating triplex or quintaplex pumps that receive low pressure stimulation fluid from the downhole blender and inject these fluids at sufficiently high pressure into the well during the stimulation process.
- **Control or Data Acquisition Unit** – telemetry from all units are connected to a central control room during the stimulation treatment. Treatment parameter data, including surface and bottom-hole pressure, pumping rate, chemical rate and fluid density, are monitored, recorded and plotted. Treatment supervisors and a Santos representative monitor and control the treatment to ensure that the treatment is pumped according to design.
- **'Coil Tubing' Unit** – a Coiled Tubing unit (CTU) has many uses within Santos operations but is not always required as part of a stimulation operation. On some occasions the stimulation treatments are placed using coiled tubing assisted annular fracturing, as opposed to "perf and plug" completions. The coiled tubing can be used in place of wireline jet perforating by jetting holes through the casing and cement using abrasive jetting. Once the perforations are jetted, the coiled tubing is left inside the well and the stimulation treatment is pumped down the coiled tubing / casing annulus. Part of the coiled tubing bottom-hole assembly allows a mechanical barrier to be set which protects a fractured interval below, while pumping a stimulation treatment in a subsequent target above. Following a treatment, the coiled tubing is pulled up to the next interval and the abrasive jetting procedure is repeated.

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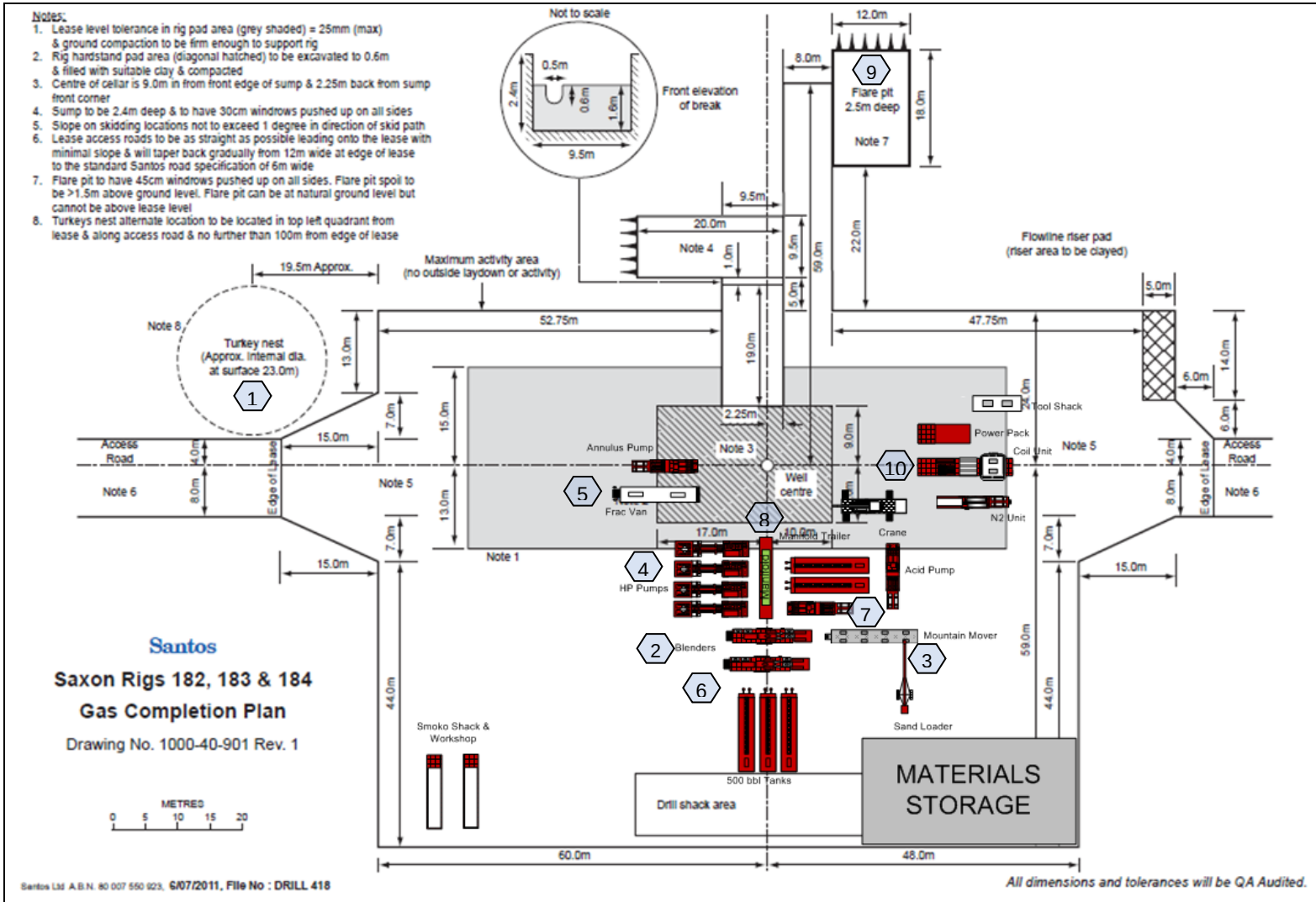
Figure 33: Diagrammatic Layout of a Typical Stimulation Operation on a Conventional Oil or Gas Well Lease (Saxon Rigs 182, 183 and 184)*



1) 'Clean Fluids' Pit or Turkeys nest
2) Blender Units *(one hydration blender and one down-hole blender)*
3) Proppant Storage Unit
4) High Pressure Pumps
5) Control or Data Acquisition Unit
6) Frac Tanks for water storage
7) Additional Pump Unit
8) Manifold Trailer
9) Lined Flare Pit or 'Return Fluids' Pit
10) Coiled Tubing equipment and associated equipment (if required: power pack, N_2 Unit, coil unit, crane, acid pump)

*Note: This figure shows a deep gas well set up for Coiled Tubing Assisted Annular Stimulation. Conventional oil or gas rig set up is similar (lacks items 10 above).

3.3.7 Stages of Stimulation

3.3.7.1 Stimulation Event Design

Stimulation events are individually designed in detail as part of the well completions design process described in Section 3.2. The design input parameters are described in that section.

Key to a successful and contained stimulation event is the inclusion of detailed fracture modelling and fracture monitoring by Santos Fracture Stimulation Engineers and its contractor of each targeted reservoir zone using computer modelling methods.

Design outcomes include:

- Equipment requirements based on expected treating pressures and pump rates;
- Stimulation fluid type and volumes required;
- Volumes of water required on location to be available for designed treatment;
- Proppant types and volumes required;
- Simulated hydraulic fracture geometry and expected treating pressure;
- Fluid pumping schedule describing stage volumes, rates, and proppant concentration;
- Shut-down and flowback procedures; and
- Site preparations and logistics for material supply and accessory equipment required.

3.3.7.2 Stage Perforation/Jetting

To provide communication between the wellbore and the reservoir, perforations are required. In wireline deployed perforation, these are created using charges. Alternatively, perforations are created using a CTU, where low concentrations of an abrasive sand slurry are used to create holes of much lower shot density.

The length of the perforated interval is determined by the thickness of the sand layer to be stimulated. A typical perforated interval across a given sand layer is 3 m in length; however, this interval can vary between 0.3 m to 6 m or more. The perforations within the interval are placed at varying shot densities, or shots per metre. Typical perforation or shot densities are 9 shots per meter (spm) to 20 spm. The perforation diameter will vary based on the method of perforating, as well as other variables, but typical dimensions are 10 mm to 25 mm in diameter.

The preference for deploying one method over another depends on several factors, the main ones being: resource availability; number of zones to be stimulated in the well; efficiency and cost.

3.3.7.3 Pre-Treatment

In some formations, the initial breakdown can create significant near wellbore pressure (NWBP) drop and can be calculated from Minifrac results (Section 3.3.7.4). This can be caused by various conditions but can result in difficulties placing the proppant volumes and concentrations designed for. This NWBP loss needs to be remediated in some cases prior to pumping the main treatment. One method is to use a small volume of dilute hydrochloric acid (15% wt/wt HCl acid) as a pre-flush to the main treatment. Typical volumes of acid ahead of the main treatment are of the order of 1,000 to 1,500 L of acid. Any acid soluble materials, in the near wellbore area, are removed and an improved connection between the wellbore and the reservoir is created. However, acid pre-treatments are not routinely required, and many stimulation treatments are performed without pre-treatment. If stimulation is undertaken in deep gas reservoirs, a dilute acid is commonly used as a pre-stimulation treatment. This is primarily to reduce friction pressure for future pumping operations by improving access through the perforations to the reservoir. It is carried out after completion of the well casing and ‘well screen’ perforations, but prior to stimulation.

3.3.7.4 Minifrac

A Minifrac is a small volume injection of clean fluid (such as friction reduced water or linear gel) into the perforated or jetted holes for the purpose of ascertaining design related parameters such as NWBP, frac gradient, treatment rate, treatment pressures and fluid leakoff signatures. These parameters can influence a design change in the main treatment and in cases where high NWBP is encountered, warrant an acid pre-treatment.

3.3.7.5 Corrosion Inhibitor

Weak acids are corrosive to metals and the corrosion rate increases with higher temperatures. On any acid treatment, a corrosion inhibitor is added to protect against any corrosion of the casing during the pumping operation. This ensures that the well integrity is maintained by applying a protective coating on the surface of the casing. The concentration of the corrosion inhibitor is based on lab testing with the same material at downhole temperature conditions for a given period of time. Typical corrosion inhibitor concentrations used are 2% by volume or 20 L inhibitor per m^3 of acid blend.

The acid is mixed into a surface tank prior to pumping. The mixing procedure is controlled while mixing all the chemicals from bunded containers. The order of mixing is to add the fresh water to the tank, add the additives including the corrosion inhibitor and then the concentrated acid (32% hydrochloric acid, HCl). The total blend will be the required volume of acid at a concentration of 15% HCl. This acid blend is pumped directly into the well using a single high pressure pump.

3.3.7.6 Pad Volume Injection

The stimulation process is initiated by pumping a designed volume of the stimulation fluid without proppant, referred to as the “pad”. This fluid is carefully prepared using the equipment described in Section 3.3.6. Prior to pumping into the well, the base gel is prepared and tested using specific QA/QC procedures. The main polymer used for Cooper Basin stimulation is a guar derivative (Figure 34) which is combined with bore water in the pre-gel blender, providing the base gel viscosity. Programmed and automated control systems are used to maintain the fluid properties during the pumping of the treatment. Fluid sampling occurs during the treatment to ensure that the fluid maintains the desired properties.

The purpose of the pad volume is to create the fracture area required to receive the designed proppant volume. Once the pad volume is pumped, and without shutting down the pumps, the proppant is added to the downhole blender and proportioned into the stimulation fluid. The concentration of proppant increases through each stage as designed within the stimulation simulator. The stimulation fluid with proppant is referred to as “slurry” and the proppant concentration is measured up to the maximum designed concentration in kg/m^3.

The pad fluid comprises a mix of water (typically 99.5% by volume) and is usually comprised of groundwater obtained from nearby water bores or formation water. A mix of water and guar gum, together with a number of additives such as crosslinkers, buffers, and breakers, make up the crosslinked stimulation fluid.

Figure 34: Example of a Typical Slurry Gum Constituent: Guar Gum

Illustrated in its native form, seed form, splits and powder

**Note: Guar gum is a vegetable product which is ground into a powder and used to create a viscous liquid for stimulation. Source: Economides and Martin, 2007

The gum (Figure 35) is allowed to hydrate in a baffled tank, referred to as the Hydration Unit, for several minutes prior to being pumped to the downhole blender. The base gel viscosity of the fluid is typically in the region of 30 to 40 centipoise (cp), depending on the specific fluid designed.

Subsequently, additives including cross-linkers, buffers, breakers, and surfactants are added at the downhole blender to provide a suitable fluid for transporting proppant into the hydraulic fracture.

At this point, the guar gum and associated ingredients comprise approximately 0.050% by volume of the pad volume. The viscosity of the crosslinked fluid will vary with time and temperature, but typical designs will provide a fluid with viscosities in the several hundreds of centipoise (Figure 35). This viscosity is required to propagate the fracture and to transport proppant well into the created fracture. Following the treatment, this fluid viscosity will break back to close to water viscosity due to added breakers and the bottom hole temperature.

Figure 35: Example of Typical Stages of Gum (Guar) Cross-linking to Achieve 300 cp.

Source: Economides and Martin, 2007

The pump rate or rate of injection on a stimulation treatment is based on the design factors discussed in Section 3.2.2 and will vary depending on the reservoir. Typical Cooper Basin injection rates range from 15 bbl/min (2.4 m^3/min) to 35 bbl/min (5.6 m^3/min). Surface treating pressures can range from 5,000 psi (35,000 kPa) to 11,000 psi (76,000 kPa).

At the initial stage of injection, the pressure will increase until a breakdown of the formation occurs. This is evident by a drop in the injection pressure and signals that the stimulation has been initiated. Pumping of the pad volume will continue at the designed rate, in order to promote the designed fracture geometry. Once the pad volume is pumped, the injection of the slurry stages begins without interruption to the treatment.

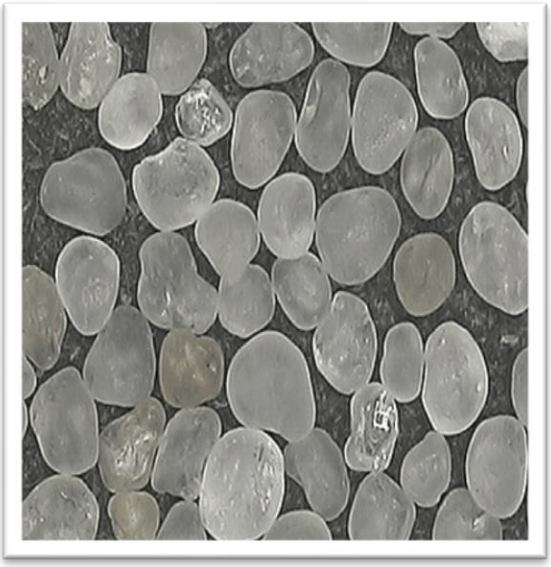
3.3.7.7 Slurry Volume Injection

Following the injection of the pad volume, the proppant stages are pumped according to the design. Proppant addition begins at low concentrations and is staged up to the final designed concentration which is specific to the formation being fracture stimulated. Typical proppant concentrations will range from 0.5 lb/gal (60 kg/m^3) to 8 lb/gal (1000 kg/m^3).

Proppants used in stimulation range from graded quartz sand to higher strength ceramic proppants (refer to Figure 36 and Figure 37). The strength of these materials increases based on the material, with ceramic being much stronger than quartz sand. Ceramic proppant is most often used in the Cooper Basin due to the high effective closure stresses. Proppant grain size varies and is also chosen based on the required conductivity for the specific fracture design. Each size and type of proppant has a number of specifications that must be met for consistency with API conditions.

Figure 36: (Left) Typical 20-40 Grade Sand used in Stimulation

Figure 37: (Right) Typical Sand-Guar Gum Fluid Mix



Source: Economides and Martin, 2007

Once the final slurry stage is pumped on surface, the final flush stage is pumped. The flush stage is a linear gel fluid (non-crosslinked) and is used simply to displace the last stage of slurry down to the perforations. This leaves the wellbore volume free of any proppant and has all proppant placed within the fracture. It is just as important not to over displace the proppant away from the wellbore. Once this flush or displacement volume has been pumped, the high pressure pumps are shut down and the main stimulation treatment is considered complete.

Breaker compounds are added at progressively increasing concentrations throughout the pad and slurry stages. The breaker comprises an oxidizing compound or enzyme that breaks the crosslink sites, as well as the long chain polymers. The end result is a fluid with lower viscosity that can be easily flowed back from the fracture to assist with clean-up. The “break time” is designed to coincide with the known pump time at reservoir conditions plus some additional time to ensure the treatment is pumped to completion. An unbroken fluid will restrict the ability for the fracture to clean up and hydrocarbon production will be impaired.

The duration of the stimulation treatment is dependent on the specified volumes to be pumped and the rate at which the treatment is pumped.

The above procedure is carried out for each target zone (pay zone) in the reservoir formations. In the case of Santos’ oil reservoirs, this typically equates to one target zone per well. In the case of gas reservoirs, the number of sands or fracture stages can range from 1 stage to 10 stages in a single well, depending on the reservoirs contacted during the drill.

A typical Cooper Basin stimulation treatment may use from 40,000 gallons (150 m^3) to 100,000 gallons (400 m^3) of water for the main stimulation treatment. The required volume is dependent on the size of the treatment required for the particular formation to be stimulated. The amounts of proppant required typically range from 40,000 lb (18 tonne) to 200,000 lb (90 tonne) and, again, is dependent on the specific formations being stimulated.

3.3.7.8 Flush Volume

As discussed above, a flush stage or displacement stage is pumped at the end of the treatment to ensure that all of the proppant is within the fracture and not within the wellbore. On occasion, proppant placement is restricted due to near wellbore width restrictions. If this restriction completely blocks the entry of proppant, the pressure rises quickly and terminates the treatment. This termination is referred to as a “screenout” and requires the wellbore to be cleaned out to enable production of the well.

3.3.7.9 Flowback

The fluid used to create the fracture and place the proppant will restrict the ability of the well to clean up and produce hydrocarbons. As mentioned, the use of breakers and reservoir temperature will assist with viscosity reduction. With the fluid viscosity reduced to near water (1 cp), the well is allowed to flowback to reduce the amount of leak off into the formation. Often recovered fluid volumes are in the range of 30% to 60% of the total volume pumped. This is usually enough to allow the well to flow on its own energy or with assistance from artificial lift.

Light condensate entrained in the flowback fluid is often removed with a vacuum truck and taken to a nearby oil facility. The clean-up of conventional oil zones is often bypassed due to the fact that artificial lift systems are installed as part of the final completions program. These lift systems include typical installation beam pumps which can lift both the oil and fluid out of the well.

Flowback fluids are removed from site and transported to and disposed to a dedicated flowback fluid pond located in Naccowlah.

After the well has been equipped with all the required completion and gathering equipment, the well is put on production. Production continues for the life of the well, with produced water (groundwater, condensation and frac fluid) over that period ranging less than 1 ML up to 30 ML for gas wells, increasing to a maximum of approximately 340 ML for oil wells. This flow is likely to flush all the available (mobile) components of the original stimulation fluid which may remain in the formation *after* flowback.

3.3.7.10 Stimulation Treatment Monitoring

As described in Section 3.3.4, the stimulation for each reservoir layer is modelled using an industry accepted stimulation simulator. Based on the final pumping schedule from the optimized design, a predicted fracture geometry and expected pressures are available.

During the treatment key parameters such as surface, bottom hole and annular treatment pressures, proppant concentrations, volume of injected fluid and fluid additives are monitored live from the Frac Van as well as at Santos' offices. The modelled pressures are compared with the actual pressures. The overall pressure response can provide useful information in evaluating the fracture growth and containment. A contained fracture will exhibit a pressure profile different from an uncontained fracture. The mechanical properties of the interbedded sandstones, shales coals mean that horizontal propagation of the fracture network dominates. Treatment parameters are used with the stimulation model, following the treatment, to achieve a history match and predict the actual fracture geometry.

Live monitoring allows for potential problems (surface or downhole) to be identified and corrected quickly. In the event that a problem develops on the surface (e.g. leak in line, pumps shut down), the use of live monitoring as a control measure for early detection can prevent the problem from escalating. An example of live monitoring applied to downhole conditions is if pressure communication is seen between the annulus of the well and inside of the well, the well's integrity may have been breached and the treatment is stopped immediately.

Santos has trialled in South Australia the use of advanced monitoring techniques such as micro-seismic monitoring, which can be used to evaluate fracture azimuth and fracture half length. This additional information can be used to further calibrate the stimulation model predictions. The additional cost of this technology precludes the use on every treatment and will be evaluated as the technology is better understood.

Microseismic monitoring involves the use of a string of sensitive receivers (“geophones”) in one or more nearby wells to detect and locate in 3D space the releases of energy associated with the propagation of the hydraulically-induced fractures. Figure 38 shows an example of a side-view of the locatable microseismic events that were detected during the multi-stage fracture stimulation of Cowralli-10 (in South Australia), with the positions of the events colour-coded by frac stage. The viewpoint for the figure is at approximately the same depth as the upper frac stages (shown in red, mid-blue and grey), and it can be seen that the fracture propagation is predominantly horizontal, with the coals being effective at confining the vertical propagation of the fractures. All of the locatable microseismic events for each frac stage were contained within the formation that was being stimulated. Figure 39 shows a map view of the locatable microseismic events; these are shown in red, and the ellipses around each well show the expected (modelled) fracture-extents. The modelling and actual results show good agreement, although in practice the fractures seem to have propagated horizontally slightly less far than expected. The technique has limitations, in that it requires at least one pre-existing nearby well (within approximately 500 - 700 m) to use for the monitoring, and it is also expensive, meaning that the use of the technique is necessarily selective.

The use of radioactive tracers (as impregnated beads) involves incorporating a different short half-life radioactive isotope into the proppant slurry for each stage, and then monitoring for the distribution of each of these isotopes along the wellbore after the stimulation treatment. However, there are presently no plans to use radioactive materials in SWQ, should this alter Santos will comply with all applicable legislative requirements concerning their use, storage and disposal.

Figure 38: Lateral View of the Locatable Microseismic Events during Monitoring of Multi-Stage Fracture Stimulation of Cowralli-10 (SA)

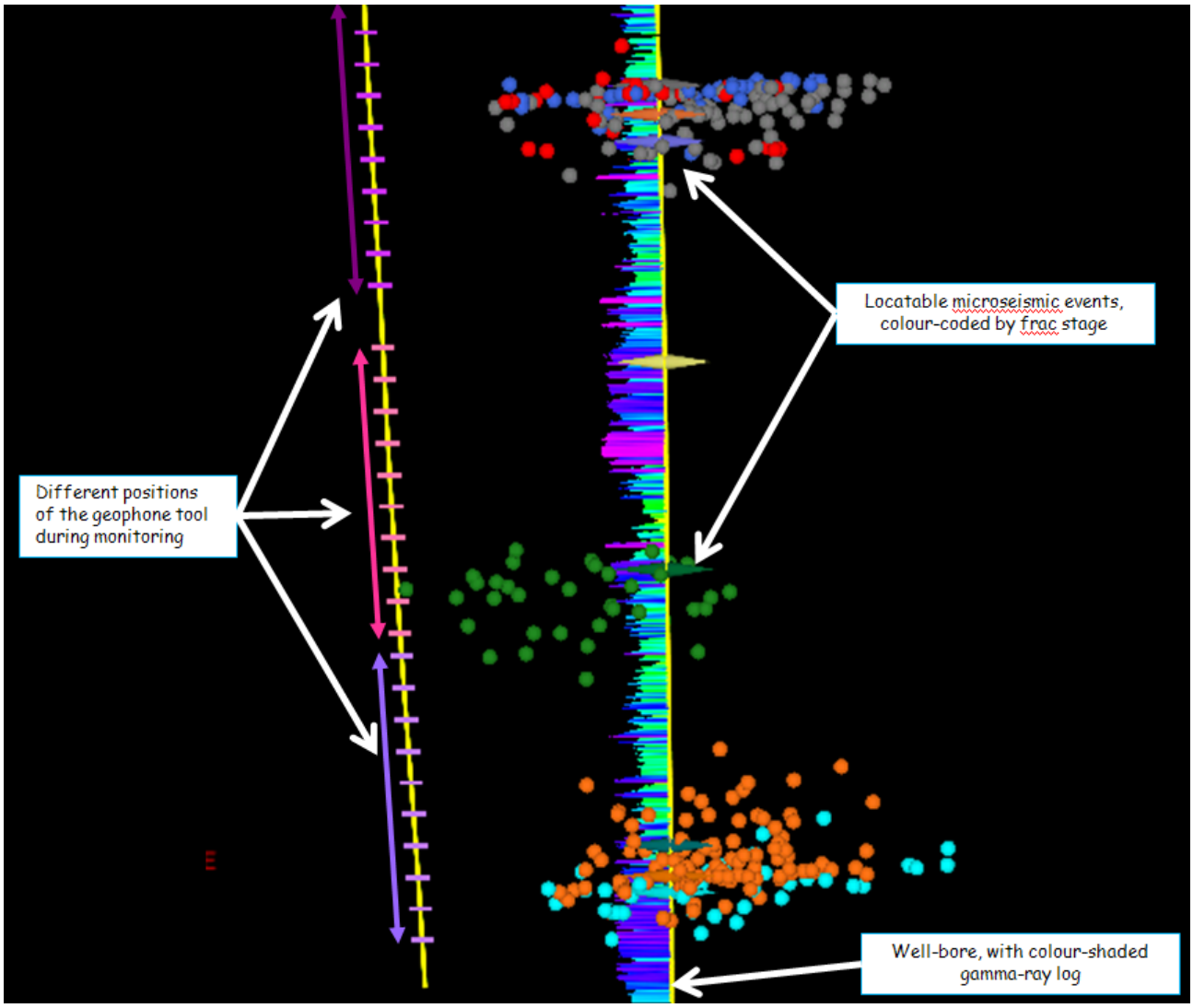
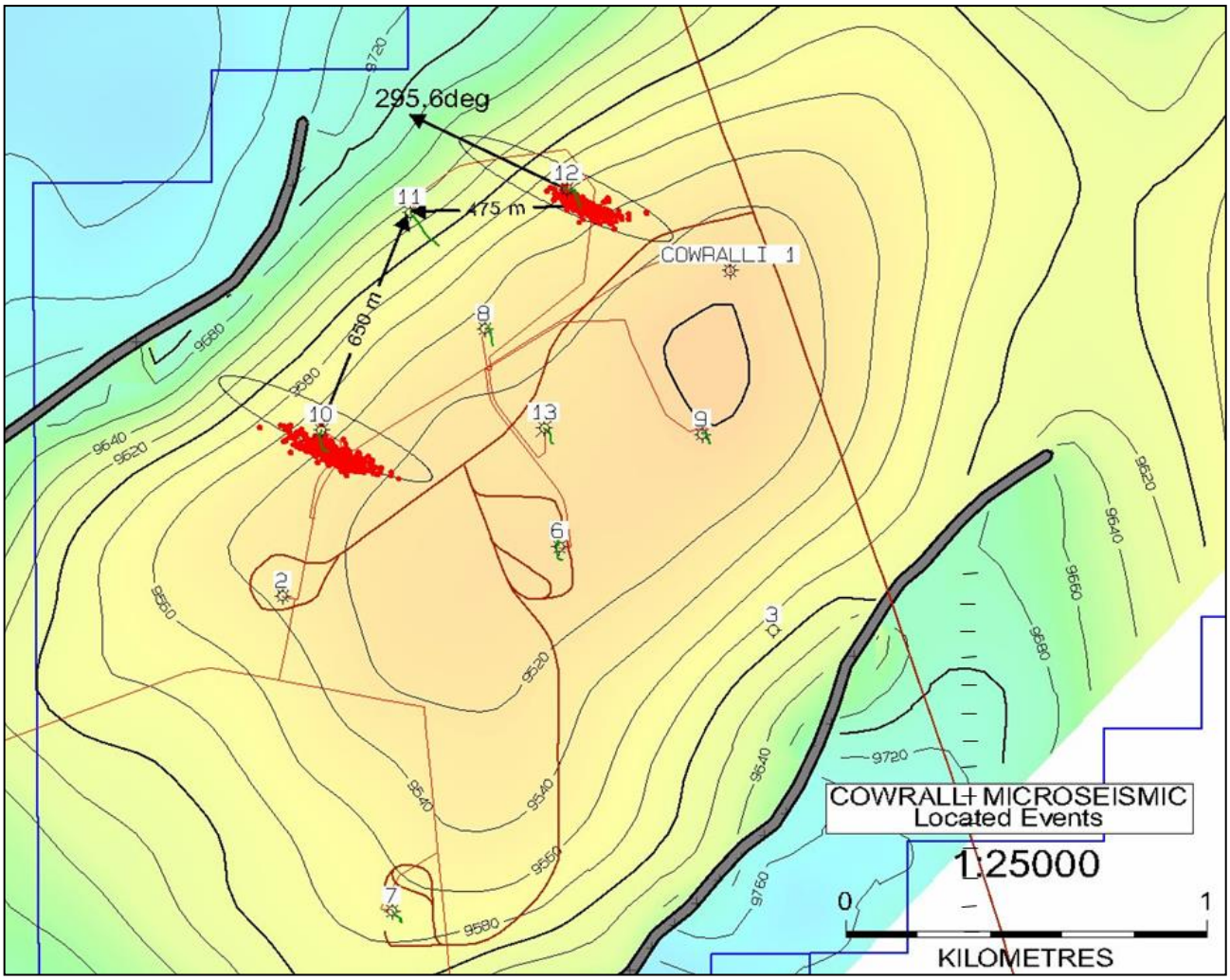


Figure 39: Map View of the Locatable Microseismic Events During Monitoring of Multi-stage Fracture Stimulation of Cowralli-10 and Cowralli-12 (SA)



3.3.7.11 Timing of Stimulation Process

The stimulation of a typical conventional oil well takes two to three days to complete a treatment. The stimulation of a deep gas well with multiple stages can require anywhere from five to ten days to complete the stimulation operation. The flowback period can extend from three to ten days depending on the reservoir and clean up profile.

At the end of the clean-up phase, Santos completions engineers install the production tubing and associated completion equipment such as packers, nipple profiles, tubing hanger, and the production tree.

3.4 Program for Wells to be Stimulated

3.4.1 Frequency of Stimulation

Selected wells will be stimulated prior to being brought into production, involving the various tasks described previously. At the time of writing, Santos has indicated that approximately 67 wells are proposed for stimulation in SWQ. The potential wells scheduled for stimulation are expected to occur over the period 2020 to 2022. However, the program of wells is *indicative* only and prone to change.

During the life of the well, the formation may be re-stimulated at a later date, which would essentially be a repeat of the initial stimulation process.

3.4.2 Distribution of Completed and Scheduled Stimulation Locations

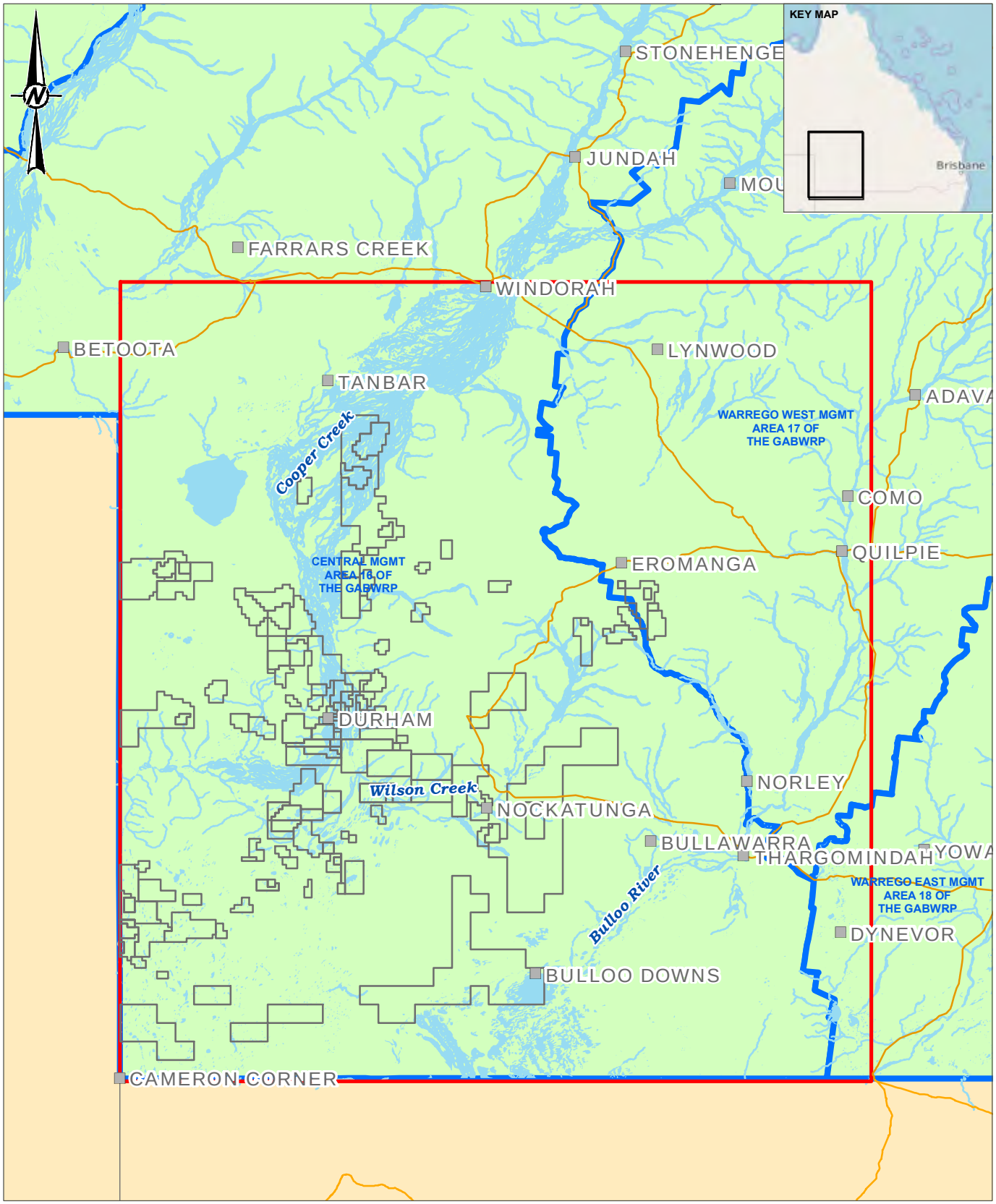
Oil and gas wells that have been stimulated to date are listed in Figure 40 and presented in APPENDIX E. Since 1987, a total of 376 wells have been stimulated in SWQ. Golder understands that have been no recorded incidents associated with these activities. Indicative wells that are scheduled for fracturing until 2022 are presented in APPENDIX F.

According to information provided by Santos, the well spacing varies between the oil and gas well heads, from 400 m in the oil fields, up to tens of kilometres in the gas fields. Santos is moving toward “Pad” wells, where multiple deviated wells emanate from a single wellsite. Proposed deviated gas wells for the Santos project are listed in APPENDIX E and include “DEV” in the well name. These are generally shown as clusters within tenements (e.g. Baryulah Gas, PL131).

It should be noted that for a variety of reasons (including but not limited to future production performance and access-related issues such as the flooding of the Cooper Creek system), the geographic distribution of the forward fracturing programme is frequently reviewed and is subject to change, although the overall number of fracture stimulations is likely to remain similar to that outlined here.

Queensland legislation regarding notice of intent and reporting of activities allows for flexibility to change the program of wells to be fractured. According to the Petroleum and Gas regulations, 2004 (PGGD-03, s35, and subsections s35A and S46A) the holder of a petroleum tenure must lodge a notice prior to activity commencement with the (now) Department of Natural Resources and Mines and Energy (DNRME, formerly Department of Natural Resources and Mines), followed by a notice of completion after activities have ended. These notices must be distributed to the landholder and land occupier. A detailed stimulation activities completion report must then be lodged no later than two months after activities have been carried out including a stimulation fluid statement and if any material environmental harm has occurred (relevant to the definitions of the EPA 1994).

Santos proposes to copy DES on the notification of stimulation operations on the same timescales as required by the above DNRME legislation. Adjustments to the locations or schedule of future stimulation activities will be managed in the context of the outcomes of this risk assessment.



LEGEND

- Historical Stimulation Locations
- Town/Locality
- Highway/Major Road
- River/Creek
- Groundwater Management Area
- Santos Tenements
- Study Area

0 KILOMETERS 100

1:2,750,000 GCS GDA 1994

NOTE(S)

REFERENCE(S)

1. BASE INFORMATION COPYRIGHT MAPINFO AUSTRALIA PTY LTD
2. ATP/PL TENURE SUPPLIED BY SANTOS, NOVEMBER 2019
3. GROUNDWATER MANAGEMENT AREA SOURCED DEPARTMENT OF NATURAL RESOURCES & WATER, QLD GOVERNMENT 2008

CLIENT
SANTOS

PROJECT
HYDRAULIC FRACTURING RISK ASSESSMENT – SANTOS SOUTHWEST QUEENSLAND TENEMENTS

TITLE
HISTORICAL HYDRAULIC FRACTURING LOCATIONS IN SW QLD

CONSULTANT
GOLDER

DD-MM-YYYY	19-03-2020
DESIGNED	KB
PREPARED	KB
REVIEWED	CB
APPROVED	CB

PROJECT NO.	CONTROL	REV.	FIGURE
127666004	011-R	2	40

3.5 Location of Landholders Active Bores

The locations of licensed water bores relative to the Santos tenement boundaries are discussed in Section 2.5.8 and are presented in Figure 40. The results of the WBBA completed (as of December 2012 (updated 2020), Section 2.5.8) identified eight active private bores and one additional bore being within potential impact zones. The vertical proximity of the target petroleum formations to aquifers utilised for private or commercial/industrial water supply is discussed in Section 2.6.

The proximity of the identified water supply bores to the proposed stimulation locations is presented in APPENDIX F and the distances are listed in Table 11 (refer to Sections 0 and 2.6.2 for the stratigraphic thickness ranges separating hydrocarbon-bearing formations from aquifers).

The active landholder bores in the oil fields in the east of the project range from approximately 3 to 10 km from the closest proposed oil well. The upper-most formation proposed for stimulation is the Wyandra Sandstone (Upper Cadna-Owie). The closest bore, Mt Margaret No 14, targets the shallower Winton formation for stock purposes. At this location the vertical separation between the Winton Formation and the Wyandra Sandstone is at least 750 m, including the low permeability mudstones of the Wallumbilla and Toolebuc Formation and the Allaru Mudstone (Section 0).

The active landholder bores within, or near, the gas fields in the west of the project range from approximately 25 to 90 km from the closest proposed stimulation location. The upper-most target proposed for stimulation are formations within the Nappamerri Group. The closest bore was the Whim Well however this well is not in operation. The Coothero Bore which targets the Hooray Sandstone for stock water is the closest operational bore. The Coothero Bore and is located more approximately 44 km from the closest proposed location for gas production, and more than 80 km from the closest location proposed for oil production from the Hooray Sandstone. The Coothero Bore is monitored by Santos as part of the UWIR monitoring program.

Table 11: Distance of Active Landholder Bores in the Study Area to the Closest Proposed Stimulation Location

Bore Name	DEHP RN	Distance	Target Aquifer
Mt Margaret No 14	9096	3 km	Winton Formation
Walla Wallan Bore 5	6373	5 km	(no data)
Mt Margaret No 20	10565	3 km	(no data)
Cherry Cherry Bore	6369	10 km	(no data)
Tarbat Job No 1947	12036	8 km	Winton Formation
Palara Bore	6057	12 km	(no data)
Grahams Bore	14955	87 km	Glendower Formation
Moon Road Field Bore	0**	81 km	-**
Coothero Bore*	23569	44 km	Hooray Sandstone

* Potentially within the impact zone as described in Section 2.5.8
** Bore not observed in database records. Referred to as “Moon Field Road Bore” in WBBA.

4.0 CONCLUSIONS

4.1 Environmental Setting

Santos operates conventional gas and oil fields across petroleum tenements within an approximately 30,000 km^2 portion of Southwest Queensland. The operations are divided into three sub-areas of interest: *Western, Central* and *Eastern Project Areas*. At the time of preparation of this report the three project areas were no longer in effect, with the project area (Figure 1) now referred to as "SWQ". The terrain in the study area is generally characterised by low undulating topography (hills and ridges) between the drainage channel systems of the Cooper Creek. The area is sparsely developed, and generally comprises rural communities and homesteads that are largely engaged in pastoralism.

It is within the stratigraphy that comprises the Eromanga Basin and the underlying Cooper Basin that oil and gas reservoirs are located which contain the proposed target formations for hydraulic fracturing. A detailed description of key geological and hydrogeological features is provided in the text, including geological models for the study area, target hydrocarbon-bearing sandstone formations (oil in the Eromanga Basin formations at depths ranging from 700 to 1,200 m below ground level (mbgl); and gas in the Cooper Basin formations at depths of 1,500 to greater than 2,000 mbgl), their hydraulic characteristics, adjacent aquifers and aquitards, structural features including faults and fracture characteristics (and their potential to behave as barriers or conduits), regional and local seismicity characteristics, aquifer environmental values and the location of groundwater users.

In terms of the environmental setting, this stimulation risk assessment (SRA) document has provided specific information which addresses the requirements anticipated of the EA conditions regarding stimulation that will apply to new areas proposed for production.

This version of the SRA updates a 2012 version (127666004-011-R-Rev0, December 2012). Updated content includes reference to the updated Environment Authority (EA) Blueprint conditions (December, 2019), updated tenements (as of January 2020), historical well stimulation events and potential future stimulation dates. Background information, such as the geological setting, hydrogeology, environmental values and stimulation process, etc has not changed in this version of the HFRA.

Specific inclusions addressing consent conditions are located within the logical flow of the description of the existing environment in the Santos SWQ petroleum field areas, with the specific information located as follows:

- a geological model of the field to be stimulated including geological names, descriptions and depths of the target producing reservoir(s) (Sections 2.4 and 0);
- naturally occurring geological faults (Sections 2.4.3.5 and 2.4.5);
- seismic history of the region (e.g. earth tremors, earthquakes) (Section 2.4.5);
- proximity of overlying and underlying aquifers (Section 2.6);
- description of the depths that aquifers with environmental value(s) occur, both above and below the target producing reservoir (Section 2.6);
- description of overlying and underlying formations in respect of porosity, permeability, hydraulic conductivity, faulting and fracture propensity (Sections 2.4.4 and 2.5.5);
- consideration of barriers or known direct connections between the target producing formation and the overlying and underlying aquifers (Section 0);
- the environmental values of groundwater in the area (Section 2.6);
- locations of landholders' active groundwater bores (Section 2.5.7); and
- groundwater transmissivity**,** flow rate, hydraulic conductivity and direction(s) of flow (Sections 2.5.3, 2.5.4 and 2.5.5);

Based on understanding of the environmental setting, this qualitative risk assessment considered the key environmental values as follows:

Groundwater environmental values:

- Town water supply;
- Stock and domestic water supply;
- Sandstone aquifers of the GAB; and
- Groundwater Dependant Ecosystems (GDEs).

Surface water environmental values:

- Protection of aquatic ecosystems;
- Recreation and aesthetics: primary recreation with direct contact, and visual appreciation with no contact; and
- Cultural and spiritual values.

Terrestrial environmental values:

- Protection of flora and fauna, particularly small mammals, reptiles and birds.

The report considered the applicable environmental values in the context of the proposed fracturing activities within the study area.

4.2 Stimulation Process Description

A detailed description of the stimulation process was provided in Section 3.0; with an emphasis on the safeguards inherent in the planning and implementation of fracturing events to ensure that the stimulation fluid and proppant are delivered (and maintained) within the target formation. The specific information required in the EA consent conditions can be found in the following sections:

- practices and procedures to ensure that the stimulation activity(ies) is designed to be contained within the target gas producing formation (Sections 3.3.4 and 3.3.7);
- provide details of where, when and how often stimulation is to be undertaken on the tenures covered by this environmental authority (Section 3.4);
- a description of the well mechanical integrity testing program (Section 3.2.2);
- process control and assessment techniques to be applied for determining extent of stimulation activity(ies) (e.g. microseismic measurements, radioactive tracers, modelling etc.) (Sections 3.3.4 and 3.3.7); and
- a process description of the stimulation activity to be applied, including equipment and a comparison to best international practice (Sections 3.2.1 and 3.3).

4.3 Summary

Based on the available geological information for the study area, the following key points are noted:

- The DEHP database and the interim results of the WBBA program indicate that groundwater supply development in the vicinity of Santos' tenements is limited to the Glendower and Winton Formations, and to a lesser extent the Hooray Sandstone. The minimum vertical offset between the Glendowner and Winton Formations and the shallowest hydrocarbon reservoirs (oil reservoirs of the Cadna-Owie Formation) is 400 to 800 m, which includes the low permeability formations of the Wallumbilla Formation and Allaru Mudstone, which form a thick, competent and regionally extensive seal between the Cadna-Owie Formation and the shallower aquifers. The vertical offset to gas reservious is much greater (1,000 m to 1,800 m).

- Within formations that host both aquifers and hydrocarbon reservoirs (e.g. Hooray Sandstone), the water-bearing zones are separated from hydrocarbon reservoirs by intra-formational seals. However, there is not enough information available to discretise the internal stratigraphy of these formations. Where petroleum activities (including fracturing) occur within a formation that hosts both aquifers and hydrocarbon reservoirs, the lateral distance of the water supply bores accessing the aquifer to Santos' tenements was considered.
- The closest beneficial use bore to the Santos tenements targeting the Hooray Sandstone in the DEHP database records is the Coothero Bore, is at least 25 km from the closest tenement proposed for stimulation and more than 80 km from the closest tenement with activities proposed at a similar.

Based on the available site setting information for the study area, the following key points are noted:

- Cooper Creek is largely influenced by surface water flows and evaporation, with negligible contribution from groundwater. Waterholes and billabongs occur throughout the Cooper Creek floodplain and channel complex, some of which coincide directly with Santos tenements.
- Three of the identified wetlands (Cooper Creek – Wilson River Junction, Bulloo Lake and Cooper Creek Swamps – Nappa Merri) are within boundaries of Santos' tenements. It should be noted that hydraulic fracturing activities may be completed within any tenement boundary over the life of the Project.
- The Cooper Creek catchment and downstream Lake Eyre are popular recreational fishing destinations. Popular fishing spots include Bulloo River at Thargomindah, Wilson River at Nockatunga and Cooper Creek flows (episodically).

Based on the provided Santos stimulation process information, the following key points are noted:

- Buffers to are assigned during establishment of well leases between petroleum operations and potential "environmentally sensitive areas" identified though database review and site-specific ecological assessment where warranted.
- The procedures employed by Santos' and its contractors follow a design philosophy predicated on the guidance, specifications and recommended practices of the American Petroleum Institute (API), considered to represent international best practice.
- The procedures employed by Santos' and its contractors for mechanical integrity and surveillance follow a design philosophy with international best practice. Practices for ensuring well mechanical integrity consist of a robust surveillance plan.
- OH&S procedures are implemented during stimulation operations to prevent workers from direct contact with chemicals during spills and when handling flowback water or sediments. Golder understands that there has not been a recordable spill since hydraulic fracturing commenced in 1987.
- Santos operational procedures monitor fracture design to stay within the target formation.
- Santos implement spill containment procedures during operations to prevent migration of and exposure to chemicals.

5.0 REFERENCES

Alexander, E.M., Reservoirs and Seals of the Eromanga Basin (undated).

API Specification 5CT/ISO 11960, Specification for Casing and Tubing.

API Specification 6A/ISO 10423, Specification for Wellhead and Christmas Tree Equipment.

API Specification 10A/ISO 10426-1, Specification for Cements and Materials for Well Cementing .

API Recommended Practice 10B-2/ISO 10426-2, Recommended Practice for Testing Well Cements.

API Recommended Practice 10B-3/ISO 10426-3, Recommended Practice on Testing of Deepwater Well Cement Formulations.

API Recommended Practice 10B-4/ISO 10426-4, Recommended Practice on Preparation and Testing of Foamed Cement Slurries at Atmospheric Pressure.

API Recommended Practice 10B-5/ISO 10426-5, Recommended Practice on Determination of Shrinkage and Expansion of Well Cement Formulations at Atmospheric Pressure.

API Recommended Practice 10B-6/ISO 10426-6, Recommended Practice on Determining the Static Gel Strength of Cement Formulations.

API Specification 10D/ISO 10427-1, Specification for Bow-Spring Casing Centralizers.

API Specification 10D-2/ISO 10427-2, Recommended Practice for Centralizer Placement and Stop Collar Testing.

API Recommended Practice 10F/ISO 10427-3, Recommended Practice for Performance Testing of Cementing Float Equipment.

API Technical Report 10TR1, Cement Sheath Evaluation.

API Technical Report 10TR2, Shrinkage and Expansion in Oil Well Cements.

API Technical Report 10TR3, Temperatures for API Cement Operating Thickening Time Tests.

API Technical Report 10TR4, Technical Report on Considerations Regarding Selection of Centralizers for Primary Cementing Operations.

API Technical Report 10TR5, Technical Report on Methods for Testing of Solid and Rigid Centralizers.

API Specification 13A /ISO 13500, Specification for Drilling Fluid Materials.

API Recommended Practice 13B-1/ISO 10414-1, Recommended Practice for Field Testing Water-Based Drilling Fluids.

API Recommended Practice 13B-2/ISO 10414-2, Recommended Practice for Field Testing Oil-based Drilling Fluids.

API Recommended Practice 45, Recommended Practice for Analysis of Oilfield Waters.

API Recommended Practice 53, Blowout Prevention Equipment Systems for Drilling Operations.

API Recommended Practice 65, Cementing Shallow Water Flow Zones in Deep Water Wells.

API Recommended Practice 65-2, Isolating Potential Flow Zones during Well Construction (provides guidance on well planning, drilling and cementing practices, and formation integrity pressure testing).

API Recommended Practice 90, Annular Casing Pressure Management for Offshore Wells.

Australian and New Zealand Environment Conservation Council (ANZECC) and Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ). 2000. Australian and New Zealand Guidelines for Fresh and Marine Water Quality for protection of aquatic ecosystems and stock watering.

BRS. 2000. Radke B.M, Ferguson J., Cresswell R.G, Ransley T.R, Habermehl M.A, Hydrochemistry and implied hydrodynamics of the Cadna-Owie-Hooray Aquifer Great Artesian Basin, Bureau of Rural Sciences, Canberra.

Bulloo Shire Council. 2012. Our Community: Sport and Recreational Facilities – Fishing. Accessed at: http://www.bulloo.qld.gov.au.

Bunn, S.E., Thoms, M.C., Stephen, K.H., Capon, S.J. 2006. Flow variability in dryland rivers: boom, bust and the bits in between. River Research and Applications, 22, 179–186.

Bureau of Meteorology (BOM). 2012. Climate Data Windorah Station 038024. Accessed at: http://www.bom.gov.au/.

Carpenter G. and Armstrong D. 2001. Biological survey – Ballera Region – Cooper Floodplain. Produced by Social & Ecological Assessment Pty Ltd. Unpublished report prepared for Santos Ltd.

Carpenter G. & Armstrong D. 2002. Field investigation of fauna listed in the Environment Protection and Biodiversity Conservation Act, 1999 – Dunefields, Undulating Downs and Dissected Residuals, Ballera South West Queensland. Social & Ecological Assessment Pty Ltd. Unpublished report prepared for Santos Ltd.

Cendon, D.I., Larsen, J.R., Jones, B.G., Nanson, G.C., Rickleman, D., Hankin, S.I., Pueyo, J.J., Maroulis, J. 2010. Freshwater recharge into a shallow saline groundwater system, Cooper Creek floodplain, Queensland, Australia. Journal of Hydrology, 392, 150-163.

Costelloe, J.F., Shields, A., Grayson, R.B., McMahon, T.A. 2007. Determining loss characteristics of arid zone river waterbodies. River Research and Applications, 23, 715–731.

Commonwealth of Australia. 2010. Ramsar Wetlands of Australia. Produced by Department of the Environment, Water, Heritage and the Arts, April 2010.

Department of Environment and Heritage Protection (DEHP). 2010. Regional Ecosystems, updated April 2010. Accessed at: http://www.ehp.qld.gov.au/ecosystems/

Department of Environment and Resource Management (DERM). 2005 GAB Hydrogeological Framework for the GAB WRP Area, QLD Department of Environment and Resource Management.

DERM. 2007. Great Artesian Basin Resource Operations Plan (GAB ROP), Queensland.

DERM. 2010. The Cooper Creek Basin Wild River Area Summary: Natural Values Assessment, QLD Department of Environment and Resource Management.

Draper, J.J. (Editor). 2002. Geology of the Cooper and Eromanga Basins, Queensland. Queensland Mineral and Energy Review Series, Queensland Department of Natural Resources and Mines.

Economides, M.J. and Martin, T. 2007. Modern Fracturing, Enhancing Natural Gas Production. Energy Tribune Publishing Inc.

Enever, J. R. & Lee, M. F. 2000. On the Prediction of Rock Stress. Proceedings of GeoEng2000, Melbourne, Technomic Publishing.

EnHealth. 2012. Environmental Health Risk Assessment. Guidelines for Assessing Human Health Risks from Environmental Hazards. June 2012. www.health.gov.au

Environment Australia. 2001. A Directory of Important Wetlands in Australia, Third Edition. Environment Australia, Canberra.

Fensham, RJ and Fairfax, RJ. 2003. Spring wetlands of the Great Artesian Basin, Queensland, Australia, *Wetland Ecology and Management,* vol. 11, pp. 343–362.

Fensham and Fairfax., 2005. The Great Artesian Basin Water Resource Plan: Ecological Assessment of GABsprings in Queensland.

Geosciences Australia. 2012. Surface Geology of Australia (1:1M scale dataset) A3 map.

Gibson, E., Strudwick, D and P. Walker. 1997. Draft National Framework for Ecological Risk Assessment of Contaminated Sites, Victorian Environment Protection Authority (VIC EPA),

Golder. 2012a. Underground Water Impact Report for Santos Cooper Basin Oil and Gas Fields (ref. no. 117636010-3000-001-Rev1, dated 20 December 2011).

Golder. 2012b. Regional Water Bore Baseline Assessment Report (Priority 1 & 2 Bores) (ref. no. 117666006-019-R-Rev0, dated 29 May 2012)

Golder. 2012c. Santos Cooper Basin Oil and Gas Fields, Southwest Queensland – Interim Groundwater Monitoring Plan (ref. no. 127666003-002-R-Rev2, dated 30 July 2012).

Golder. 2020. Underground Water Impact Report for Santos Cooper Basin Oil and Gas Fields, South-West Queensland (ref. no. 19126485 (document number: 0007-650-REP-0025), dated February 2020).Government of South Australia, Primary Industries and Resources, SA. 2009. Petroleum and Geothermal in South Australia – Cooper Basin.

Gravestock DI, Benbow MC, Gatehouse CG and Krieg GW. 1995. Eastern Officer Basin. In JF Drexel and WV Preiss eds, The geology of South Australia, Volume 2, The Phanerozoic, Bulletin 54. Geological Survey of South Australia, pp. 35–41.

Habermehl, M.A. 1986. Regional groundwater movement, hydrochemistry and hydrocarbon migration in the Eromanga Basin. *In:* Gravestock, D.I., Moore, P.S. and Pitt, G.M. (Eds), Contributions to the geology and hydrocarbon potential of the Eromanga Basin. Geological Society of Australia. Special Publication, 12:353-376.

Habermehl MA and Lau JE. 1997. Hydrogeology of the Great Artesian Basin (Map at scale 1:2500000), Australian Geological Survey Organisation, Canberra.

Hamilton, S.K., Bunn, S.E., Thoms, M.C., Marshall, J.C. 2005. Persistence of aquatic refugia between flow pulses in a dryland river system (Cooper Creek, Australia). Limnology and Oceanography, 50, 743–754.

Hillis, R. R., Meyer, J. J., and Reynolds, S.D. 1998. The Australian Stress Map. *Journal of the Geological Society of London,* 157, p 915-921.Accessed at: http://www.asprg.adelaide.edu.au/asm/

Hillis, R. R. and Reynolds, S. D. 2003. In-Situ Stress Field of Australia. *Geological Society of Australia Special Publication 22*, p 43-52.

Hillis, R. R., Enever, J. R. & Reynolds, S. D. 1999. In situ Stress Field of Eastern Australia. Australian Journal of Earth Sciences,46, pp. 813-825.

Kotwicki, V., Allan, R. 1998. La Niña de Australia-Contemporary and palaeohydrology of Lake Eyre. Palaeogeography, Palaeoclimatology, Palaeoecology, 144, 265–280.

NEPC. 2013. National Environment Protection (Assessment of Site Contamination) Measure.1999 (updated 2013). National Environment Protection Council.

Nanson, G.C., Price, D.M., Jones, B.G., Maroulis, J.C., Coleman, M., Bowman, H., Cohen, T.J., Pietsch, T.J., Larsen, J.R. 2008. Alluvial evidence for major climate and flow regime changes during the middle and late Quaternary in eastern central Australia. Geomorphology, 101, 109–129.

PIRSA, Cooper Basin. 1998. The petroleum geology of South Australia, Volume 4, Cooper Basin (Gravestock).

PIRSA, Eromanga Basin. 2006. The petroleum geology of South Australia, Eromanga Basin, Volume 2, PIRSA.

Reynolds, S.D., Mildren, S.D., Hillis, R.R., and Meyer, J.J. 2004. The in situ stress field of the Cooper Basin and its implications for hot dry rock geothermal energy development: PESA Eastern Australian Basins Symposium II, p. 431-440.Reynolds, S., Mildre, S., Hillis, R., Meyer, J., Flottman, T. (2006). Cooper Basin Stress Map. Australian School of Petroleum, Accessed at: http://www.asprg.adelaide.edu.au/asm/

SA DPI. 1998. Cooper-Eromanga Basin – Exploration opportunities Blocks CO98A-K. Primary Industries and Resources SA, Report book 98/00029.

Santos. 2004. Cooper Basin, Review of Regional Petroleum Potential. Santos 2009. PE Operations Standard procedures (PEOSP's): Section 9 Procedures for Well Integrity, Procedure 9.1 Well Integrity Schedule and Reporting. Santos Approved Procedure, Rev 1, November 2009.

Santos. 2009. Drilling operations manual – Onshore Australia and CSG Drilling. April 2009 Rev 4.0. Santos Limited, April 2009.

Santos. 2011a. Extract from DEEDI Presentation, Power Point Presentation, 28 July 2010.

Santos 2011b. Environmental Management Plan for the South West Queensland Eastern Project Area, 2011.

Santos. 2011c. Environmental Management Plan for the South West Queensland Central Project Area, 2011.

Santos. 2011d. Environmental Management Plan for the South West Queensland Western Project Area, 2011.

Santos. 2014. Santos Environmental Management Plan for South West Queensland. March 2014.

SKM. 2001. (Sinclair Knight Merz Pty Ltd). Environmental Water Requirements of Groundwater Dependent Ecosystems, Environmental Flows Initiative Technical Report Number 2, Commonwealth of Australia, Canberra State of Queensland, 2009. Environmental Protection (Water) Policy 2009.

Torgersen, T., M.A. Habermehl, F.M. Phillips, David Elmore, Peter Kubik, B. Geoffrey Jones, T. Hemmick, and H.E. Gove. 1991. Chlorine 36 dating of very old groundwater 3. Further Studies in the Great Artesian Basin, Australia. Water Resources Research, vol. 27, no. 12, 3201-3213.UNECE (2009) Globally Harmonised System (GHS) of Classification and Labelling of Chemicals. Revision 3. Part 4 Environmental Hazards and Annex 9 Guidance on hazards to the aquatic environment.

URS. 2010. Water Flooding Impact Assessment: Further Information to Support Assessment of Potential Impacts of Water Flooding in PL295USEPA, 2004. Characteristics of Coalbed Methane Production and Associated Hydraulic Fracturing Practices (Chapter 3). *In:* Evaluation of Impacts to Underground Sources June 2004 of Drinking Water by Hydraulic Fracturing of Coalbed Methane Reservoirs. June 2004.

Welsh WD. 2000. GABFLOW: A steady state groundwater flow model of the Great Artesian Basin, Bureau of Rural Sciences, Canberra.

Signature Page

Golder Associates Pty Ltd

APPENDIX A

Limitations

The document ("Report") to which this page is attached and which this page forms a part of, has been issued by Golder Associates Pty Ltd ("Golder") subject to the important limitations and other qualifications set out below.

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Golder accepts no responsibility for and makes no representation as to the accuracy or completeness of the information provided to it by or on behalf of the Client or sourced from any third party. Golder has assumed that such information is correct unless otherwise stated and no responsibility is accepted by Golder for incomplete or inaccurate data supplied by its Client or any other person for whom Golder is not responsible. Golder has not taken account of matters that may have existed when the Report was prepared but which were only later disclosed to Golder.

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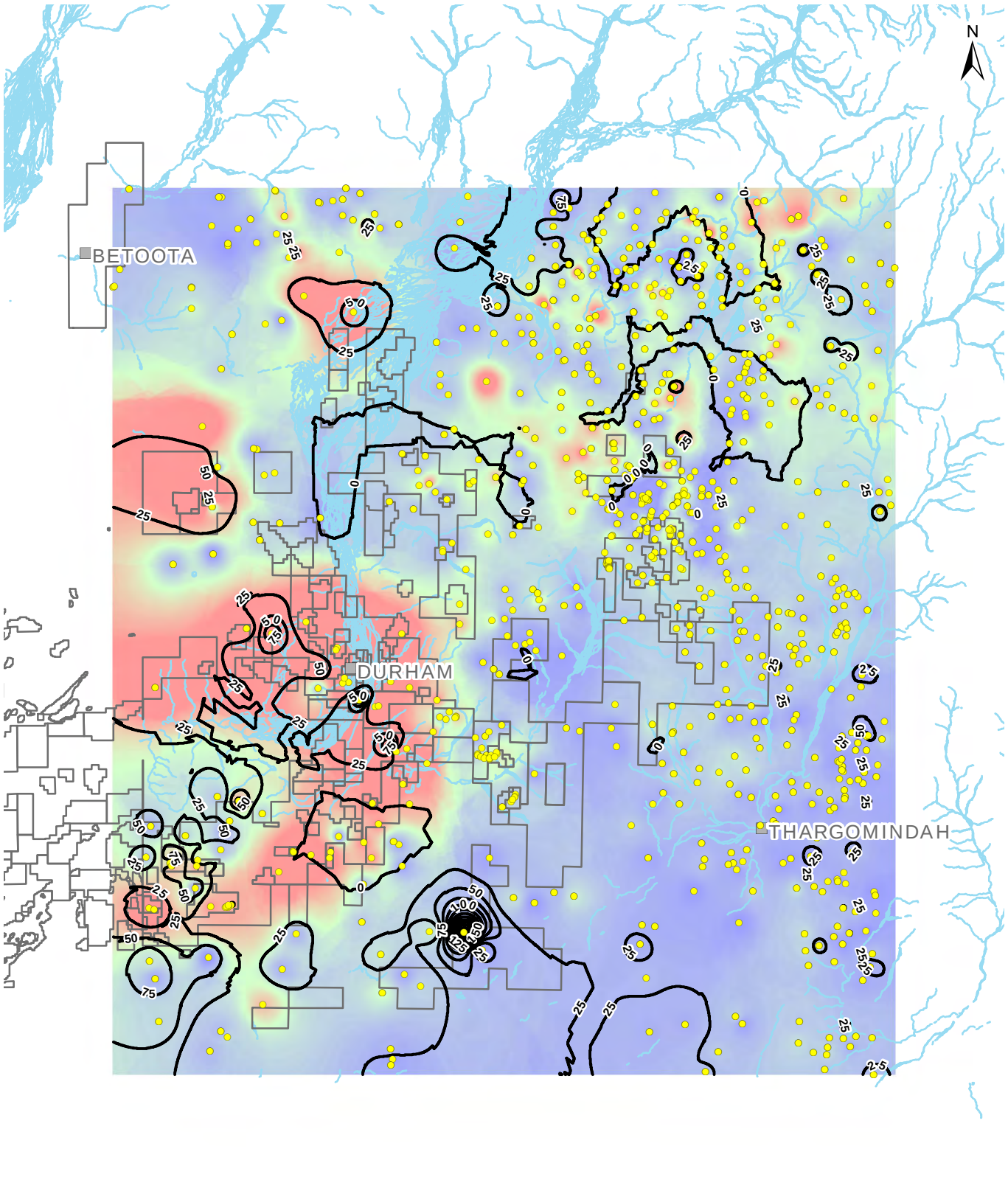
Any uncertainty as to the extent to which this Report can be used or relied upon in any respect should be referred to Golder for clarification

APPENDIX B

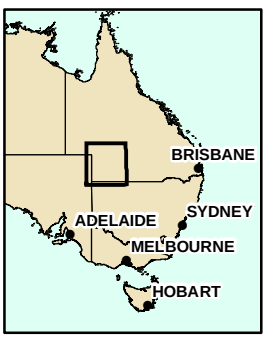
Geological Contour Plans



SWQ HYDRAULIC FRACTURING RISK ASSESSMENT

SANTOS

GEOLOGICAL CONTOUR MAP: WINTON FORMATION



LEGEND

- Geology Data Point
- Town/Locality
- Depth to Winton Formation (m)
- River/Creek
- Santos Operated Permits

Thickness of Winton Formation (m)

High : 970

Low : 1

0 5 10 20 30 40 50 Kilometres

SCALE (at A3) 1:2,500,000

Coordinate System: GCS GDA 1994

PROJECT: **127666004**
DATE: **27/09/2012**
DRAWN: **FA**
CHECKED: **RS**

APPENDIX C1

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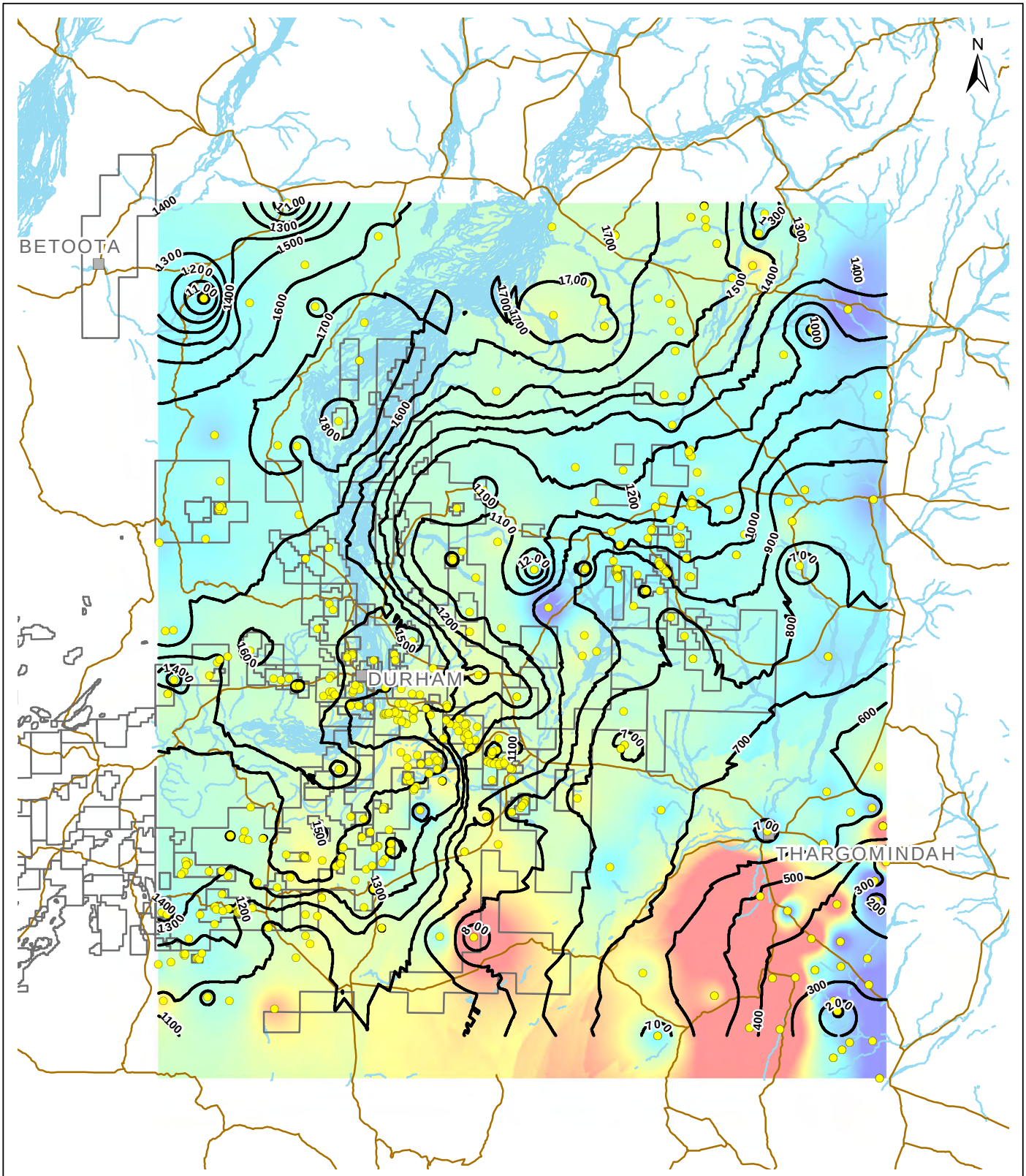
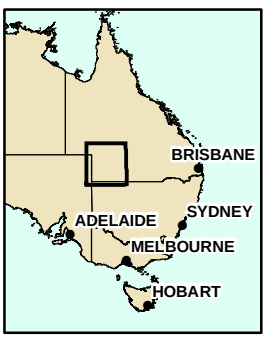


SWQ HYDRAULIC FRACTURING RISK ASSESSMENT

SANTOS

GEOLOGICAL CONTOUR MAP: HOORAY FORMATION



LEGEND

- Geology Data Point
- Town/Locality
- Depth to Hooray Sandstone (m)
- Highway / Major Road
- River/Creek
- Santos Operated Permits

Thickness of Hooray Sandstone (m)

High : 595

Low : 1.8

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APPENDIX C2

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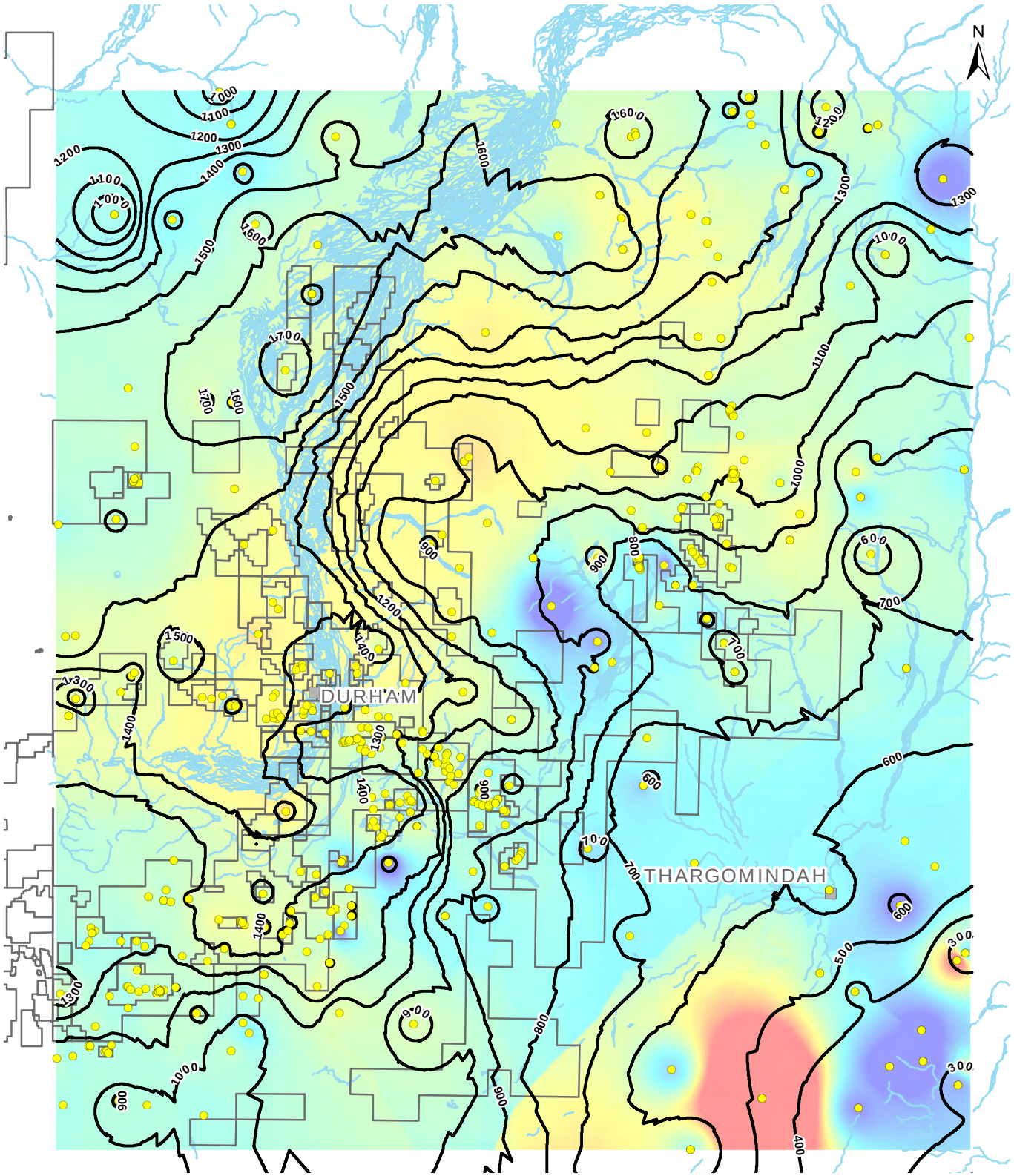
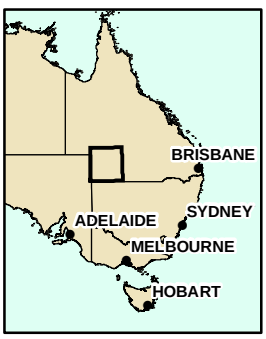


SWQ HYDRAULIC FRACTURING RISK ASSESSMENT

SANTOS

GEOLOGICAL CONTOUR MAP: CADNA OWIE FORMATION



LEGEND

- Geology Data Point
- Town/Locality
- Depth to Cadna Owie (m)
- River/Creek
- Santos Operated Permits

Thickness of Cadna Owie Formation (m)

High : 390

Low : 18

0 5 10 20 30 40 50 Kilometres

SCALE (at A3) 1:2,000,000

Coordinate System: GCS GDA 1994

PROJECT: 127666004
DATE: 27/09/2012
DRAWN: FA
CHECKED: RS

APPENDIX C3

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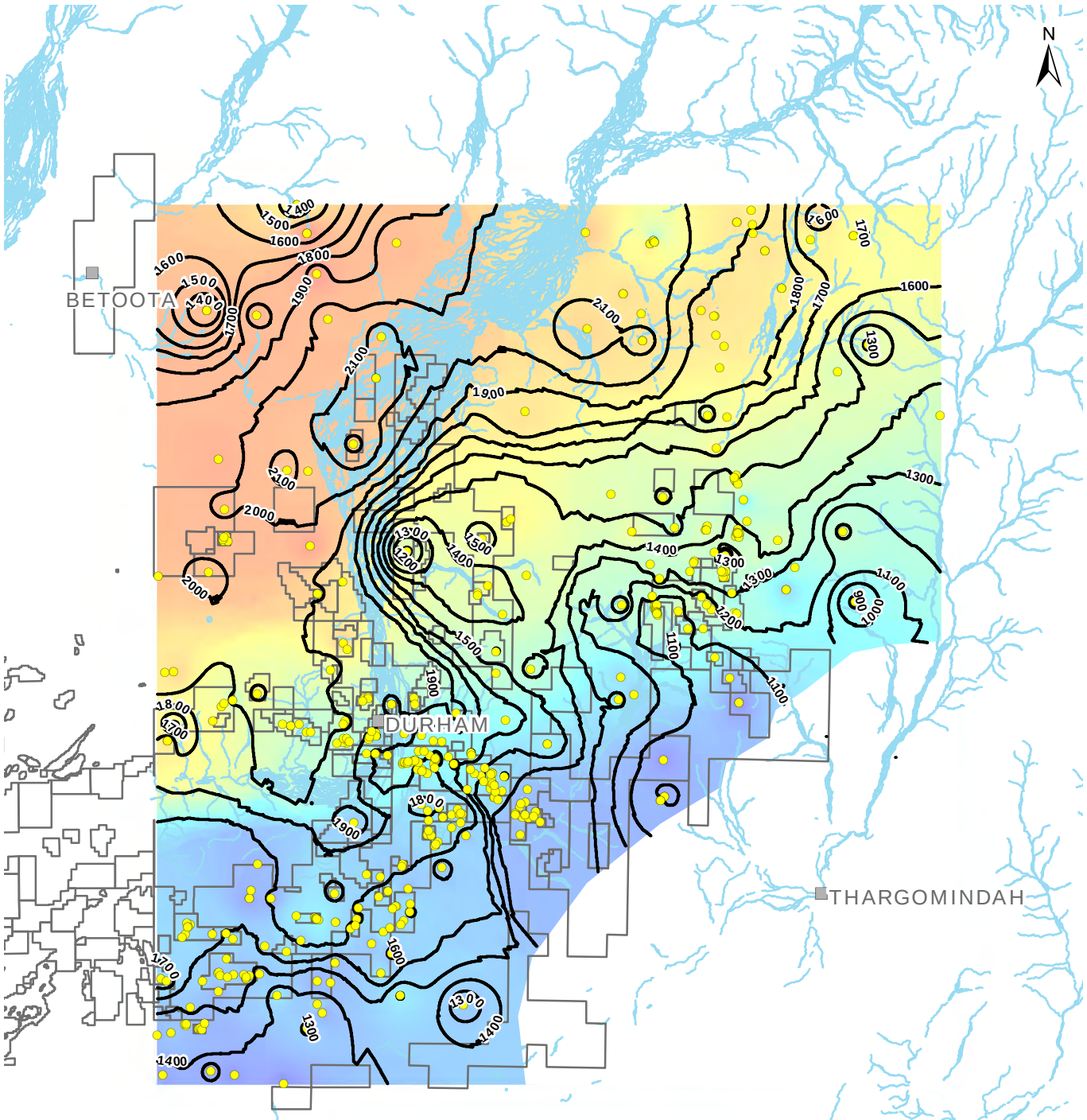
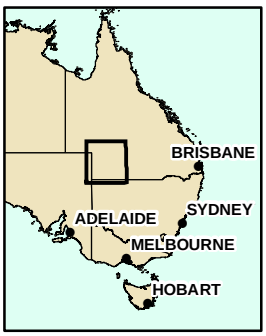


SWQ HYDRAULIC FRACTURING RISK ASSESSMENT

SANTOS

GEOLOGICAL CONTOUR MAP: HUTTON SANDSTONE

1. Base information copyright MapInfo Australia Pty Ltd
2. ATP/PL tenure supplied by Santos, August 2011
3. Golder Associates 2012a Cooper Basin UWIR Report



LEGEND

- Geology Data Point
- Town/Locality
- Depth to Hutton Sandstone (m)
- River/Creek
- Santos Operated Permits

Thickness of Hutton Sandstone (m)

High : 241

Low : 2.

0 5 10 20 30 40 50 Kilometres

SCALE (at A3) 1:2,500,000

Coordinate System: GCS GDA 1994

PROJECT: 127666004
DATE: 27/09/2012
DRAWN: FA
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APPENDIX C4

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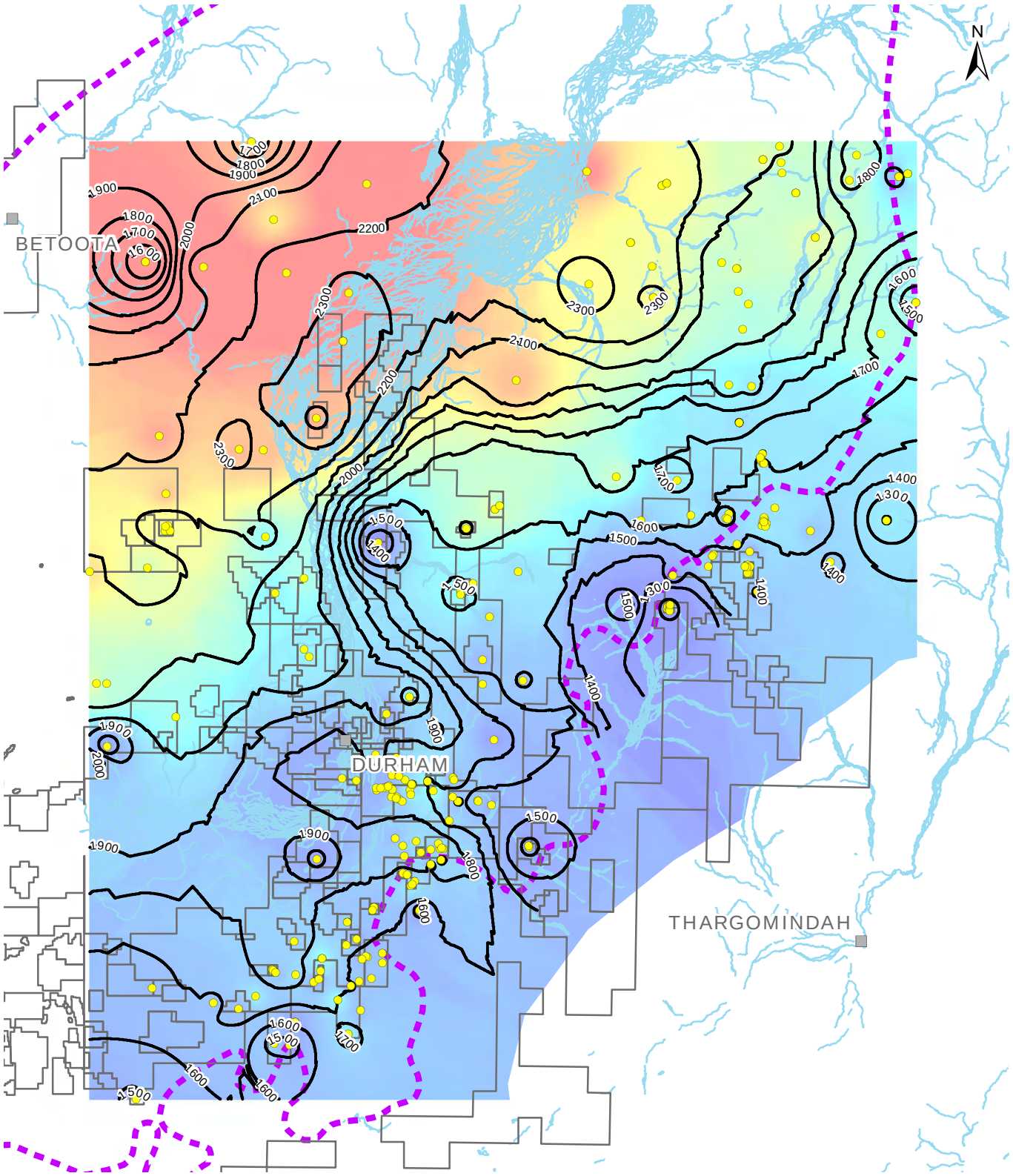

SWQ HYDRAULIC FRACTURING RISK ASSESSMENT

SANTOS

GEOLOGICAL CONTOUR MAP: POOLOWANNA FORMATION

LEGEND

- Geological Data Point
- Town/Locality
- Depth to Poolowanna Formation (m)
- River/Creek
- Santos Operated Permits
- Cooper Basin

Thickness of Poolowanna Formation (m)

170

3

0 5 10 20 30 40 50 Kilometres

SCALE (at A3) 1:2,000,000

Coordinate System: GCS GDA 1994

PROJECT: **127666004**
DATE: **27/09/2012**
DRAWN: **FA**
CHECKED: **RS**

APPENDIX C5

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GOLDER

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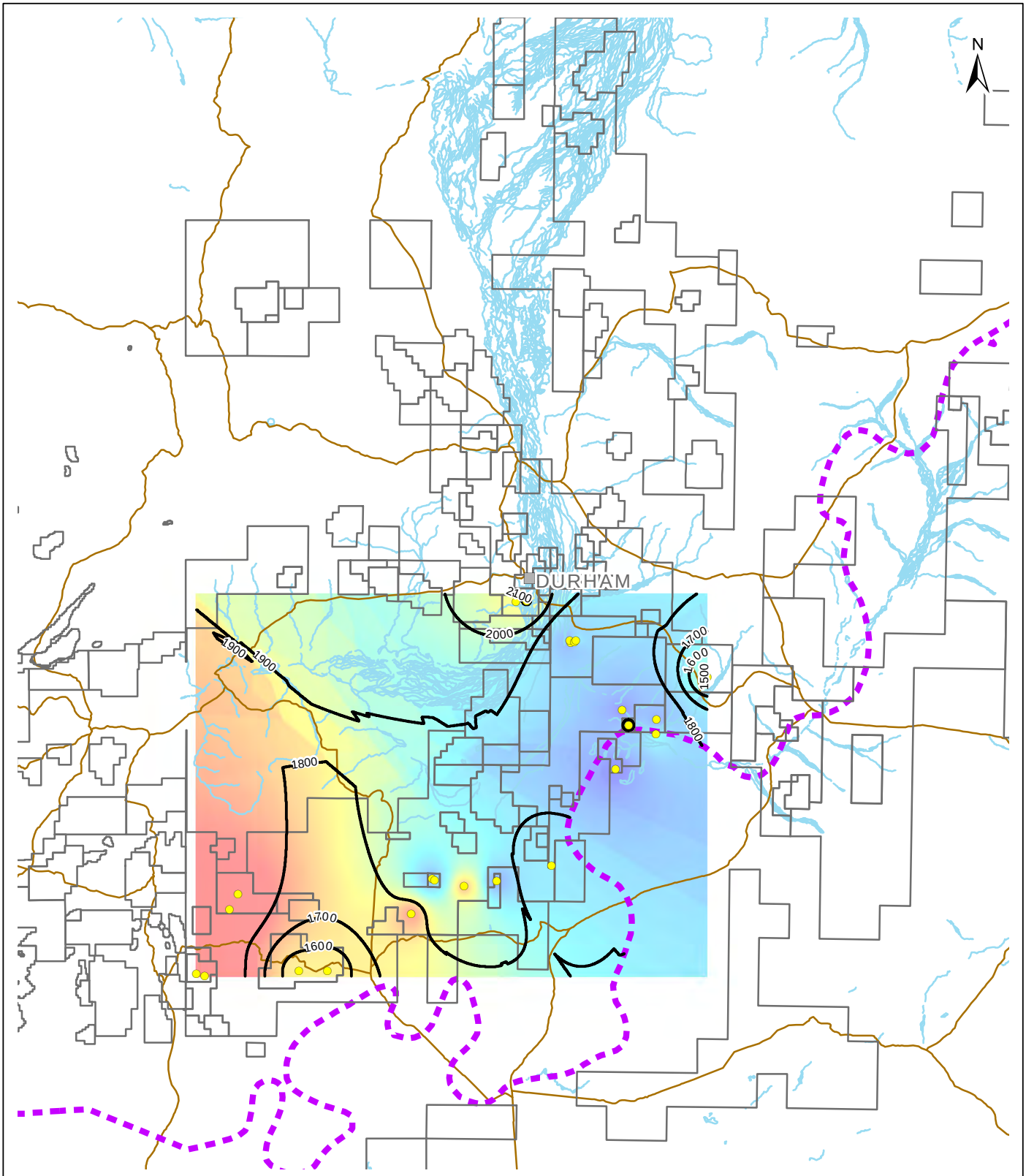

SWQ HYDRAULIC FRACTURING RISK ASSESSMENT

SANTOS

GEOLOGICAL CONTOUR MAP: TOOLACHEE FORMATION

LEGEND

- Geology Data Point
- Town/Locality
- Depth to Toolachee Formation (m)
- Highway / Major Road
- River/Creek
- Santos Operated Permits
- Cooper Basin

Thickness of Toolachee Formation (m)

160

7

0 5 10 20 30 40 50 Kilometres

SCALE (at A3) 1:1,500,000

Coordinate System: GCS GDA 1994

PROJECT: **127666004**
DATE: **27/09/2012**
DRAWN: **FA**
CHECKED: **RS**

APPENDIX C6

DRAFT

GOLDER

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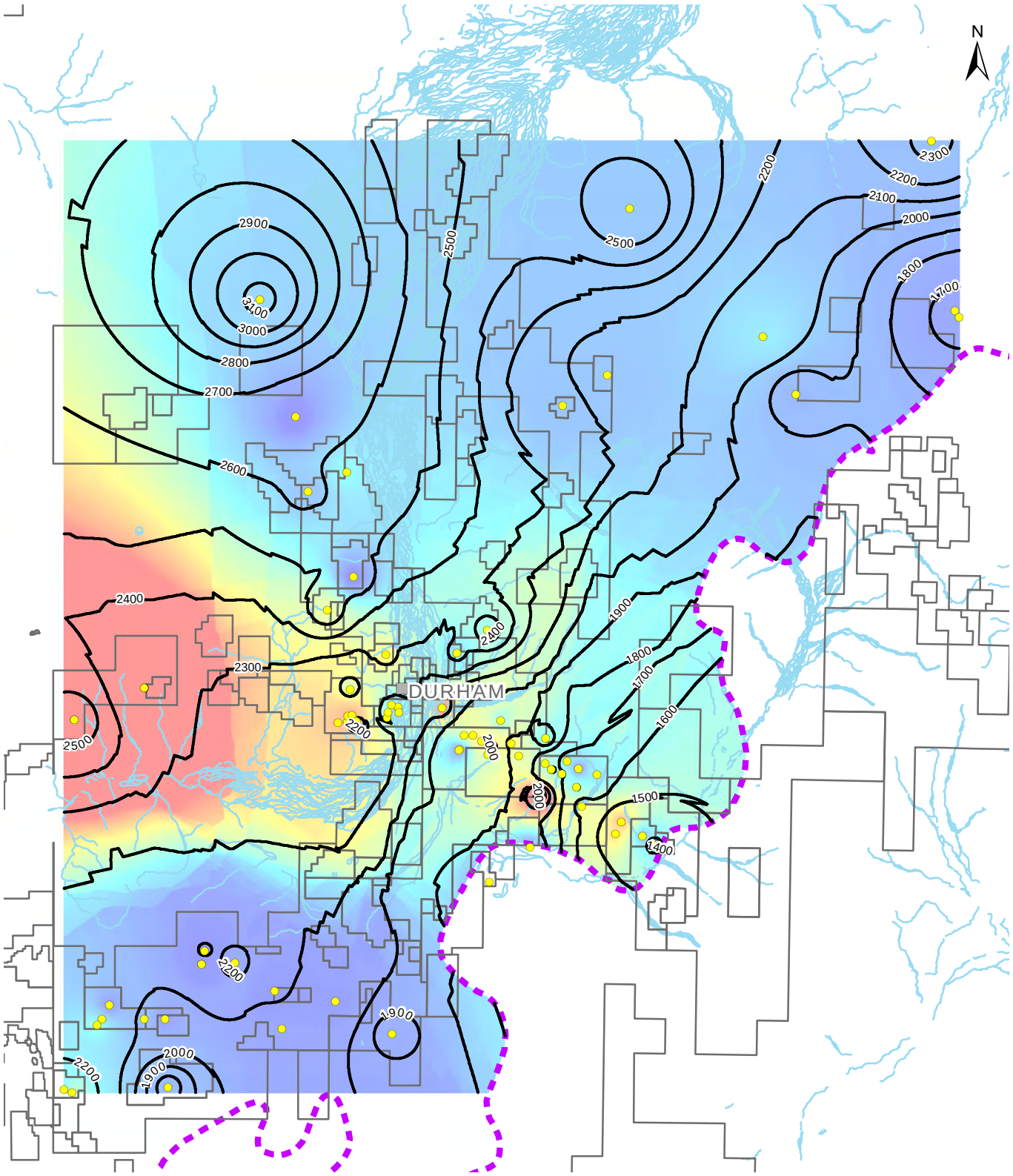


SWQ HYDRAULIC FRACTURING ASSESSMENT

SANTOS

GEOLOGICAL CONTOUR MAP: PATCHAWARRA FORMATION

LEGEND

- Geology Data Point
- Town/Locality
- Depth to Patchawarra Formation (m)
- River/Creek
- Santos Operated Permits
- Cooper Basin

Thickness of Patchawarra Formation (m)

745

Low : 7.5

0 5 10 20 30 40 50 Kilometres

SCALE (at A3) 1:1,500,000

Coordinate System: GCS GDA 1994

PROJECT: **127666004**
DATE: **27/09/2012**
DRAWN: **FA**
CHECKED: **RS**

APPENDIX C7

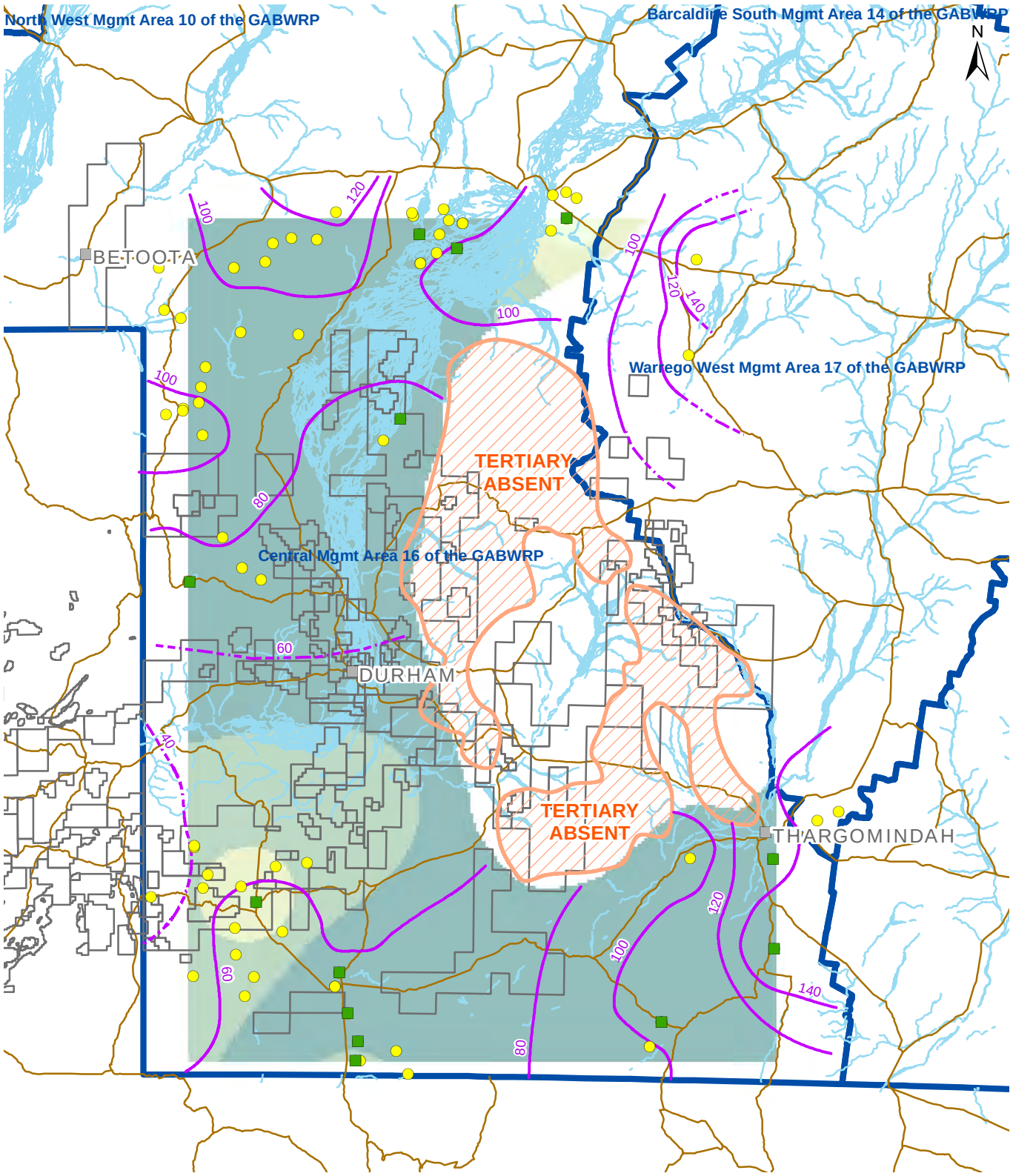
DRAFT

GOLDER

File Location: J:\hyd\2012\127666004_SWQLD_HFRA_Adelaide\Technical Doc\GIS\Project\127666004_R_F0046_SWQHFRA_GeologicalMap_PatchawarraFormation.mxd

APPENDIX C

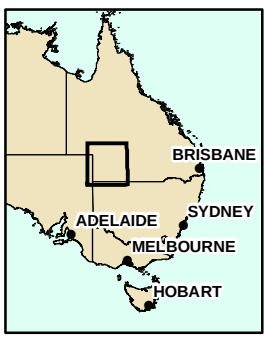
Hydrogeological Contour Plans



SWQ HYDRAULIC FRACTURING RISK ASSESSMENT

SANTOS

HYDROGEOLOGICAL MAP: TERTIARY FORMATION



LEGEND

- Town/Locality
- Water Level and Electrical Conductivity Data Point
- Water Level Data Point
- Piezometric Isoline (mAHD) 20 m Interval
- Inferred Piezometric Isoline (mAHD) 20 m Interval
- Highway / Major Road
- River/Creek
- Santos Operated Permits
- Groundwater Management Area

Electrical Conductivity (µS/cm)

- 0 - 3000
- 3,000 - 4,500
- 4,500 - 6,000
- 6,000 - 7,500
- 7,500 - 9000

0 5 10 20 30 40 50 Kilometres

SCALE (at A3) **1:2,500,000**

Coordinate System: GCS GDA 1994

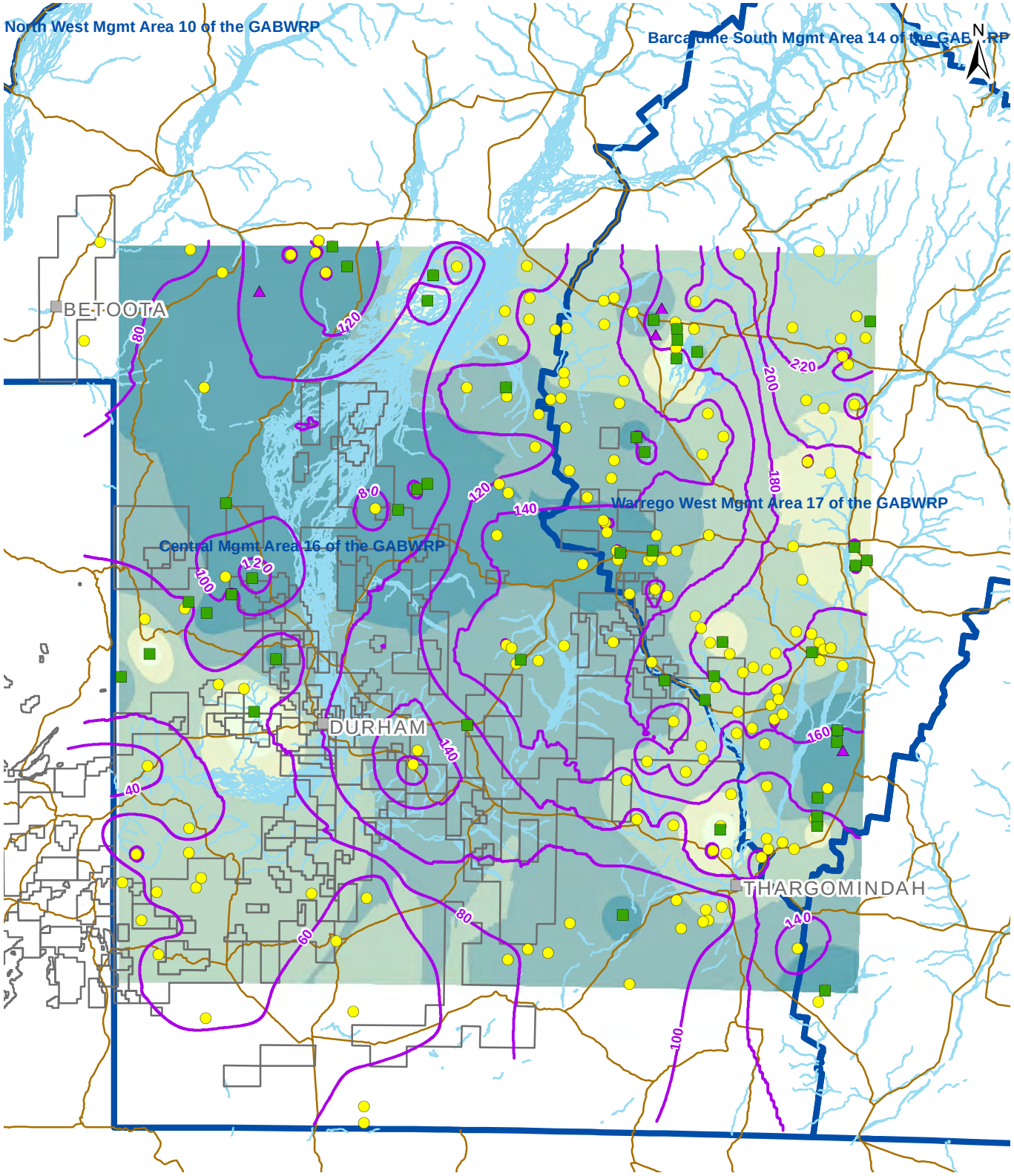
PROJECT: **127666004**
DATE: **27/09/2012**
DRAWN: **FA**
CHECKED: **RS**

APPENDIX D1

DRAFT

GOLDER

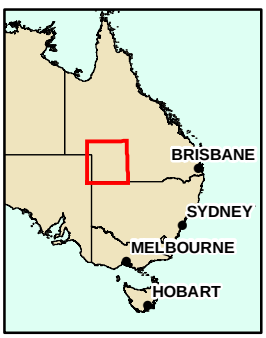
File Location: J:\hyd\2012\127666004_SWQLD_HFRA_Adelaide\Technical Doc\GIS\Project\127666004_R_F0050_SWQHFRA_HydrogeologicalMap_Tertiary.mxd



SWQ HYDRAULIC FRACTURING RISK ASSESSMENT

SANTOS

HYDROGEOLOGICAL MAP: WINTON FORMATION



LEGEND

- Town/Locality
- Water Level and Electrical Conductivity Data Point
- Electrical Conductivity Data Point
- Water Level Data Point
- Inferred Piezometric Isoline (m AHD) 20 m interval
- River/Creek
- Highway / Major Road
- Santos Operated Permits
- Groundwater Management Area

Electrical Conductivity (µS/cm)

- 0 - 3,000
- 3,000 - 4,500
- 4,500 - 6,000
- 6,000 - 7,500
- 7,500 - 15000

0 5 10 20 30 40 50 Kilometres

SCALE (at A3) 1:2,500,000

Coordinate System: GCS GDA 1994

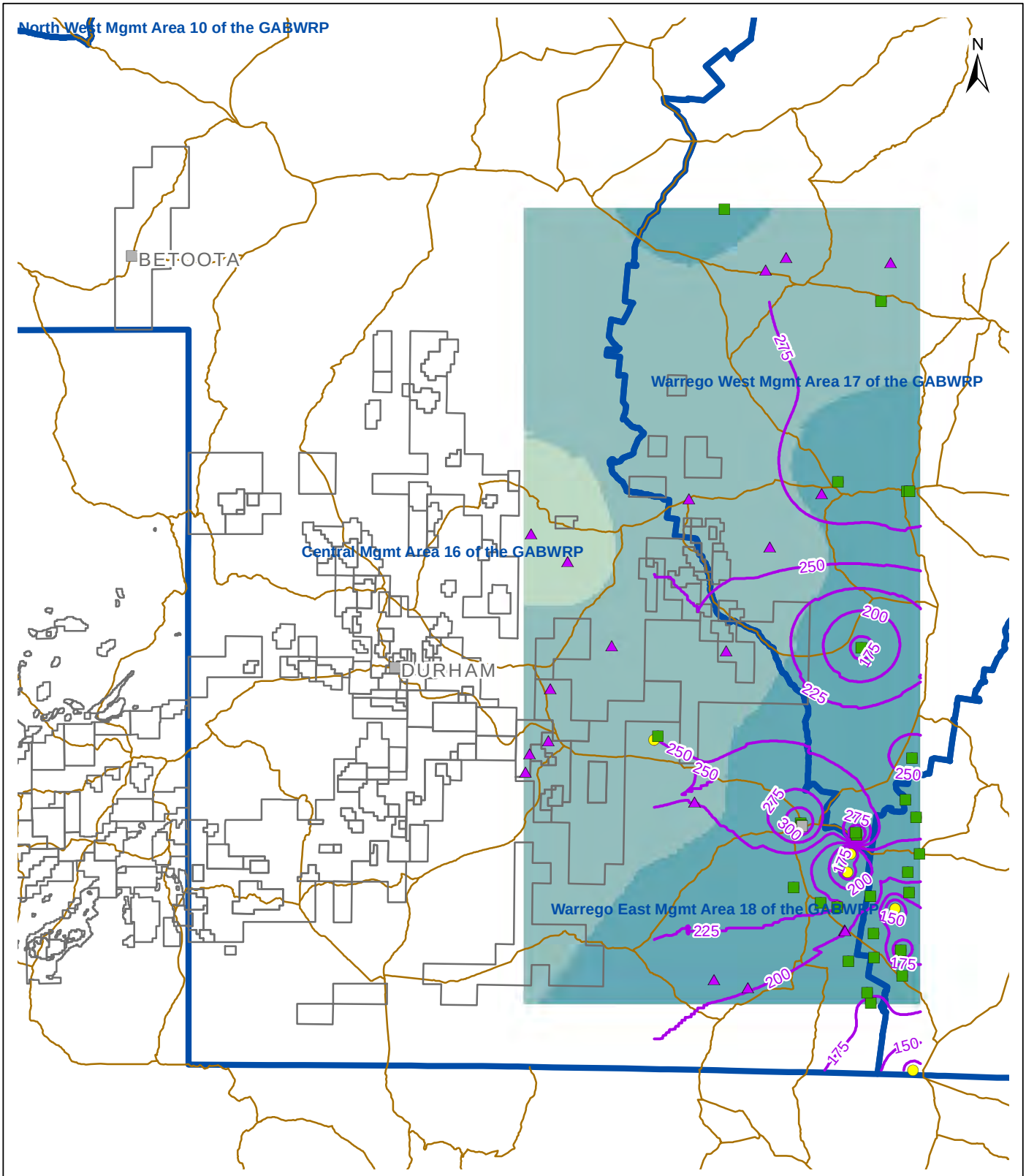
PROJECT: **127666004**
DATE: **27/09/2012**
DRAWN: **FA**
CHECKED: **RS**

APPENDIX D2

DRAFT

GOLDER

File Location: J:\hyd\2012\127666004_SWQLD_HFRA_Adelaide\Technical Doc\GIS\Project\127666004_R_F0051_SWQHFRA_HydrogeologicalMap_Winton.mxd



SWQ HYDRAULIC FRACTURING RISK ASSESSMENT

SANTOS

HYDROGEOLOGICAL MAP: HOORAY SANDSTONE

LEGEND

- Town/Locality
- Water Level and Electrical Conductivity Data Point
- Electrical Conductivity Data Point
- Water Level Data Point
- Inferred Piezometric Isoline (metres AHD - Interval 25 metres)
- Highway / Major Road
- Santos Operated Permits
- Groundwater Management Area

Electrical Conductivity (µS/cm)

- 0 - 1,500
- 1,500 - 3,000
- 3,000 - 4,500

0 5 10 20 30 40 50 Kilometres

SCALE (at A3) 1:2,500,000

Coordinate System: GCS GDA 1994

PROJECT: **127666004**
DATE: **27/09/2012**
DRAWN: **FA**
CHECKED: **RS**

APPENDIX D3

DRAFT

GOLDER

File Location: J:\hyd\2012\127666004_SWQLD_HFRA_Adelaide\Technical Doc\GIS\Project\127666004_R_F0052_SWQHFRA_HydrogeologicalMap_Hooray.mxd

APPENDIX D

Santos Hydraulic Stimulation - Schematic Well Lease Setup

Figure D1: Conventional Oil Well Lease Set-up (Batch Mixing)

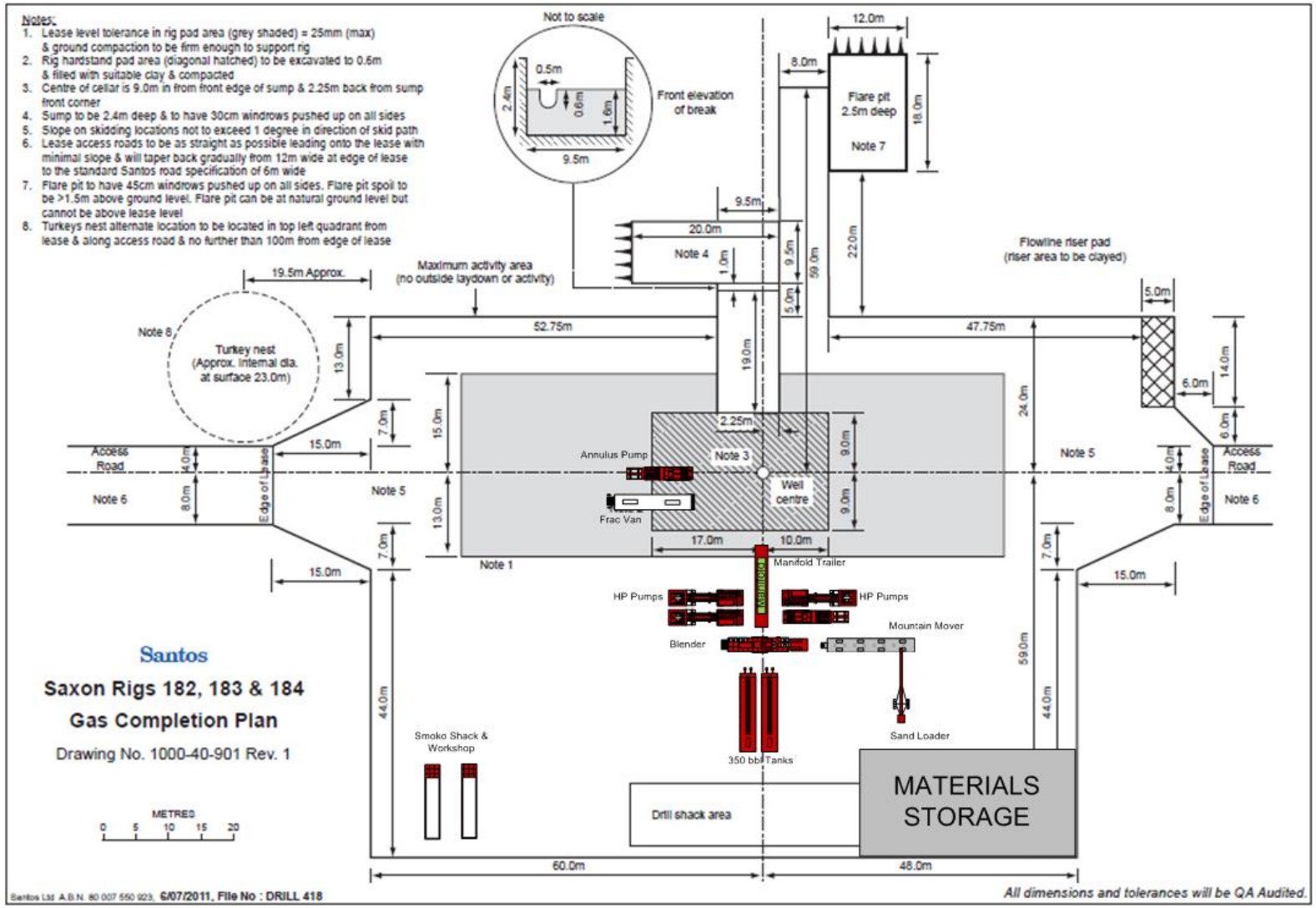


Figure D2: Conventional Gas Well Lease Set Up

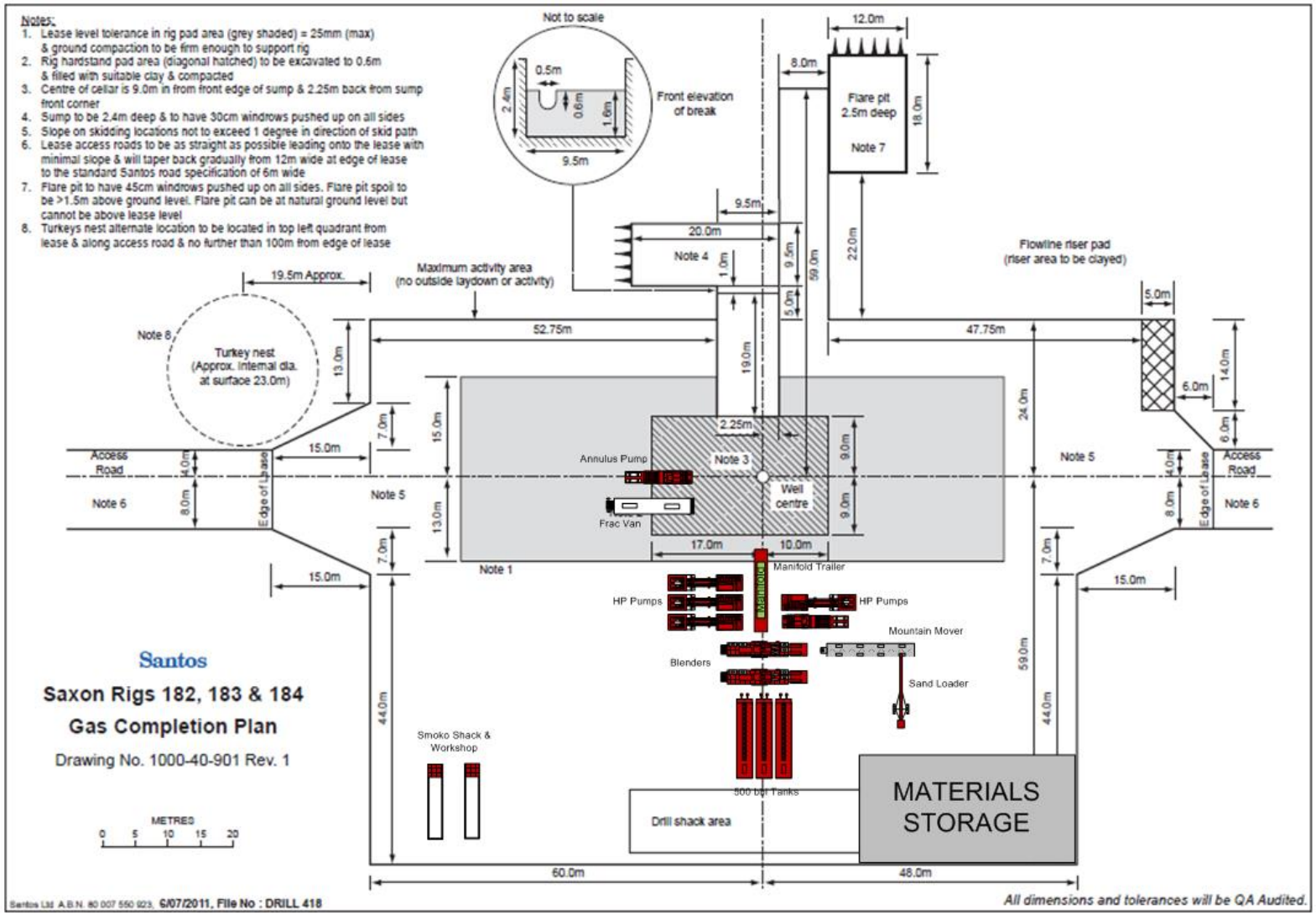
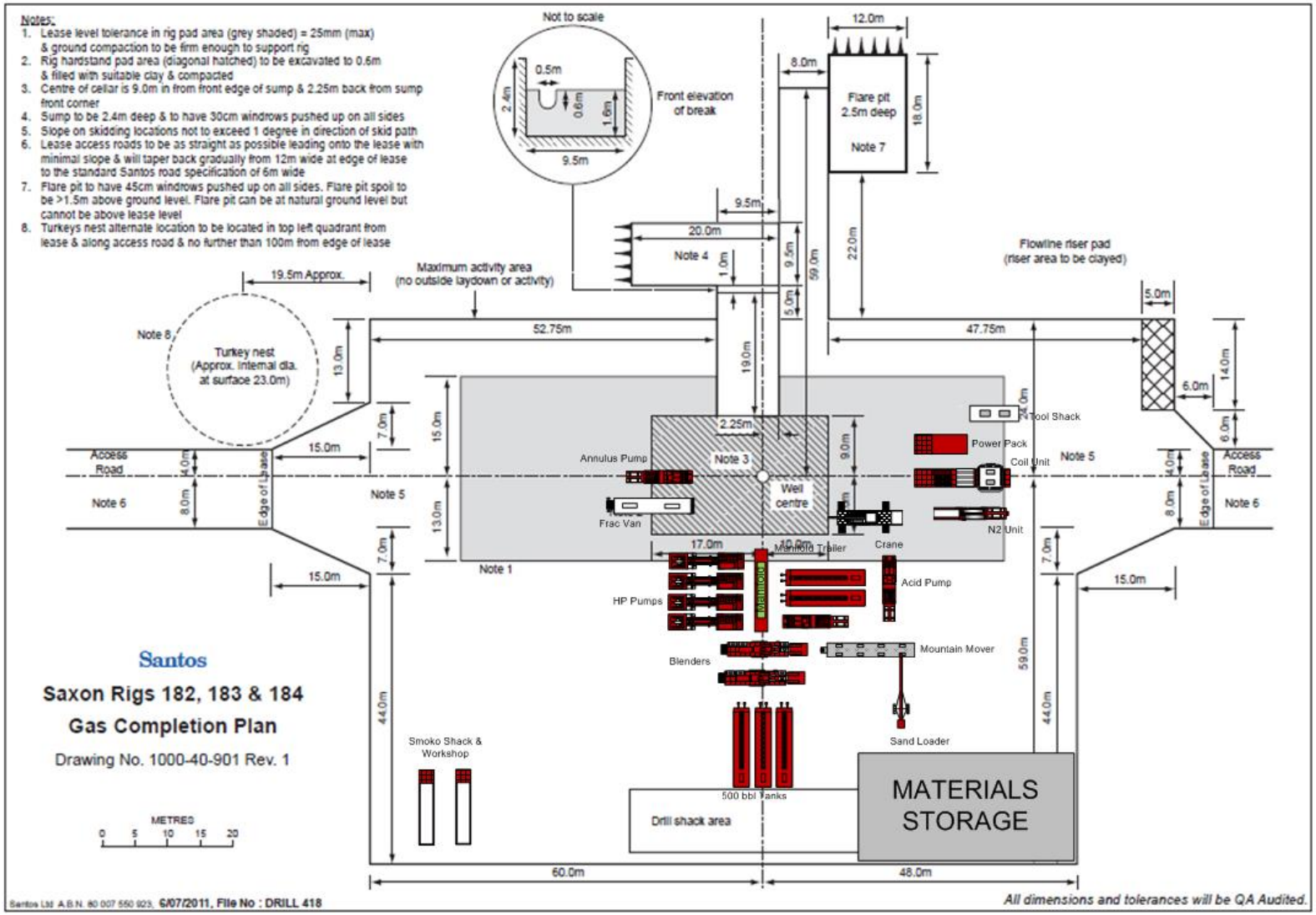


Figure D3: Deep Gas Well Lease Set Up (Coil Tubing Assisted Stimulation)



APPENDIX E

Historical Well Hydraulic Stimulations in SWQ

Appendix E - Historical Well Hydraulic Fracturing Events in SW Queensland

Name	Latitude	Longitude	Date Fractured
Challum 1	-27.393	141.574	Sep-1987
Brumby 2	-28.381	140.959	Jun-1989
Wilson 4	-27.566	142.426	Jul-1989
Brumby 1	-28.409	140.991	Aug-1991
Epsilon 2	-28.142	141.133	Dec-1991
Epsilon 1	-28.145	141.154	Apr-1992
Thungo 2	-27.735	142.577	Jan-1993
Patroclus 1	-28.111	141.681	Dec-1994
Stokes 1	-28.345	141.029	Mar-1997
Yanda 8	-27.452	141.821	Jun-1997
Challum 3	-27.388	141.537	Oct-1998
Coolah 2	-26.956	141.835	Nov-1998
Challum 13	-27.373	141.571	May-1999
Wolgolla 2	-28.193	141.334	May-2002
Dartmoor 1	-27.687	142.540	Sep-2002
Thungo 7	-27.722	142.582	Sep-2002
Juno 5	-27.697	141.829	Oct-2002
Thungo 7	-27.722	142.582	Oct-2002
Juno 5	-27.697	141.829	Oct-2002
Juno 2	-27.688	141.829	Oct-2002
Juno 5	-27.697	141.829	Oct-2002
Coonaberry 1	-26.851	142.104	Oct-2002
Ramses 1	-26.764	142.102	Nov-2002
Moon 1	-28.227	141.042	Nov-2002
Ipundu North 2	-26.911	143.307	Jan-2004
Talgeberry 2	-26.948	143.430	Jan-2004
Talgeberry 8	-26.952	143.432	Jan-2004
Challum 24	-27.381	141.598	Jan-2004
Challum 22	-27.408	141.650	Jan-2004
Karmona 3	-27.304	141.883	Jan-2004
Ipundu North 11	-26.917	143.310	Jan-2004
Ipundu North 11	-26.917	143.310	Jan-2004

Name	Latitude	Longitude	Date Fractured
Thungo 8	-27.719	142.585	Jan-2004
Ipundu North 2	-26.911	143.307	Feb-2004
Mulberry 1	-26.892	143.402	Feb-2004
Roti West 1	-27.367	142.143	Mar-2004
Gimboola West 1	-26.872	143.403	Oct-2004
Winninia 1	-27.856	141.836	Nov-2004
Winninia North 2	-27.828	141.894	Nov-2004
Baryulah 6	-27.753	141.869	Dec-2004
Baryulah 6	-27.753	141.869	Dec-2004
Baryulah 6	-27.753	141.869	Dec-2004
Baryulah 6	-27.753	141.869	Dec-2004
Baryulah 6	-27.753	141.869	Dec-2004
Baryulah 6	-27.753	141.869	Dec-2004
Winninia North 3	-27.826	141.879	Jan-2005
Winninia North 3	-27.826	141.879	Jan-2005
Winninia North 3	-27.826	141.879	Jan-2005
Winninia North 3	-27.826	141.879	Jan-2005
Winninia North 3	-27.826	141.879	Jan-2005
Endeavour 1	-26.789	143.382	Feb-2005
Endeavour 2	-26.796	143.379	Feb-2005
Talgeberry 7	-26.944	143.430	Feb-2005
Talgeberry 7	-26.944	143.430	Feb-2005
Cranstoun 1	-26.814	143.387	Apr-2005
Takyah 1	-27.010	143.301	Apr-2005
Takyah 1	-27.010	143.301	Apr-2005
Mulberry 2	-26.891	143.397	May-2005
Mulberry 3	-26.895	143.409	May-2005
Ipundu North 9	-26.918	143.305	May-2005
Ipundu North 4	-26.914	143.306	May-2005
Mulberry 4	-26.890	143.405	Jun-2005
Ipundu North 9	-26.918	143.305	Jun-2005
Ipundu North 4	-26.914	143.306	Jul-2005
Ipundu North 4	-26.914	143.306	Jul-2005

Name	Latitude	Longitude	Date Fractured
Iliad 1	-28.294	141.366	Aug-2005
Iliad 2	-28.294	141.355	Aug-2005
Jackson 45	-27.578	142.414	Aug-2005
Ipundu 12	-26.936	143.332	Aug-2005
Ipundu 12	-26.936	143.332	Aug-2005
Tartulla 6	-27.207	142.139	Oct-2005
Psyche 4	-27.929	141.810	Oct-2005
Baryulah 8	-27.738	141.834	Nov-2005
Baryulah 8	-27.738	141.834	Nov-2005
Baryulah 8	-27.738	141.834	Nov-2005
Baryulah 8	-27.738	141.834	Nov-2005
Baryulah 7	-27.750	141.857	Nov-2005
Baryulah 7	-27.750	141.857	Nov-2005
Baryulah 7	-27.750	141.857	Nov-2005
Baryulah 7	-27.750	141.857	Nov-2005
Talgeberry 6	-26.945	143.420	Nov-2005
Ipundu 4A	-26.936	143.333	Nov-2005
Ipundu 4A	-26.936	143.333	Nov-2005
Wellington 5	-27.739	141.865	Nov-2005
Thoar 3	-28.025	141.775	Nov-2005
Baryulah 9	-27.759	141.847	Dec-2005
Baryulah 9	-27.759	141.847	Dec-2005
Baryulah 9	-27.759	141.847	Dec-2005
Baryulah 9	-27.759	141.847	Dec-2005
Wellington 5	-27.739	141.865	Dec-2005
Juno 4	-27.687	141.837	Dec-2005
Juno 4	-27.687	141.837	Dec-2005
Juno 4	-27.687	141.837	Dec-2005
Juno 4	-27.687	141.837	Dec-2005
Juno 4	-27.687	141.837	Dec-2005
Juno 4	-27.687	141.837	Dec-2005
Psyche 3	-27.942	141.824	Dec-2005
Durham Downs North 2	-27.054	141.821	Jan-2006

Name	Latitude	Longitude	Date Fractured
Baryulah 10	-27.756	141.878	Jan-2006
Baryulah 10	-27.756	141.878	Jan-2006
Baryulah 10	-27.756	141.878	Jan-2006
Baryulah 10	-27.756	141.878	Jan-2006
Winna 4	-27.725	142.540	Jan-2006
Talgeberry 4	-26.945	143.435	Jan-2006
Talgeberry 4	-26.945	143.435	Jan-2006
Tickalara 10	-28.344	141.378	Feb-2006
Iliad 3	-28.293	141.364	Feb-2006
Tickalara 3	-28.341	141.384	Mar-2006
Sigma 1	-28.335	141.340	Mar-2006
Sigma 2	-28.340	141.341	Mar-2006
Mulberry 6	-26.894	143.399	Mar-2006
Dululu 1	-28.326	141.440	Mar-2006
Yanda 16	-27.449	141.826	Apr-2006
Tickalara 3	-28.341	141.384	Apr-2006
Mulberry 8	-26.899	143.399	Apr-2006
Yanda 16	-27.449	141.826	Apr-2006
Mulberry 9	-26.899	143.406	May-2006
Mulberry 10A	-26.902	143.414	May-2006
Chancett 1	-26.856	143.406	May-2006
Mulberry 14	-26.899	143.411	May-2006
Mulberry 16	-26.888	143.399	May-2006
Gimboola 3	-26.880	143.412	May-2006
Epsilon 3	-28.161	141.137	Jun-2006
Toby 1	-26.685	142.368	Jun-2006
Mulberry 15	-26.888	143.393	Jun-2006
Kercummurra 1	-27.108	142.433	Jul-2006
Endeavour 8	-26.800	143.377	Jul-2006
Mulberry 17	-26.899	143.388	Jul-2006
Gimboola 2	-26.880	143.418	Jul-2006
Mulberry 12	-26.884	143.392	Jul-2006
Gimboola 4a	-26.875	143.412	Aug-2006

Name	Latitude	Longitude	Date Fractured
Endeavour 9	-26.781	143.391	Aug-2006
Endeavour 7	-26.795	143.382	Aug-2006
Talgeberry 12	-26.941	143.433	Aug-2006
Talgeberry 13	-26.940	143.427	Aug-2006
Minni Ritchi 1	-26.825	143.375	Aug-2006
Cranstoun 3	-26.817	143.390	Sep-2006
Talgeberry 9	-26.948	143.424	Sep-2006
Talgeberry 11	-26.948	143.436	Sep-2006
Patroclus 1	-28.111	141.681	Sep-2006
Patroclus 1	-28.111	141.681	Sep-2006
Orientos 2	-28.048	141.428	Oct-2006
Talgeberry 14	-26.946	143.441	Oct-2006
Endeavour 18	-26.800	143.370	Oct-2006
Kooyong 1	-26.809	143.355	Oct-2006
Endeavour 19	-26.806	143.370	Oct-2006
Mulberry 19	-26.899	143.393	Oct-2006
Mulberry 22	-26.904	143.405	Oct-2006
Mulberry 21	-26.904	143.400	Oct-2006
Mulberry 23	-26.910	143.399	Oct-2006
Endeavour 5	-26.789	143.377	Oct-2006
Mulberry 5	-26.894	143.405	Oct-2006
Endeavour 16	-26.795	143.370	Nov-2006
Endeavour 13	-26.789	143.370	Nov-2006
Barrolka 9	-26.862	141.758	Nov-2006
Barrolka 9	-26.862	141.758	Nov-2006
Yanda 19	-27.459	141.793	Nov-2006
Durham Downs 4	-27.077	141.786	Nov-2006
Winninia North 1	-27.814	141.888	Nov-2006
Yanda 20	-27.453	141.796	Nov-2006
Yanda 19	-27.459	141.793	Nov-2006
Baryulah 12	-27.740	141.847	Nov-2006
Endeavour 15	-26.795	143.376	Nov-2006
Baryulah 12	-27.740	141.847	Dec-2006

Name	Latitude	Longitude	Date Fractured
Baryulah 12	-27.740	141.847	Dec-2006
Baryulah 12	-27.740	141.847	Dec-2006
Baryulah 12	-27.740	141.847	Dec-2006
Baryulah 12	-27.740	141.847	Dec-2006
Baryulah 11	-27.753	141.843	Dec-2006
Yanda 20	-27.453	141.796	Dec-2006
Baryulah 11	-27.753	141.843	Dec-2006
Baryulah 11	-27.753	141.843	Dec-2006
Baryulah 11	-27.753	141.843	Dec-2006
Yanda 24	-27.458	141.808	Dec-2006
Baryulah 11	-27.753	141.843	Dec-2006
Yanda 21	-27.449	141.804	Dec-2006
Baryulah 11	-27.753	141.843	Dec-2006
Theta 1	-27.979	141.745	Jan-2007
Yanda 22	-27.446	141.814	Jan-2007
Theta 1	-27.979	141.745	Jan-2007
Kooroopa North 1	-27.001	143.230	Feb-2007
Kooroopa North 2	-26.996	143.218	Feb-2007
Jackson 28	-27.583	142.413	Feb-2007
Endeavour 34	-26.803	143.373	Mar-2007
Endeavour 33	-26.803	143.367	Mar-2007
Endeavour 26	-26.783	143.388	Mar-2007
Mulberry 11	-26.894	143.393	Mar-2007
Thungo 9	-27.725	142.583	May-2007
Thungo 13	-27.734	142.581	May-2007
Dilkera North 1	-27.739	142.641	May-2007
Thungo 10	-27.728	142.583	May-2007
Thungo 11	-27.729	142.573	May-2007
Endeavour 28	-26.789	143.388	May-2007
Mulberry 29	-26.893	143.388	May-2007
Mulberry 42	-26.888	143.381	May-2007
Mulberry 44	-26.899	143.382	May-2007
Mulberry 26	-26.886	143.389	May-2007

Name	Latitude	Longitude	Date Fractured
Endeavour 39	-26.806	143.364	May-2007
Endeavour 25	-26.783	143.381	May-2007
Endeavour 35	-26.787	143.373	May-2007
Talgeberry 5	-26.936	143.435	May-2007
Mulberry 27	-26.888	143.387	May-2007
Currambar 1	-27.753	142.666	Jun-2007
Muthero 6	-27.712	142.615	Jun-2007
Muthero 7	-27.712	142.612	Jun-2007
Endeavour 29	-26.793	143.367	Jun-2007
Mulberry 35	-26.913	143.403	Jun-2007
Yanda 25	-27.460	141.799	Jun-2007
Takyah 2	-27.011	143.282	Jul-2007
Kooroopa 3	-27.024	143.236	Jul-2007
Coonaberry 2	-26.842	142.109	Aug-2007
Coonaberry 2	-26.842	142.109	Aug-2007
Challum West 1	-27.358	141.503	Aug-2007
Lepard 1	-27.827	141.732	Aug-2007
Lepard 1	-27.827	141.732	Aug-2007
Lepard 1	-27.827	141.732	Aug-2007
Lepard 1	-27.827	141.732	Aug-2007
Lepard 1	-27.827	141.732	Aug-2007
Patroclus 4	-28.116	141.689	Sep-2007
Ipundu 2	-26.926	143.321	Sep-2007
Ipundu 14	-26.937	143.337	Sep-2007
Mulberry 33	-26.896	143.402	Oct-2007
Mulberry 34	-26.896	143.402	Oct-2007
Mulberry 31	-26.896	143.402	Oct-2007
Mulberry 32	-26.896	143.402	Oct-2007
Talgeberry 18	-26.945	143.427	Oct-2007
Talgeberry 22	-26.940	143.438	Oct-2007
Dilkera 2	-27.744	142.629	Jan-2008
Jackson 17	-27.598	142.419	Mar-2008
Mama 1	0.000	0.000	Aug-2008

Name	Latitude	Longitude	Date Fractured
Yanda 15	-27.452	141.807	Sep-2008
Durham Downs North 1	-27.054	141.810	Oct-2008
Tartulla 8	-27.195	142.151	Oct-2008
Ramses 2	-26.755	142.106	Nov-2008
Iliad 4	-28.294	141.370	Nov-2008
Iliad 6	-28.297	141.365	Nov-2008
Galex 2	-27.453	141.852	Nov-2008
Yawa 2	-27.376	141.929	Nov-2008
Vega 3	-27.719	141.864	Dec-2008
Vega 3	-27.719	141.864	Dec-2008
Vega 3	-27.719	141.864	Dec-2008
Vega 3	-27.719	141.864	Dec-2008
Vega 3	-27.719	141.864	Dec-2008
Vega 3	-27.719	141.864	Dec-2008
Vega 3	-27.719	141.864	Dec-2008
Iliad 5	-28.296	141.353	Sep-2009
Baryulah 4	-27.752	141.873	Sep-2009
Baryulah 4	-27.752	141.873	Sep-2009
Baryulah 4	-27.752	141.873	Sep-2009
Baryulah 4	-27.752	141.873	Oct-2009
Baryulah 4	-27.752	141.873	Oct-2009
Baryulah 5	-27.755	141.865	Oct-2009
Baryulah 5	-27.755	141.865	Oct-2009
Baryulah 5	-27.755	141.865	Oct-2009
Baryulah 5	-27.755	141.865	Oct-2009
Theta 2	-27.960	141.726	Oct-2009
Psyche 6	-27.903	141.818	Oct-2009
Okotoko West 2	-27.351	141.956	Oct-2009
Baryulah 5	-27.755	141.865	Nov-2009
Ipundu 16	-26.928	143.320	Jun-2010
Ipundu North 13	-26.916	143.302	Jun-2010
Patroclus 3	-28.114	141.687	Jun-2010
Moon 1	-28.227	141.042	Jul-2010

Name	Latitude	Longitude	Date Fractured
Moon 1	-28.227	141.042	Jul-2010
Moon 1	-28.227	141.042	Jul-2010
Moon 1	-28.227	141.042	Jul-2010
Challum 5	-27.416	141.657	- [1]
Dingera 2	-27.957	141.901	- [1]
Dilkera 3	-27.742	142.634	- [1]
Psyche 2	-27.916	141.836	- [1]
Mulberry 24	-26.910	143.417	- [1]
Psyche 2	-27.916	141.836	- [1]
Endeavour 11	-26.791	143.385	- [1]
Ramses 2	-26.755	142.106	- [1]
Genoa 2	-28.141	141.853	- [1]
Challum 23	-27.403	141.589	Mar-13
Challum 5	-27.416	141.657	Mar-13
Karmona 5	-27.312	141.89	Mar-13
Durham Downs 2	-27.104	141.811	Mar-13
Psyche 1	-27.913	141.813	Mar-13
Baryulah 15	-27.762	141.835	Mar-13
Baryulah 13	-27.755	141.883	Apr-13
Brumby 13	-28.388	141.002	Apr-13
Baryluah 14	-27.756	141.87	Apr-13
Lepard 2	-27.836	141.736	Jul-13
Psyche 7	-27.921	141.814	Jul-13
Juno 6	-27.701	141.823	Jul-13
Karmona 6	-27.303	141.901	Jul-13
Galex 2	-27.453	141.852	Aug-13
Curri 1	-27.365	141.821	Aug-13
Challum 7	-27.39	141.55	Aug-13
Raffle 1	-28.011	141.588	Aug-13
Okotoko West 3ST1	-27.354	141.963	Oct-13
Barrolka 12	-26.88	141.761	Mar-14
Barrolka 11	-26.863	141.743	Apr-14
Barrolka 13	-26.851	141.776	Apr-14

Name	Latitude	Longitude	Date Fractured
Durham Downs 1	-27.081	141.79	Apr-14
Baryulah 18	-27.74	141.844	Apr-14
Baryulah 17	-27.75	141.878	May-14
Vega 4	-27.72	141.875	Jul-14
Vega 5	-27.725	141.881	Jul-14
Kanook 1	-27.106	141.915	Jul-14
Bolah 1	-26.969	141.638	Jul-14
Toby 1	-26.685	142.368	Aug-14
Hera 3	-27.689	141.862	Aug-14
Hera 4	-27.689	141.862	Aug-14
Durham Downs 6	-27.066	141.78	Nov-14
Durham Downs 7ST1	-27.096	141.795	Nov-14
Durham Downs 8	-27.112	141.791	Nov-14
Durham Downs North 4	-27.041	141.806	Nov-14
Cook 29H	-26.692	141.291	Dec-14
Monte 1	-27.29	141.775	May-15
Beeree 1	-26.91	141.614	Jun-15
Barrolka 15	-26.894	141.762	Jun-15
Barrolka 17	-26.86	141.672	Jun-15
Barrolka 16	-26.838	141.7	Jun-15
Barrolka 14	-26.86	141.672	Jun-15
Toby 2	-26.676	142.371	Aug-15
Whanto 2	-26.523	142.186	Aug-15
Whanto 3	-26.523	142.186	Aug-15
Mt Howitt 3DW1	-26.594	142.489	Aug-15
Hebe 1	-27.73	141.958	Aug-15
Bolah 2	-26.986	141.661	Dec-15
Cuisinier 14	-26.669	141.232	Dec-15
Cuisinier 9	-26.704	141.233	Dec-15
Cuisinier 5	-26.704	141.224	Dec-15
Cuisinier 12	-26.675	141.231	Dec-15
Cuisinier 3	-26.693	141.226	Dec-15
Durham Downs North 6	-27.058	141.826	Nov-16

Name	Latitude	Longitude	Date Fractured
Whanto 3	-26.523	142.186	Aug-15
Whanto 2	-26.523	142.186	Aug-15
Whanto 4	-26.535	142.213	Nov-16
Whanto South West 1	-26.607	142.16	Nov-16
Whanto West 1	-26.526	142.157	Oct-16
Barta North 1	-26.705	141.184	Dec-16
Cuisinier 22	-26.658	141.229	Dec-16
Dilkera 3	-27.742	142.634	Dec-16
Maxwell 2	-27.886	142.695	Dec-16
Wippo East 1	-27.294	142.121	Apr-17
Roti South 1	-27.397	142.149	Apr-17
Windigo 3	-27.391	142.112	Apr-17
Galex 4	-27.455	141.856	May-17
Galex 5	-27.455	141.856	May-17
Coolah 3	-26.955	141.814	May-17
Whanto West 1	-26.526	142.157	Jul-17
Marama West 1	-26.056	142.099	Jul-17
Kaiden 1	-26.337	142.053	Aug-17
Lepard 3	-27.825	141.717	Sep-17
Wippo 1	-27.286	142.091	Oct-17
Roti 3	-27.389	142.181	Nov-17
Roti 5	-27.379	142.164	Oct-17
Roti 6	-27.379	142.164	Oct-17
Takyah 6	-27.006	143	Feb-18
Epsilon 4	-28.176	141.13	Mar-18
Mountain Goat 1	-27.407	141.145	Jul-18
Cocinero 6	-26.721	141.268	Aug-18
Shefu 1	-26.674	141.169	Aug-18
Cuisinier North 1	-26.665	141.232	Aug-18
Cuisinier 24	-26.701	141.24	Aug-18
Cocinero 2	-26.705	141.262	Aug-18
Whanto 5	-26.536	142.17	Aug-18
Coonaberry 4	-26.866	142.102	Aug-18

Name	Latitude	Longitude	Date Fractured
Cuisinier 19	-26.724	141.244	Dec-18
Cocinero 3	-26.695	141.257	Dec-18
Bearcat 1	-27.752	141.726	Mar-19
Bolah 3	-26.985	141.646	Jan-19
Bolah 4	-26.986	141.646	Feb-19
Ipundu 20	-26.924	143.311	Mar-19
Ipundu 19	-26.946	143.339	Mar-19
Cuisinier 28	-26.698	141.232	May-19
Cuisinier 27	-26.699	141.247	May-19
Cuisinier 21	-26.666	141.214	May-19
Cuisinier 15	-26.695	141.237	May-19
Barrolka 20	-26.876	141.742	May-19
Anna North 1	-27.099	141.693	May-19

(1) No record

APPENDIX F

Potential Hydraulic Stimulation Locations

Appendix F – Potential Hydraulic Fracture Locations

	Proposed Fracture Dates		
Field	**2020**	**2021**	**2022**
ANNA NORTH	0	1	0
BARROLKA	3	4	1
BASSET	1	0	0
BEARCAT	0	1	0
BOLAH	1	1	0
BOLAN EAST	0	1	0
COCINERO	0	3	0
COOLAH	0	4	0
CORRIDOR NORTH	0	1	0
COUGAR	0	1	0
CUISINIER	3	3	3
DILKERA	0	0	1
DURHAM DOWNS	1	1	0
ENDEAVOUR	0	0	2
HEMNANT	0	1	0
HERA	0	0	1
HOUBY	0	1	0
KANOOK SOUTH	0	1	0
MAYA	0	0	1
MIRANDA	1	0	0
MOOLIAMPAH	0	0	1
MOON	1	0	0
MOUNTAIN GOAT	0	1	0
PSYCHE	0	1	0
SNOWBALL	1	0	0
TARTULLA	1	0	0
THUNGO	0	0	1
TOBY	0	2	0
VEGA	0	0	1
WACKETT	2	0	0
WATSON NORTH	2	0	2

	Proposed Fracture Dates		
Field	**2020**	**2021**	**2022**
WOLGOLLA WEST	1	0	0
DUNADOO/ DUNADOO EAST	0	4	0
JUNO/ JUNO NORTH	0	0	1
WIPPO/WIPPO SOUTH	1	1	0

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REPORT

Stimulation Risk Assessment - Santos Southwest Queensland Tenements

Human Health and Ecological Risk Assessment - Halliburton

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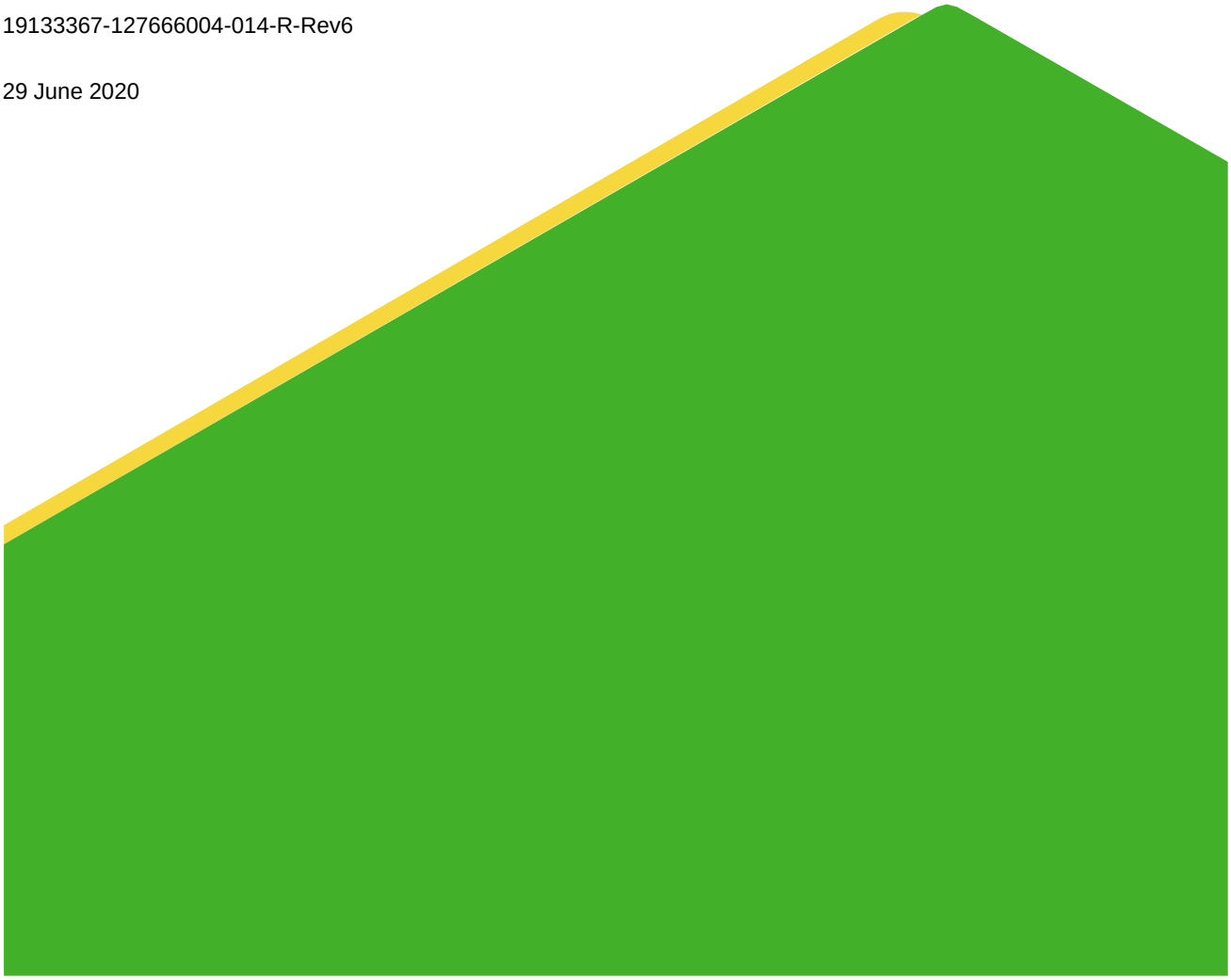
19133367-127666004-014-R-Rev6

29 June 2020



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Executive Summary

Introduction

Santos Ltd (Santos) engaged Golder Associates Pty Ltd (Golder) to prepare this desktop risk assessment of stimulation activities for conventional oil and gas production in their Southwest Queensland (SWQ) tenements. This Stimulation Risk Assessment (SRA) is undertaken to meet Department of Environment and Science (DES; formerly Department of Environment and Heritage Protection (DEHP)) Environmental Authority (EA) consent conditions.

An earlier version of this report was prepared in 2012. This current version has been updated with new information on revised fluid systems and EA consent conditions. As a consequence, the Product Descriptions (Section 3.0), and chemical assessments in Sections 4.0 (Aquatic Assessment), 5.0 (Terrestrial Assessment), and 6.0 (Human Health Assessment) in this report have been updated with new chemicals and new data on previously identified chemicals. Within these report sections, however, the approach to the chemical hazard assessments has largely remained the same. Section 7.0 (Risk Characterisation) has also been updated with the new chemical information.

This desktop SRA is presented in two report volumes, as follows:

- Volume One discusses the environmental and geological settings within which Santos' stimulation activities take place and the general techniques for the drilling, completion and stimulation of wells. The report also discusses why stimulation is essential in SWQ and outlines Santos' current forward programme for fracture-stimulation, although it should be noted that for a variety of reasons (including but not limited to future production performance and / or access-related issues such as the flooding of the Cooper Creek system), the forward program is frequently reviewed and is subject to change.
- Volume Two (this report) relates specifically to the stimulation fluids proposed to be used by *Halliburton* on Santos wells in the SWQ. Stimulation fluids specifically assessed in this report are:
  - '*DeltraFrac(H) Treatments*'
  - '*DFS-BCG Treatments'*
  - '*DFS-BCG(H)* (formally *HyborH*) *Treatments*'
  - '*High Temperature Acid Spearheads*'.

Halliburton stimulation fluid proprietary chemical information was disclosed directly to Golder by Santos on 24 October 2019. Full disclosure was provided for the chemical constituents in each of the fluids considered, including the mass of each constituent in a typical fluid mixture.

Comparison of Conventional Oil and Gas Operations to Coal Seam Gas (CSG) Operations

There are key differences between CSG and conventional oil and gas production, both in the geographic and geological setting of the resource and the methodology for accessing the resource, that have a substantial bearing on the risk profile presented by stimulation activities. These include:

- Santos' conventional oil and gas operations in SWQ are located in an arid, sparsely populated area of central Australia. Whilst groundwater is an important water supply to support the rural land uses, the extent of water supply development is limited (commensurate with the small population base)
- In Santos' SWQ operations, the hydrocarbon reservoirs generally occur in anticlines capped with thick, laterally-extensive low permeability formations that isolate the reservoirs from overlying water-bearing formations; and
- The oil and gas reservoirs in the SWQ study area are very deep, of the order of 1500 to 3000 m below ground level, which provides hundreds to over a thousand metres vertical separation between the

formations in which stimulation activities are proposed and the shallow groundwater resources. There is also no requirement to remove formation water in order to facilitate gas flow, with the possible exception of well blow downs on a case by case frequency.

Hence, the combination of the remote project location, low population density (and limited water supply development), and the substantial vertical separation of oil and gas reservoirs from primary groundwater supply aquifers results in an inherently low risk profile with regard to stimulation activities.

Environmental Setting and Environmental Values

Santos operates conventional gas and oil fields within scattered petroleum production tenements that, along with Santos' exploration licences cumulatively cover approximately 30,000 km^2 of Southwest Queensland. These tenements, exploration licenses and the land surrounding the Santos tenements comprise the Santos SWQ *study area*. The study area is described in detail within Volume One of the SWQ SRA report.

The terrain in the study area is generally characterised by low undulating topography (hills and ridges) between the various river and creek systems and associated floodplains. The area is sparsely developed, and generally comprises rural communities and homesteads that are largely engaged in farming and livestock. The oil and gas reservoirs which are the targets for stimulation lie within the Cooper Basin and the overlying Eromanga Basin.

Based on an understanding of the environmental setting, this risk assessment considered the following key environmental values:

Groundwater Environmental Values:

- Town water supply
- Stock and domestic water supply
- Sandstone aquifers of the GAB; and
- Groundwater Dependant Ecosystems (GDEs).

Surface Water Environmental Values:

- Protection of aquatic ecosystems
- Recreation and aesthetics: primary recreation with direct contact, and visual appreciation with no contact; and
- Cultural and spiritual values.

Terrestrial Environmental Values:

- Protection of flora and fauna, such as small mammals reptiles and birds.

Environmental values are further considered and evaluated in Volume One of the SWQ SRA report.

Stimulation Process Description Summary

With regard to the process of stimulation, the requirements of the EA approval conditions are considered within Volume One of the SWQ SRA report, with the following specific information included:

- Practices and procedures to ensure that the stimulation activities are designed to be contained within the target gas producing formation.
- Indicative details of where, when and how often stimulation is to be undertaken on the tenures covered by this environmental authority.
- A description of Santos' well mechanical integrity testing program.
- Process control and assessment techniques to be applied for determining extent of stimulation activity(ies) (e.g. microseismic measurements, modelling etc.); and

- A process description of the stimulation activity to be applied, including equipment and a comparison to best international practice.

Evaluation of Exposure Pathways

Potential exposure pathways were evaluated for on-site (i.e. within the well lease), and those relevant for off-site (i.e. anything beyond the well lease boundary). Potentially complete exposure pathways were evaluated for workers, trespassers, native fauna and flora and livestock. The environment immediately surrounding the well lease (i.e. off-site) throughout the study area may vary from lease to lease, but, was considered to potentially include homesteads (adult and child residents), water supply bores, creeks or wetlands/waterholes, livestock and native flora and fauna.

The on-site assessment indicated that the majority of potential exposure pathways were unlikely or incomplete, given the application of operational controls by Santos. These operational controls include:

- Occupational health & safety procedures implemented during stimulation operations to prevent workers from direct contact and inhalation exposure to chemicals during standard operations, spills and when handling flowback water or sediments.
- Implementation of spill containment procedures during operations to prevent migration of and exposure to chemicals.
- Vacuum removal of sediments and fluids contained within panel tanks, to prevent exposure to contaminants in windborne dust.
- Installation of signs to indicate the well lease (including the panel tank area) is a work zone to be accessed by authorised personnel only; and
- The use of lined above ground panel tanks (several metres high) to store flowback fluids, reducing access to the majority of potential ecological receptors including livestock and large mammals.

Within the well pad area, reasonable measures will be implemented to discourage entry of native fauna and livestock into the well lease area during stimulation operations. However, a potentially complete exposure pathway was identified for birds coming in direct contact with the flowback water in the panel tanks.

Potential off-site exposure pathways were evaluated for homesteads, livestock, native flora and fauna and aquatic ecosystems. Three possible chemical sources were identified: injected stimulation fluids, sediments from the panel tanks and flowback water. The exposure assessment concluded:

- Subsurface exposure to stimulation fluids is controlled by Santos' well design, well integrity testing procedures and operational monitoring, and this pathway (whereby stimulation fluids could escape into the formation and contaminate adjacent aquifers that are used for domestic or stock water supply) is considered unlikely or incomplete.
- Based on an understanding of the Eromanga and Cooper Basin geology and hydrogeology, and the nature and extent of groundwater supply development, exposure to residual stimulation chemicals through subsurface pathways is considered unlikely and incomplete, due to:
  - Significant vertical offset between the beneficial use aquifers and the shallowest hydrocarbon reservoirs (oil reservoirs of the Cadna-Owie Formation - 400 to 800 m). These formations are separated by low permeability formations and form a thick, competent and regionally extensive seal. The vertical offset to gas reservoirs is much greater (1,000 m to 1,800 m).
- Within formations that host both aquifers and hydrocarbon reservoirs (e.g. Hooray Sandstone), the water-bearing zones are separated from hydrocarbon reservoirs by intra-formational seals. However, there is not enough information available to discretise the internal stratigraphy of these formations. Where petroleum activities (including stimulation) occur within a formation that hosts both aquifers and hydrocarbon reservoirs, the lateral distance of the water supply bores accessing the aquifer to Santos' tenements was considered.

- The closest beneficial use bore to the Santos tenements targeting the Hooray Sandstone in the DES (formerly DEHP) database records is the Coothero Bore, which is located approximately 45 km from the closest tenement with stimulation activities proposed.
- At the surface, a spill or leak of flowback water from a panel tank was considered as a potential exposure scenario, however the implementation of operational controls, including use of liners in panel tanks, removal of fluid and sediment using vacuum techniques and engineering and operational controls (grading of well leases and stormwater controls) is considered sufficient to limit the potential for uncontrolled releases of flowback water to the environment. A further margin of safety is provided by Santos' evaluation of 'environmentally sensitive areas' when establishing well leases, which includes the establishment of buffers between petroleum (and stimulation) activities and features of potential environmental concern. Subsequently, the potential off-site exposure scenarios are considered unlikely and incomplete.

Hazard Assessment

The toxicity of the chemicals used in the stimulation process by Halliburton have been assessed for persistence, bioaccumulation and aquatic toxicity (PBT), terrestrial toxicity and human health toxicity including the physical hazards of fire and explosion. The review of toxicity is qualitative in that it has provided a relative ranking of chemicals considered to represent a high, moderate or low hazard in respect to the ecological or human health end points with qualification of health issues arising from the ranking.

The evaluation of the hazards was based on the available data obtained from a range of literature sources and databases. As a consequence, data are limited to the quantity and quality of information available in those sources. A measure of the data completeness for the toxicological and hazard parameters used has been estimated using a percentage of the parameters for which data were available. An assessment of the quality of the available data is beyond the scope of this report. In the absence of verifying the data by going to the primary literature sources, the selection of data for use in the assessment has been confined to established, robust and reputable sources such as WHO (World Health Organisation) and US EPA (United States Environmental Protection Agency) where available. As new toxicological data are generated and becomes available in the published literature, the information presented in this hazard evaluation and the associated conclusions may be subject to change. This was realised in 2013 with the publication of new human health chemical hazard assessment approaches (NICNAS, 2013). As a result chemicals assessed after this date have been reviewed on the basis of the new national approach which incorporates a weighting for specific toxicological parameters. It should be noted that this methodology has not been employed for chemicals assessed prior to 2013, and so no change is reflected in previous assessments.

This hazard assessment did not consider the combined effects of the constituents when present in a mixture. Assessment of mixtures is considered beyond the scope of a screening level human health and ecological risk assessment.

Environmental Hazard

Approaches for environmental risk assessment of individual chemicals are inherently conservative and designed to over-estimate risk as a precautionary approach and in recognition of the uncertainty surrounding effects of mixtures.

Aquatic Ecosystems

Based on the hazard classification of the stimulation chemicals, seven chemicals were classified as a high hazard and considered to be COPC, as follows:

- Alcohols, C12-C15, Ethoxylated
- Surrogate for Amides, tall-oil fatty, N-N-bis(hydroxyethyl)
- Tall-oil, fatty, N,N-bis(hydroxyethyl)

- Chlorous acid, sodium salt
- Disodium octaborate tetrahydrate
- Sodium bisulfite
- Sodium iodide; and
- Surrogate for Ulexite.

The certainty of the hazard classification varies depending on the extent of data gaps and the reliance on modelled data. The percentage data gaps for the high hazard chemicals ranged from very low (Alcohols, C12-C15, Ethoxylated) to relatively high (Sodium iodide).

Terrestrial Ecosystems

The organic chemicals classified as high hazard to terrestrial ecosystems were assessed according to their toxicological and physico-chemical properties. The following organic chemicals were assessed to have the potential to pose a higher environmental hazard to terrestrial ecosystems relative to the other chemicals assessed based on persistence (including volatility and soil half-life), and potential to biomagnify:

- Diethanol amine; and
- Hydrotreated light petroleum distillate.

Diethanol amine has low volatility but it does not persistent in the soil and it does not biomagnify. Hydrotreated light petroleum distillate has a high potential to biomagnify but it does not persist in the environment based on its fast half-life and high volatility. Therefore, although these chemicals appear to pose a higher hazard than others, their risk profile to terrestrial receptors is relatively low.

The remaining chemicals were considered likely to degrade quickly or moderately quickly and/or have a high or moderate volatility. Hence, whilst direct toxicity to terrestrial receptors could occur from exposure to these chemicals (for example, following a spill or breach of containment, or from direct exposure via accidental entry into a panel tank) the effect will likely be reduced over time.

Human Health Hazard

The hazard evaluation for human health undertaken in accordance with the ‘low-medium-high’ hazard ranking methodology indicated three of the twenty chemicals assessed to have a ‘moderate to high’ relative ranking:

- Methanol
- Sodium iodide
- Acetic acid.

The hazard evaluation for human health undertaken in accordance with the IMAP Framework hazard ranking methodology indicated twelve of the seventeen chemicals assessed under this methodology to be a Hazard Rank of 4 or 3.

- Ethylene Glycol
- Sodium bisulfite
- Ulexite
- Diethanolamine
- Sodium polyacrylate
- Butyl alcohol
- Tributyl tetradecyl phosphonium chloride

- Guar gum
- Hydrotreated light petroleum distillate
- Glutaraldehyde
- Monoethanolamine borate.

The hazard evaluation for human health suggests that the dominant concerns are related to occupational hazards such as carcinogenicity, silicosis, skin, eye and respiratory irritancy or corrosivity and sensitisation. In some cases, physical hazards of flammability and explosion prevail and are identified in this report. While extensive dilution of the stimulation chemicals is anticipated such that potential exposure concentrations would be much reduced for fluids injected into the well and in flowback fluid, there are a number of hazards that are suggested from this human health evaluation. These include the potential for:

- Residual elevation of organic moieties e.g. some salts have an organic part that will be present following dissociation that may increase in environmental waters.
- Changes in pH of environmental waters due to alkaline or acidic components.
- Elevations of certain metal concentrations in environmental waters.
- Some additives to exert endocrine disruption effects.
- Certain inorganic substances to generate atmospheric particulates that may impact nearby communities; and
- Volatile components to comprise nuisance or irritant effects should atmospheric concentrations be elevated in close proximity to communities.

These environmental hazards may be assessed further, and/or managed as required.

Golder notes that benzene, toluene, ethylbenzene and xylene (BTEX) and polycyclic aromatic hydrocarbon (PAH) compounds were not identified in the confidential disclosure of stimulation fluids chemicals provided to Golder by Halliburton on 13 July 2012 and to Golder by Santos in October 2019.

Qualitative Assessment of Fluids

In 2012 Santos collected seven fluid samples during South Australian stimulation activities for chemical analysis. Two of these fluids (‘*DFS-BCG(H) (formally HyborH) Treatments’* and ‘*High Temperature Acid Spearheads*’) are still in use or proposed for use by Haliburton in SWQ stimulation activities. The other two fluids assessed in this report *(‘DeltaFrac(H) Treatments’ and ‘DFS-BCG Treatments’*) were not assessed in the qualitative assessment of fluids.

These stimulation activities were undertaken by Halliburton in 2012 and are considered reasonably indicative of the proposed SWQ activities. The samples included:

- ‘Stimulation fluid additives mixed with distilled water to assess the quality of the additives in isolation.
- Formation make up water prior to mixture with stimulation fluid additives to assess the quality of the formation water; and
- Flowback fluids as they were returned from the subsurface to assess the overall fluid quality (including the contribution of reservoir fluids to the overall flowback fluid quality).

Detectable concentrations of toluene, xylenes and hydrocarbon fractions were reported in two samples of distilled water mixed with stimulation fluid additives, prepared by Halliburton. The reported concentrations were below the DES BTEX standard.

Review of the data indicates that the flowback fluids contain substantially higher concentrations of hydrocarbons, which are considered to represent geogenically derived substances and these exceed the

respective water quality guideline concentrations (where available). The presence of geogenic hydrocarbons represents a key difference between conventional formations and those targeted through CSG production.

Examination of the make-up water drawn from formation water sources suggests the hydrocarbon concentrations are lower and range from concentrations below the limits of reporting to concentrations approaching or in some cases exceeding the respective water quality guidelines. This includes both potable water quality guidelines and ecological guidelines from both the Netherlands (RIVM, 2004) and Canada (CCME, 2008), which were referenced in the absence of water quality guidelines for hydrocarbon fractions in Australia. This represents a gap in the literature and needs to be addressed on an Industry wide basis. These exceedances only apply to the TPH fractional ranges and the aesthetics-based health values for ethyl benzene and total xylenes. It is noted that comparison of flowback water quality to potable water quality guidelines constitutes a conservative, screening level assessment as the exposure scenario upon which the guidelines were derived (i.e. chronic exposure from direct ingestion of water) is not strictly relevant to the management of flowback fluids.

The distilled water fluid formulations present a similar hydrocarbon concentration profile to the make-up water, with generally lower concentrations albeit with exceptions in some TPH fractional ranges and for p-isopropyltoluene. The latter are within an order of magnitude of the make-up water concentrations. In the case of the BTEX group the distilled water formulations have not identified BTEX concentrations exceeding BTEX water quality criteria specified in the Queensland Environmental Protection Regulation.

These results suggest that stimulation fluid formulations are not contributing substantial amounts of BTEX and TPH into the subsurface regions, and certainly at concentrations that are both below the regulated criteria (where available) and below the concentrations in the hydrocarbon reservoirs being fractured. Some qualification of this statement is required as a result of residual uncertainties. These uncertainties require further exploration and reflect:

a) Limited sampling frequencies for the respective fluids examined.

b) Confidence in the sampling integrity and any potential for introduction of extraneous contamination. There is potential in view of the immediate environmental surrounds of the stimulation conditions.

c) The sampling process and its consistency with stimulation procedures at the time of sampling including spatial and temporal references, i.e. what was happening at the time of sampling and process locations, etc.

At the time of reporting, no information on fluid chemical volume per stimulation event for the two new fluids *('DeltaFrac(H) Treatments' and 'DFS-BCG Treatments'*) had been provided to Golder and has therefore not been included in this report.

Overall Risk Evaluation and Management Measures

Considering the hazard, exposure assessment and qualitative assessment of fluids, although unlikely, flowback water at surface presents a possible risk. However, with Santos operational controls and management, the overall risk to human health and environment associated with the chemicals involved in stimulation are expected to be low. The management measures implemented through operational controls include:

- OH&S procedures implemented during stimulation operations to prevent workers from direct contact with chemicals during spills and when handling make up and flowback waters and sediments.
- Santos operational procedures regarding well integrity verification and fracture design to stay within the target formation.

- Assigning buffers during establishment of well leases between petroleum operations and potential “environmentally sensitive areas” identified though database review and site-specific ecological assessments.
- Implementation of spill containment procedures during operations to prevent migration of and exposure to chemicals.
- Vacuum removal of sediments and fluids contained within panel tanks, to prevent exposure to contaminants in fluids and windborne dust.
- Installation of signs to indicate that the well lease (including the panel tank area) is a work zone to be accessed by authorised personnel only.
- Lining (double lining) of panel tanks to prevent seepage of flowback water into the underlying aquifer; and
- Engineering and operational controls (grading of well leases and stormwater controls) to limit the potential for uncontrolled surface releases of flowback water to the environment.

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1.0 INTRODUCTION

1.1 Preamble

Santos Ltd (Santos) is a holder of numerous existing Environmental Authorities (EAs) for activities and operations throughout Southwest Queensland (SWQ), collectively referred to as "SWQ". To meet EA consent conditions, a formal risk assessment of stimulation activities is required and subsequently, Golder Associates Pty Ltd (Golder) has been engaged by Santos to prepare this Stimulation Risk Assessment (SRA).

This version of the Stimulation Risk Assessment (SRA) updates a 2012 version (127666004-014-Rev3, dated August 2013 previously referred to as a Hydraulic Stimulation Risk Assessment (HSRA)). Updated contents include reference to the updated Environment Authority (EA) Blueprint Conditions (updated December 2019) and new information on revised fluid systems. As a consequence, the Product Descriptions (Section 3.0) and the chemicals assessments in Sections 4.0 (Aquatic Assessment), 5.0 (Terrestrial Assessment), and 6.0 (Human Health Assessment) of this report have been updated with new chemicals and new data on previously identified chemicals. Within these report sections, however, the approach to the chemical hazard assessments has largely remained the same. Section 7.0 (Risk Characterisation) has also been updated with the new chemical information.

This desktop SRA is presented in two volumes, as follows:

- Volume One discusses the environmental and geological settings within which Santos' stimulation operations take place and the general techniques for the drilling, completion and stimulation of wells. The report also discusses why stimulation is essential in SWQ and outlines Santos' current forward programme for fracture-stimulation, although it should be noted that for a variety of reasons (including but not limited to future production performance and / or access-related issues such as the flooding of the Cooper Creek system), the forward programme is frequently reviewed and is subject to change.
- Volume Two (this report) relates specifically to the stimulation fluids proposed to be used by *Stimulation Service Providers* on Santos wells in the SWQ conventional oil and gas fields. The report considers the ecological and human health toxicity of the chemical constituents in the stimulation fluids and includes an exposure pathway assessment and risk characterisation based on a review of complete exposure pathways and controls to mitigate exposure.

This reporting structure has been developed to accommodate the chemical assessment requirements of various stimulation fluids as they are introduced to the Australian market, for which the remainder of the EA conditions relating to the environmental setting and stimulation process description remain consistent over time. This reporting structure also affords greater ability to manage commercial-in-confidence issues associated with certain stimulation fluids.

This report specifically addresses the requirements of EA conditions related to the assessment of chemical constituents for the following *Halliburton* stimulation fluids:

- '*DeltraFrac(H) Treatments'*
- *'DFS-BCG Treatments'*
- *'DFS-BCG(H) (formally HyborH) Treatments'*
- '*High Temperature Acid Spearheads*'

Halliburton stimulation fluid proprietary chemical information was disclosed directly to Golder by Santos on 24 October 2019. Full disclosure was provided for the chemical constituents in each of the fluids considered, including the mass of each constituent in a typical fluid mixture.

This report should be read in conjunction with report entitled, *Stimulation Risk Assessment, Site Setting and Fracturing Process* [Volume One], (reference: 127666004-011-R-Rev0, dated 8 April 2020); which discusses

the environmental and geological settings within which Santos' stimulation operations take place in Southwest Queensland (SWQ) and the general techniques for the drilling, completion and stimulation of wells. The same report also evaluates exposure pathways and Santos management and control measures.

1.1.1 EA Consent Conditions

The Environmental Authority (EA) approval requirements for the Santos' SWQ operations necessitate the collection and provision of information on stimulation. Detailed regulatory requirements contained in these approvals and the sections of this risk assessment where the conditions are met are provided in Table 1. Conditions related to stimulation risk assessments can vary between Santos SWQ EAs and can also vary to include those with DES' Streamlined model conditions for petroleum activities guideline (ESR/2016/1989).

Table 1: Summary of Consent Conditions Related to Stimulation Fluid Chemical Assessment

Condition		Report Volume	Report Section
(a)	a process description of the stimulation activity to be applied, including equipment	One	3.3
(b)	provide details of where, when and how often stimulation is to be undertaken on the tenures covered by this environmental authority	One	3.4.1
(c)	a geological model of the field to be stimulated including geological names, descriptions and depths of the target gas producing formation(s)	One	2.4 and 2.5
(d)	naturally occurring geological faults	One	2.4.3.5 and 2.4.5
(e)	seismic history of the region (e.g. earth tremors, earthquakes)	One	2.4.5
(f)	proximity of overlying and underlying aquifers	One	2.5
(g)	description of the depths that aquifers with environmental values occur, both above and below the target gas producing formation	One	2.6
(h)	identification and proximity of landholders' active groundwater bores in the area where stimulation activities are to be carried out	One	2.5.7
(i)	the environmental values of groundwater in the area	One	2.6
(j)	an assessment of the appropriate limits of reporting for all water quality indicators relevant to stimulation monitoring in order to accurately assess the risks to environmental values of groundwater	Refer Stimulation Impact Monitoring Program	-
(k)	description of overlying and underlying formations in respect of porosity, permeability, hydraulic conductivity, faulting and fracture propensity	One	2.4.4 and 2.5.5
(l)	consideration of barriers or known direct connections between the target formation and the overlying and underlying aquifers	One	2.5.2.3, 3.3.4 and 3.3.7
(m)	a description of the well mechanical integrity testing program	One	3.2.2
(n)	process control and assessment techniques to be applied for determining extent of stimulation activities (e.g. microseismic measurements, modelling etc.)	One	3.3.4 and 3.3.7
(o)	practices and procedures to ensure that the stimulation activities are designed to be contained within the target gas producing formation	One	3.3.4 and 3.3.7

Condition		Report Volume	Report Section
(p)	groundwater transmissivity, flow rate, hydraulic conductivity and direction(s) of flow	One	2.5.3, 2.5.4 and 2.5.5
(q)	a description of the chemicals used in stimulation activities (including estimated total mass, estimated composition, chemical abstract service numbers and properties), their mixtures and the resultant compounds that are formed after stimulation	Two	3.0
(r)	a mass balance estimating the concentrations and absolute masses of chemicals that will be reacted, returned to the surface or left in the target gas producing formation subsequent to stimulation	Two	3.2
(s)	an environmental hazard assessment of the chemicals used including their mixtures and the resultant chemicals that are formed after stimulation including: (i). toxicological and ecotoxicological information of chemicals used (ii). information on the persistence and bioaccumulation potential of the chemical compounds used (iii). identification of the chemicals of potential concern in stimulation fluids derived from the risk assessment	Two	4.0, 5.0, 6.0 and 7.3.2
(t)	an environmental hazard assessment of the chemicals used including mixtures and the resultant chemicals that are formed after stimulation	Two	4.0, 5.0, 6.0 and 7.3.2
(u)	identification and an environmental hazard assessment of using radioactive tracer beads in stimulation activities where such beads have been used or are proposed to be used	One	3.3.7.10
(v)	an environmental hazard assessment of leaving chemical compounds in stimulation fluids in the target formation for extended periods subsequent to stimulation	Two	2.1.2.1
(w)	human health exposure pathways to operators and the regional population	Two	6.0
(x)	risk characterisation of environmental impacts based on the environmental hazard assessment	Two	7.0
(y)	potential impacts to landholder bores as a result of stimulation activities	Two	2.2.3.1
(z)	an assessment of cumulative underground impacts, spatially and temporally of the stimulation activities to be carried out on the tenures covered by this environmental authority	Two	7.5
(aa)	potential environmental or health impacts which may result from stimulation activities including but not limited to water quality, air quality (including suppression of dust and other airborne contaminants), noise and vibration	One and Two	1.3 (Report Version One) 4.0, 5.0, 6.0 and 7.3.2 (Report Version 2)

*Consent conditions from Schedule K (Well Construction, Maintenance and Stimulation), subsection K6, 21 December 2019

1.2 Risk Assessment Process

This report discusses the constituents used by Halliburton[1] with regard to toxicity to human health and the environment. The techniques used to assess the human health and environmental hazards of the constituents are described in the following sections. Where there was insufficient chemical and/or toxicological information to assess the hazards of individual constituents, an assessment was not performed.

The scope of the qualitative risk assessment comprises of:

- **Issue Identification** (Volume One) - A description of the current environmental setting (including a description of potential receiving environments and the various factors which act upon them, including climatic influences), detailed geological and hydrogeological information, gas well integrity and a description of the stimulation process including an identification of the constituents of the stimulation fluid.
- **Exposure Assessment** (This Volume) – The exposure assessment comprises of an evaluation of surface and subsurface exposure pathways assessment.
- **Hazard Assessment** (This Volume) – An evaluation of the environmental hazard of relevant chemical additives in the stimulation fluid based on aquatic toxicity, environmental persistence and bioaccumulation. The environmental hazard assessment provides a relative ranking of the chemical additives and those chemicals considered to represent a high hazard are identified as chemicals of potential concern (COPC) for further assessment. An evaluation of terrestrial and human health toxicity will also be presented; and
- **Risk Characterisation** (This Volume) – A qualitative evaluation of environmental and human health risk associated with the stimulation activities based on the identification of complete exposure pathways and hazard identification.

Human health risk assessment is limited to assessment of effects on one population: *humans*. Ecological risk assessment is concerned with assessment of effects on the ecosystem (populations and communities) and therefore is not limited to one receptor. The guidance framework for ecological risk assessment in Australia is the “Guideline on Ecological Risk Assessment” (NEPM, Schedule B(5), 2013) which refers to draft guidance prepared by EPA Victoria (Gibson *et al.*, 1997). These guidance documents focus on risks to terrestrial environments although the overall approach for assessment or risk is the same. The risk assessment was undertaken in general accordance with these guidelines and national guidelines for risk assessment recommended by enHealth (enHealth-Environmental Health Risk Assessment, “Guidelines for Assessing Human Health Risks from Environmental Hazards”, June 2012).

This hazard assessment did not consider the combined effects of the constituents when present in a mixture. Assessment of mixtures is considered beyond the scope of a screening level human health and ecological risk assessment.

If, in the future, conditions, stimulation methodologies and/or regulatory requirements change, and/or additional exposure pathways to additional receiving environments are identified, further evaluation of the associated risks *may* be warranted.

1.3 Limitations

Your attention is drawn to the document - “Limitations”, which is included in APPENDIX A of this report. The statements presented in this document are intended to advise you of what your realistic expectations of this report should be. The document is not intended to reduce the level of responsibility accepted by Golder, but rather to ensure that all parties who may rely on this report are aware of the responsibilities each assumes in so doing.

[1] Water was not assessed because it is an intrinsic constituent of all living organisms and is not inherently toxic.

2.0 EXPOSURE ASSESSMENT

This aspect of risk assessment provides perspective on the potential for COPC to become available and be taken up by human and other ecological species. Exposure assessment seeks to qualify or quantify such uptake by considering the human population groups and other organisms or group of organisms (receptors) which may be exposed to the COPCs identified for the study and outlines the mechanisms (exposure pathways) by which these receptors may be exposed.

The assessment of exposure involves the evaluation of the data available for the study and the arising issues; the details associated with the surrounding environment that influence fate and transport processes; the nature of planned operations that use the COPC; the physico-chemical characteristics of the COPC and the respective potential exposure pathways consistent with the planned operations. This allows the nature of the potential exposure to be identified taking into consideration the fate and transport potential of the COPC.

For an exposure pathway to be considered to be complete there must be all of the following:

- Source of COPC - how the chemical entered the environment and which environmental media are affected.
- A transport media - how the chemical moves or migrates through the environment from one location to another, or from one environmental medium to another.
- An exposure point - how organisms can come into contact with the chemicals (e.g. direct contact or via the food web); and
- An exposure route - how the chemical could enter the organism (e.g. inhalation, ingestion or dermal contact).

If any one of these steps (source, transport media, exposure point or route) is not present, the exposure pathway is incomplete and further assessment of risks is not required. Conclusions regarding the completeness of exposure pathways may change over time in response to new information or developments, and as such should be periodically reviewed for verification.

2.1 Identification of Exposure Pathways and Populations

A detailed description of the study area environment is provided in Volume One. In general, the area is sparsely developed, and comprises rural communities and homesteads that are largely engaged in farming and livestock production. The identification of exposure pathways and populations or ecological receptors has been split into those considered relevant for on-site (i.e. within the well lease), and those relevant for off-site (i.e. anything beyond the well lease boundary). A general description of the well lease is provided in Volume One. Individual configurations of well leases may change; however, the general layout is considered adequate for the identification of exposure pathways and receptors.

The environment surrounding the well lease (i.e. off-site) may vary. In order to provide a conservative assessment, it has been assumed there is a homestead with a water supply bore located down gradient of the well lease. It is further assumed that the distance to the homestead is over two kilometres which thus then limits the potential consideration of:

- Vapour intrusion concerns into dwellings.
- The environmental distribution of chemicals as vapours producing odours or particulates that may deposit onto roof tops and indirectly into potable water supplies; and
- The potential for entrainment of chemicals used in and around the well leases into the indoor environment of homesteads and into areas where local (homegrown) food crops may be produced.

It has also been assumed that an ephemeral creek, livestock and native flora and fauna, are present in the surrounding environment. This hypothetical assumption was considered for the purposes of the exposure pathway assessment and may not actually occur in the vicinity of a stimulated well.

2.1.1 On-site Exposure Pathways

A well lease is a defined area that contains all of the equipment and infrastructure required to stimulate a well. A typical well lease is described in Volume One. Of particular note for the exposure assessment are the panel tank and the blender unit.

As such a well lease is an occupational environment and accordingly it is unnecessary to consider any on-site residential scenarios. Workers are typically housed in existing camps or camps specifically designed for stimulation (frac camps).

The environmental receptors on a well lease are limited. Livestock and large native animals such as kangaroos are deterred from entering the pad by human activity. However, Santos have indicated that cattle and kangaroos have been noted on well leases infrequently. Smaller fauna such as rodents, lizards, snakes and birds are known to enter well leases.

As described in Volume One stimulation fluid is blended on site to the specific requirements of the fracture design. The additives required for the fracture are brought onto site and stored in storage containers, blender unit or sand trailer. Blending of the fluid is a contained and completely automated process. A typical stimulation operation is of limited duration (two to three days). As such the chemicals are on site for a short period of time prior to and during the stimulation event. The likelihood of occupational or environmental exposure to these additives prior to injection during normal operation is considered low, as long as robust operational management measures are present and implemented appropriately. Potential occupational exposure to stimulation chemicals associated with a spill prior to injection is considered to be dealt with under appropriate occupational health and safety procedures and has not been considered further in this report.

The primary pathways for environmental and occupational exposures outside of spills are considered to be dermal, ingestion and inhalation and ingestion of particulates. Inhalation of volatile chemicals is considered to be of lesser concern as there are limited indoor or confined environments with all activities conducted outside, however, large atmospheric emissions in close proximity to the source would require evaluation from both an acute and chronic exposure perspective.

The main areas on site that are considered for occupational and environmental exposure is the lined panel tank used for flowback fluid storage and this is discussed in more detail below.

2.1.1.1 Panel Tank

The panel tank is constructed during the stimulation phase, to provide containment for fluids associated with well fluids management (flowback fluids etc.) post drilling. Santos has indicated that panel tanks are approximately 2 m in height and are double lined. The length and width of the panel tank varies with the volume of fluid required to be contained. The panel tank is used during stimulation as the initial reservoir for flowback fluids. The fluid is held in the tank to allow the sediment to settle and until water and sediments can be removed via vacuum truck for offsite disposal as soon as practicable.

Human exposure to the water in the panel tank during normal operation would be limited but may occur if the tank or liner becomes damaged and requires repair. Normal OH&S procedures are expected to limit workers exposure to flowback water under these scenarios. Human and/or ecological exposure may occur in the event of a flood where the freeboard is breached.

Exposure to the sediment in the panel tank may occur if the tank is drained and the sediments dry out and contribute to wind borne dust. However, the majority of sediments are removed from the tank via vacuum

truck for off-site disposal as soon as practicable. Dust generation from a small volume of residual sediments is not likely to be of concern to human or ecological receptors and has not been considered further. Should the scale of operations result in multiple areas of residual sediments in closer proximity to townships then such an exposure pathway would warrant re-evaluation.

Cooper Basin activities are remote, and trespassers are unlikely to access the site even if the pad is not fully secure and accidental or deliberate exposure to chemicals in the flowback water in the panel tank is considered unlikely to occur.

Ecological exposures to stimulation chemicals within flowback water in the panel tank may occur for birds or flying mammals (such as bats) or from contact with sediments following drainage.

2.1.1.2 Measures to Limit Exposure

Typically implemented measures to limit exposure include:

- Exposure to trespassers is limited through the use of signs which are clearly displayed indicating the well lease is a work zone and is to be entered by authorised personnel only.
- Height of the panel tanks (approximately 2 m) and the use of signage to indicate that the panel tanks are for access by authorised personnel only.
- Exposure of livestock and other terrestrial mammals to stimulation chemicals and/or flowback water is limited due to the presence of workers during stimulation activities (which is a deterrent to animals in the lease area), the height of the panel tanks and/or fencing (if required) on site during stimulation activities.
- Exposure to sediments in the lined panel tanks is limited by effective and efficient (as soon as practicably possibly) removal and off-site disposal.

A summary of the on-site qualitative exposure assessment is provided in Table 2.

Table 2: On-site Exposure Assessment Summary

Source	Exposure Scenario	Receptors	Exposure Pathways	Likelihood of Exposure Scenario	Comments
Lined panel tank sediments	Entry to panel tank or excavation/stockpiling of tank sediments	Workers, trespassers	Ingestion, dermal, inhalation of volatiles	Unlikely	OH&S procedures and PPE limit workers exposure to sediment. Associated risks are covered in inductions that all personnel and contractors must attend.
	Entry to panel tank	Birds, and potentially flying mammals such as bats	Ingestion, dermal, uptake	Possible	The presence of humans during stimulation activities is expected to deter majority of wildlife during operations. There is a possibility that birds and small mammals that can fly into the tanks may seek out the flowback water for drinking water or as a rest area.
	Panel tank sediment dries and sediments become windblown dusts	Workers, trespassers	Inhalation of dusts, indirect exposures through re-entrainment mechanisms	Possible	Sediments / residues are removed from site using vacuum truck and appropriately treated and disposed as soon as practicable.
	Panel tank sediment dries and sediments become windblown dusts	Native terrestrial fauna (mammals, reptiles, birds), terrestrial flora	Ingestion, inhalation of dusts, deposition of dust on foliage, uptake via roots	Possible	Sediments / residues are removed from site and appropriately treated and disposed as soon as practicable. Additionally, the height of the tanks should reduce potential dispersion of dusts to the environment. The volume of any residual sediment, mobilise as dust, from the panel tank is expected to be insufficient to adversely affect terrestrial flora.
Flowback water in panel tank	Working with panel tank inlet, liner, or extraction.	Workers	Ingestion, dermal, inhalation of volatiles, inhalation/ingestion of aerosols	Possible	OH&S procedures and PPE limit workers exposure to flowback water. Associated risks are covered in inductions that all personnel and contractors must attend.
	Entry (accidental or deliberate) to panel tank.	Trespassers	Ingestion, dermal inhalation of volatiles, inhalation/ingestion of aerosols	Possible	Trespassers entry is limited via remote location, height of panel tanks and signage. Trespassers can not be entirely precluded from areas.
	Entry to panel tank.	Birds, and potentially flying mammals such as bats	Ingestion	Possible	The presence of humans and stimulation activities is expected to deter majority of wildlife during operations. There is a possibility that birds and small mammals that can fly into the tanks may seek out the flowback water for drinking water or as a rest area.

Source	Exposure Scenario	Receptors	Exposure Pathways	Likelihood of Exposure Scenario	Comments
	Entry (accidental or deliberate) to panel tank.	Livestock	Ingestion	Unlikely	Panel tanks are approximately 2 m in height precluding potential exposure to livestock
Stimulation Chemicals	Spill, leak of well delivery system failure during surface handling. Supply or disposal vehicle accident on site	Workers	Ingestion, dermal inhalation of volatiles, inhalation/ingestion of aerosols indirect exposures through re-entrainment mechanisms	Unlikely	OH&S, PPE and spill containment, procedures adequately address this exposure. Associated risks are covered in inductions that all personnel and contractors must attend.
	Spill, leak of well delivery system failure during surface handling. Supply or disposal vehicle accident on site	Terrestrial fauna (mammals, reptiles, birds), terrestrial flora	Ingestion, dermal	Unlikely	The presence of humans and stimulation activities is expected to deter wildlife. The greatest hazard is to terrestrial flora in the immediate vicinity of a spill. Provided flora populations are not unique to the area of the well lease, re-colonisation is expected post-completion of stimulation activities.
Flowback Water	Spill, leak, delivery system failure or overflow	Workers, trespassers	Ingestion, dermal, inhalation (volatiles and aerosol)	Possible	OH&S procedures and PPE limit workers exposure to flowback water. Associated risks are covered in inductions that all personnel and contractors must attend.
	Spill, leak, delivery system failure or overflow	Terrestrial fauna (mammals, reptiles, birds), terrestrial flora	Ingestion, dermal, uptake via roots	Possible	The presence of humans and stimulation activities is expected to deter wildlife. The greatest hazard is to terrestrial flora in the immediate vicinity of a spill. Provided flora populations are not unique to the area of the well lease, re-colonisation is expected post-spill clean-up.

2.1.2 Off-site Exposure Pathways

The off-site environment is considered to be anything outside the boundary of the well lease. As discussed in Volume One the study area is sparsely developed with the predominant land use being for livestock. Volume One indicates the location of wells to be stimulated and indicates there are no major towns or homesteads within close proximity of a stimulation well.

As discussed in Volume One, published research indicates, on the basis of water level and water quality analysis (including major and minor ion chemistry and stable isotope analysis), that the surface water features in the study area (typically consisting of semi-permanent waterholes that form between episodic flood event) do not receive shallow groundwater recharge (Hamilton et al., 2005; Bunn et al., 2006; Costelloe et al., 2007, Cendon et al., 2010). The reported characteristic quality of groundwater in the shallow unconsolidated aquifers in the study area is saline, and the water quality and isotopic signature is distinct from that of the fresher water in the water holes of the Channel Country. In addition, reported water levels in the shallow aquifer are inferred to be below the base of the surface water features in the study area, such that water holes, and flowing river channels during flood events, are considered to be losing water features (i.e. exhibit leakage of water into the ground but do not receive groundwater baseflow). Hence, the potential exposure pathway comprising leakage of stimulation fluid down to shallow groundwater, off-site migration with groundwater flow and discharge to an aquatic environment associated with a surface water feature is considered to be an incomplete exposure pathway in the study area and has therefore been excluded from further consideration.

In the majority of instances, the well lease sites where stimulation will be conducted will be remote from water supply bores and will maintain an appropriate buffer distance from environmentally sensitive areas.

Table 3 provides a summary of the possible sources, exposure scenarios, human populations, ecological receptors and exposure pathways considered relevant for off-site. The main possible sources identified are the stimulation fluid, sediments in a panel tank and flowback water. These are discussed in more detail below.

2.1.2.1 Exposure to Stimulation Fluid

Potential human and ecological exposures to stimulation fluid is unlikely but theoretically could occur due to casing failures or through fractures into overlying aquifers. However, Santos currently uses an extensive system of procedures to minimise the likelihood of the fracture (and then the fluid) leaving the target area and the loss of well integrity; these are described in Volume One. The systems include extensive testing programs and operational and systems monitoring to ensure stimulation activities are confined to the target units. If a loss of integrity is identified in a well immediate measures are employed to decommission or rectify the situation.

On this basis it is considered unlikely that exposure to stimulation fluids could occur due to the fluid escaping the target formation and contaminating adjacent aquifers that are used for domestic or stock water supply.

This conclusion is supported by a study completed by Osborn et al (2011) which evaluated aquifers overlying the Marcellus and Utica shale formations of north-eastern Pennsylvania and upstate New York. The study evaluated a number of issues associated with stimulation including:

‘*Concerns for impacts to groundwater resources, from (i) fluid (water and gas) flow and discharge to shallow aquifers due to the high pressure of the injected stimulation fluids in the gas wells’*

The study evaluated groundwater from 68 private water wells which ranged in depth from 36 to 190 m. The area of the study is undergoing an expansion of gas well drilling and stimulation and is in an area with extensive fracture systems with several major faults and lineaments. The study found:

'no evidence for contamination of the shallow wells near active drilling sites from deep brines and/or stimulation fluids''

A second source of possible human and ecological exposure to stimulation fluids is residual fluid in the target formation. It is conservatively assumed that up to 40% of fluid may remain in the target formation immediately following stimulation. Based on the depth and separation of the target formations in the Cooper and Eromanga Basin, it is considered unlikely that exposure would occur if chemicals in the residual fluid migrate down gradient in the target formation. Residual stimulation fluids captured during the production stage of the well operations would act to reduce the residual volume in the reservoir over time and would be managed in accordance with the produced formation water management systems. In addition, stimulation fluid chemicals are likely to rapidly reduce through dissociation of organic chemicals and the relatively short biotransformation half-lives of the majority of the organic chemicals.

As indicated in Volume One, the results of the bore inventory in the study area indicated that the closest water supply bores installed in proximity of a hydrocarbon-bearing formation (Hooray Sandstone) to Santos production wells potentially targeting the same formation is approximately 45 km. Residual stimulation fluid constituents in groundwater would be expected to attenuate well within this distance. This conclusion is based on review of the information in the DES registered bore database, and the available results of an ongoing Water Bore Baseline Assessment program to verify the information in the database. This conclusion is subject to review, if warranted, on the basis of future bore inventory results and fracture locations.

2.1.2.2 Exposure to Sediments in the Panel Tank

Potential off-site human and ecological exposure to the sediment could occur if the panel tank is drained and the sediments were left to dry out and contribute to wind-borne dust. However, the majority of sediment is removed via vacuum truck and disposed of off-site. The volume of residual sediments in the panel tank is therefore considered to be small and unlikely to be of concern to either humans or ecological receptors. Additionally, the height of the panel tanks (approximately 2 m) is likely to minimise the potential for windblown dust to enter the environment.

2.1.2.3 Exposure to Flow Back Water

Potential off-site human and ecological exposure to chemicals in the flowback water is unlikely but could possibly occur under a range of conditions; however, the implementation of controls makes this unlikely. Exposure scenarios are considered unlikely to include the potential for releases or infiltration of flowback water into shallow aquifers that are used for domestic or stock water supply or which discharge to surface water, and direct releases to surface water.

For this exposure pathway to be complete there must be all of the following:

- A failure of the panel tank and the panel tank double lining.
- A high permeability unit beneath the well lease that is able to transmit the flowback water to an underlying aquifer; and
- A shallow aquifer present in the subsurface beneath the well lease, that is either used as water supply or discharges into a creek.

If any of the above conditions are missing, no exposure will occur. The surface lithology of the Cooper Creek drainage was described as comprising a thick layer of low permeability "mud" overlying sand beds that host the shallow, saline aquifer (e.g. Nanson et al., 2008). The fine-grained surface deposits would substantially reduce the potential for infiltration of leaking flowback water to reach the shallow aquifer, and the shallow "water table" aquifers have been reported to be saline to the extent that they are unsuitable for most beneficial uses (e.g. Cendon et al., 2010). The shallowest groundwater supply in the study area is typically sourced from either the Glendower Formation or the Winton Formation, which underlie the Quaternary unconsolidated

sediments. Surface water bodies have been reported to be disconnected from the shallow groundwater system.

The concentrations of stimulation chemicals in the flowback water are expected to be lower than those injected due to the capture of first flush, although flowback water is likely to contain concentrations of 'geogenic' chemicals from the hydrocarbon reservoir. However, the toxicity of those chemicals is expected to rapidly decrease due to dissolution, the relatively rapid biodegradation and volatilisation of many of the chemicals. The likelihood of exposure to stimulation chemicals under this scenario in concentrations likely to be of concern is considered to be low.

2.1.2.3.1 Spills and Overflows from Panel Tanks

Potential off-site human and ecological exposure to flowback water is considered unlikely but could possibly occur in the event of a spill or overflow from the panel tank. However, the panel tanks are approximately 2 m in height and are adjusted (width and length ways) to be able to hold the maximum expected amount of flow back water and stormwater for a location. On this basis, a release could only occur during a prolonged period (weeks) of heavy rainfall. The probability of a spill or overflow event occurring is further reduced by minimising the duration that flowback fluids are stored in panel tanks. In addition, the toxicity of the chemicals in the flowback fluid are likely to rapidly reduce based on the dissociation of the inorganic chemicals, and the relatively short biotransformation half-lives of the majority of organic chemicals. In the event of a release, human and ecological receptors could possibly be exposed however sampling of soil, groundwater and surface water (if relevant) in the affected area would be required to determine if unacceptable exposures had occurred.

2.1.2.4 Management Measures to Reduce Off-site Exposure

Management measures that are implemented to reduce the potential for off-site exposure or to assess the potential for exposure include:

- Double lining of panel tanks to prevent seepage of flowback water into an underlying aquifer. This is already undertaken as a minimum standard.
- Establishment of buffers during establishment of well leases between petroleum operations and potential "environmentally sensitive areas" identified though database review and site-specific ecological assessment where warranted.
- Vacuum removal and disposal of the sediments during fluid drainage of the panel tank as soon as practicably possible.
- Soil, groundwater and surface water sampling of affected area following any spill/ overflow of a panel tank.

Table 3 provides a summary of the possible sources, exposure scenarios, populations and receptors and exposure pathways considered relevant for off-site exposure concerns.

Table 3: Off-Site Exposure Assessment Summary

Source	Exposure Scenario	Receptors	Exposure Pathways	Likelihood of Exposure Scenario	Comment
Stimulation Fluids	Fracture fluid escapes into aquifer via a well casing failure, or a fault/ fracture/ unconformity in formation/strata, and fluids enter aquifer used down gradient for stock and domestic water supply	Residents: adults and children Livestock	Ingestion, dermal, inhalation Ingestion	Unlikely	The exposure scenario is unlikely given the pathway linking source to receptor is predominantly absent. The shallowest occurrence of groundwater is generally at a depth that precludes hydraulic connection with surface water features resulting in a lack of GDEs within the study area. The well lease sites are remote with limited human inhabitants in the proximity of the operations – groundwater supply development is accordingly very limited, with large vertical or lateral separation of water supply wells from hydrocarbon reservoirs. Extraction of groundwater for domestic and livestock use is limited in the study area, as evidenced by the small number of registered bores (and even smaller number whose existence was confirmed during recent bore inventory and baseline assessment). The closest groundwater to surface water discharge points occur at significant distances down-hydraulic gradient of the well lease sites (i.e. of the order of 100 km or more). Exposure concentrations of stimulation chemicals at the receptor are likely to be insignificant. Management measures include Santos operational procedures i.e. well integrity testing and design of fracture to stay with the target formation. No recorded instances in peer-reviewed literature of stimulation chemicals in down gradient water supplies (Osborn et al 2011).
	Fracture fluid escapes into aquifer via a well casing failure, or a fault/fracture/unconformity in formation/strata, and fluids enter aquifer that discharges to surface water	Aquatic ecosystems	Direct exposure	Unlikely	
	Residual stimulation fluid in the formation migrates down gradient and enters a spring or water supply bore	Residents, aquatic ecosystems, livestock	Ingestion, dermal, inhalation	Unlikely	
Panel Tank Sediments	Panel tank sediment dry and become windblown dusts, contaminating surrounding soil	Native terrestrial flora and fauna, stock, Residents adults and children	Direct exposure/ inhalation/ ingestion of dusts	Unlikely	The majority of sediments / residues are removed from site using vacuum truck and appropriately treated and disposed as soon as practicable. Residual sediments are considered to be minimal.
Flowback Water	Seepage of chemicals to a shallow aquifer used downgradient for domestic water supply	Residents: adults and children	Ingestion, dermal, inhalation	Unlikely	Panel tanks are double lined as a minimum standard. The shallowest aquifer in the Quaternary sediments is reported to be very saline and is covered by a thick layer of low permeability mud which substantially limits

Source	Exposure Scenario	Receptors	Exposure Pathways	Likelihood of Exposure Scenario	Comment
	Seepage of chemicals to a shallow aquifer used downgradient for stock water supply	Livestock	Ingestion	Unlikely	infiltration. Extraction of groundwater for domestic and livestock use is limited in the study area, with a small number of bores whose existence was confirmed during a bore inventory. Identified bores are typically remote from the well lease operations, or access groundwater resources that would be very unlikely to be affected by surface seepage of flowback fluid; hence exposure pathway is considered to be incomplete.
	Seepage of chemicals to a shallow aquifer that discharges to surface water	Aquatic ecosystems	Direct exposure	Unlikely	
	Spill or leak from panel tank or tank overflow	Terrestrial fauna (mammals, reptiles, birds), terrestrial flora	Ingestion, dermal, uptake	Possible	Possible overflows during prolonged periods of high rainfall (>300 mm of rainfall required). The panel tank size is based on maximum expected flow back and environmental waters to try to prevent overflow. The greatest hazard is to terrestrial flora in the immediate vicinity of an overflow. Provided flora populations are not unique to the area, re-colonisation is expected post-overflow event. Likelihood of occurrence can be reduced through minimising storage duration, and transition to storage tanks for flowback water transport. The toxicity of fluid is likely to decrease rapidly due to short biotransformation half-lives of most chemicals.

2.2 Identification of Complete Exposure Pathways

2.2.1 On-site Exposure Pathways

The potential on-site exposure pathways are discussed in Section 2.1.1. The most likely potential exposures were evaluated for workers, trespassers, small fauna, flora and soil microorganisms.

Based on information provided by Santos, there does not appear to be complete exposure pathways identified for on-site workers under normal circumstances, provided the following conditions are met:

- Adequate OH&S procedures are adhered to that prevent direct contact and inhalation exposure with chemicals during spills and when handling flowback water or sediments; and
- Sediments in the panel tanks are disposed of appropriately and as soon as practicable.

Exposure of trespassers is considered to be an unlikely occurrence due to the nature of the sites and their remote locations. Exposure to flowback water is a complete exposure pathway (ingestion, dermal and inhalation) if trespassing occurs on unsecured sites. Exposure will be limited through ensuring all panel tanks are at least 2m in height with signage clearly displayed to indicate that the well lease is a work zone and access is restricted to authorised personnel.

Exposure pathways to the flowback water and dried sediments in the panel tanks for large native fauna (i.e. kangaroos) and livestock can be considered incomplete on the basis that the panel tanks are at least 2 m high and the majority of sediments are removed for off-site disposal.

Exposure pathways (direct contact) for small flora and fauna (i.e. soil microorganisms, plants, small mammals, snakes, lizards and birds) is considered complete for exposure to the flowback water in the panel tanks if a spill or leak was to occur or if birds or small mammals entered the tanks. Practical measures implemented by Santos will minimise potential exposures.

2.2.2 Off-site Exposure Pathways

The on-site exposure pathways are discussed in Section 2.1.2. The most likely potential exposures were evaluated for residents, livestock, native flora and fauna and aquatic ecosystems. Three possible sources were identified: stimulation fluids, sediments from the panel tank or flowback water.

Exposures were considered unlikely for all scenarios based on the engineering (liners) and operational controls that are being implemented by Santos, and the geographical remoteness of the stimulation activities. In the unlikely event that an uncontrolled release was to occur potential exposures could include direct contact and inhalation exposures for residents, livestock, native flora and fauna and aquatic ecosystems. The probability of a release from a panel tank occurring can be reduced through minimising the duration of flowback fluid storage. In addition, the toxicity of the chemicals in the flowback fluid are likely to rapidly reduce through dissociation of organic chemicals and the relatively short biotransformation half-lives of the majority of the organic chemicals.

The potential exposure to stimulation fluids due to entry into an overlying water supply aquifer via a well casing breach or a natural preferential pathway (fault/fracture) is considered unlikely. Santos has established operational procedures to foster well integrity and that fractures are contained within the target formation. The exposure pathways associated with residual fluid in the target formation is discussed in Section 2.1.2.1.

The potential exposure to residual sediments in the panel tank becoming windblown dusts (direct contact/inhalation and ingestion of dust) and contaminating surrounding soil is considered unlikely. Sediments are removed via a vacuum truck during fluid removal and the residual volume of tank sediments is likely to be insufficient to result in concentrations in soil that would be of concern in the surrounding terrestrial

environment. Additionally, the height of the panel tanks (approximately 2m) would act to reduce sediments becoming windblown dusts.

The potential for seepage of flowback fluids from the panel tank into an underlying aquifer and migration to a domestic water supply or discharge into a creek are considered unlikely. Santos are using double lined panel tanks to prevent the loss of fluids onto the surface and subsequently into the subsurface. If releases were to occur, the typical surface lithology in the study area comprises a thick layer of fine-grained material overlying the sand beds that host a saline aquifer (e.g. Nanson et al., 1998). The fine-grained material will substantially reduce the infiltration potential of released fluids, and the shallowest aquifer is generally too saline for most beneficial uses (e.g. Cendon et al., 2010). The shallowest groundwater resource developed for water supply in the study area is the Tertiary Glendower Formation, which underlies the unconsolidated Quaternary sediments.

2.2.3 Residual Stimulation Fluids in Target Formations

The depths to oil target formations in the study area exceed 1,300 mbgl, and typical depths of stimulation operations targeting gas formations occur at depths greater than 2,000 m bgl. The exposure pathways associated with injected stimulation fluids are considered to include water supply bores screened either within the oil target formation itself, or in an aquifer formation immediately adjacent to the target formation.

2.2.3.1 Groundwater Extraction in the Eromanga Basin

Due to the depth (1,300 m bgl) and variable water quality of the oil target formations in the Eromanga Basin, and of the presence of shallower resources of suitable quality and yield, groundwater from the target formations is not typically used by the few pastoralists and residential users within the study area.

The following observations are made based on the proximity of water supply wells to oil and gas well locations in Volume One:

- The average offset between the base of the deepest (Hutton Sandstone) aquifer and the top of the Permian gas reservoirs is of the order of 200 to 300 m, with most of the intervening section consisting of impermeable mudstones and shales. However, landholder bores generally access the shallowest viable aquifer which, in the vicinity of the site, can be the shallow Glendower or Winton Formations. The vertical offset between these aquifers and the top of the gas-bearing Permian interval is of the order of 1,300 m to 1,800 m for the Glendower and 1,000 m to 1,500 m for the Winton.
- The active landholder bores in the oil fields of the *study area* range from approximately 3 to 10 km from the nearest proposed oil fracture stimulation target well. The upper-most formation proposed for stimulation is the Wyandra Sandstone (Upper Cadna-Owie). The nearest bore, Mt Margaret No 14, targets the relatively shallow Winton formation for stock purposes. The vertical distance at this location between the Winton Formation and the Wyandra Sandstone is at least 750 m.
- The active landholder bores within, or near, the gas fields of the *study area* range from approximately 45 to 90 km away from the nearest proposed stimulation location. The upper-most targets proposed for stimulation are formations within the Nappamerri Group. The vertical distance between the Hooray Sandstone and the Nappamerri group at this location is greater than 600 m; and
- The Coothero Bore was observed during the WBBA, and according to DEHP, targets the Hooray Sandstone for stock water. The Coothero Bore is located approximately 45 km from the nearest proposed location for gas production, and more than 80 km from the nearest location proposed for oil production from the Hooray Sandstone.

Hence, based on the available information, it appears unlikely that a complete exposure pathway exists in the study area for stimulation fluids to reach a water supply well.

2.2.3.2 Groundwater Extraction in the Cooper Basin

Due to the significant depth of the Cooper Basin aquifers, these have not been accessed for water supply and are only intercepted while targeting gas production. This is supported by WERD and DES (formerly DEHP) Groundwater Databases and a recent Water Bore Baseline Assessment.

While no known water supply wells are completed within the Cooper Basin, although significantly separated, water supply development in the Eromanga Basin is considered as the next vertically closest aquifer in the study area (as discussed above). However, the important water supply aquifers of the Eromanga Basin are separated from the Cooper Basin reservoir formations by a major structural unconformity and basal aquitard units of the Eromanga Basin, and therefore, hydraulic connection is limited.

Based on the absence of water supply development in the Cooper Basin formations, and the limited hydraulic connectivity and significant vertical distance between the Cooper Basin and Eromanga Basin formations, the potential for a complete exposure pathway for either an environmental or water supply receptor is considered to be very low.

3.0 PRODUCT DESCRIPTION

Halliburton provided chemical information for stimulation fluids (a.k.a, fluid systems), as follows:

- *DeltaFrac(H) Treatments'*
- *'DFS-BCG Treatments'*
- *'DFS-BCG(H) (formally HyborH) Treatments'*
- '*High Temperature Acid Spearheads*'.

Golder understands these fluids are used in SWQ stimulation operations, for stimulation oil and gas formations.

3.1 Chemical Constituents

A list of the individual stimulation fluid chemicals considered in this risk assessment and their respective Chemical Abstracts Service Registry numbers (CAS RN) are listed in Table 4. This list is similar to, but will inevitably vary from, other published sources of stimulation fluid compositions, as the specific stimulation fluid mixtures are proprietary products of the stimulation contractors and their product suppliers.

None of the stimulation fluid chemical constituents presented by Halliburton in the 13 July 2012 disclosure and in the information provided by Santos (November 2019) contained benzene, toluene, ethylbenzene, xylenes (BTEX) or polycyclic aromatic hydrocarbons (PAHs). It is noted, however, that TPH, PAHs and BTEX occur naturally in conventional oil and gas condensate and it is possible that these chemicals may naturally be present in the reservoir groundwater used in the stimulation process. In terms of the reaction by products of these chemicals none of the reaction by products are known to exhibit higher toxicity than the parent compounds. However, it is recognised that geochemical reactions in the formation are complex and there are knowledge gaps in this specific area.

Table 4: Stimulation Chemicals Sorted into Organic and Inorganic

Chemical Type	Chemical Name	CAS RN
Organic	Acetic acid	64-19-7
	Alcohols, C12-16, ethoxylated	68551-12-2
	Amine oxides, cocoalkyldimethyl	61788-90-7
	Benzaldehyde	100-52-7
	Cinnamaldehyde	104-55-2
	Citric acid	77-92-9
	Diethylene glycol	111-46-6
	Methanol	67-56-1
	Triethanol amine	102-71-6
	Diethanol amine	111-42-2
	Ethanol	64-17-5
	Hydrotreated light petroleum distillate	64742-47-8
	Sodium polyacrylate	9003-04-7
	Alcohols, C12-C15, ethoxylated	68131-39-5
	Amides, tall-oil fatty, N,N-bis(hydroxyethyl)	68155-20-4
	Fatty acids, tall-oil, ethoxylated	61791-00-2
	Butyl alcohol	71-36-3
	Tributyl tetradecyl phosphonium chloride	81741-28-8
	Glutaraldehyde	111-30-8
	Monoethanolamine borate	26038-87-9
	Guar gum	9000-30-0
	Ethylene glycol	107-21-1
	Hydroxylpropyl guar	39421-75-5
Inorganic	Aluminium oxide	1344-28-1
	Chlorous Acid, sodium Salt	7758-19-2
	Disodium octaborate tetrahydrate	12008-41-2
	Hydrochloric acid	7647-01-0
	Iron oxide	1309-37-1
	Sodium bisulfite	7631-90-5
	Sodium carbonate	497-19-8
	Sodium chloride	7647-14-5

Chemical Type	Chemical Name	CAS RN
	Sodium hydroxide	1310-73-2
	Sodium iodide	7681-82-5
	Titanium dioxide	13463-67-7
	Ulexite	1319-33-1
	Aluminium silicate	1302-76-7
	Crystalline silica, cristobalite	14464-46-1
	Crystalline Silica, quartz	14808-60-7
	Silica Gel	112926-00-8

3.2 Mass Balance Calculations

A quantitative mass balance assessment of stimulation fluid components was undertaken. Four 'fluid systems' were assessed. For each mixture, Halliburton provided to Santos details regarding the products in the mixture, and a complete inventory (including mass fraction) of the individual chemicals in the fluid mixtures. The composition of the stimulation fluids and calculated total mass and injected concentrations of the individual chemicals are summarised in further detail in Table D1, APPENDIX C. The fluid compositions in Table C1 were divided into chemical additives, proppants, water in additives, and makeup water.

Mass and mass fraction calculations were undertaken by Santos based on information provided by the stimulation service provider in their "Stimulation Fluid Disclosure". Table 5 presents the estimated mass (constituent weight) of additives, proppant and water included in the stimulation fluid systems *per stimulation event* for both the oil and gas wells. The stimulation service provider noted that typically only one stimulation event is conducted on oil production wells, whereas up to six stimulation events may be conducted on conventional gas production wells.

Table 5: Estimated Component Mass per Stimulation Event in Typical Stimulation Fluid Systems

Fluid System	DeltaFrac(H)	DFS-BCG	DFS-BCG(H)	High Temp. Acid Spearhead
Typical Fluid Volume [1]				
Mass of Stimulation Fluid Components (kg)				
Additives	566	1,904	2,064	307
Proppant	49,895	49,895	49,895	0
Water in additives	442	1298	1319	540
Makeup water	56,932	189,976	189,975	647
Proportion of Stimulation Fluid Components by Mass (%)				
Additives	0.5%	0.8%	0.8%	20.5%
Proppant	46.3%	20.5%	20.5%	-
Water in additives	0.4%	0.5%	0.5%	36.2%
Makeup water	52.8%	78.2%	78.1%	43.3%

Notes: [1]Fluid volume per stimulation event, information not provided at time of preparation of this report

The additives in typical stimulation fluid mixtures comprise approximately 0.5 to 0.8 wt.% of the injected mixture for the primary fluid systems (DeltraFrac(H), DFS-BCG and DFS-BCG(H)) and the friction reduced water typically used for flushing during the stimulation process. The relative percentage of additives is higher in the acid spearhead mixture as this is a concentrated acid, however, is used in smaller total volumes when required.

If either DeltraFrac(H), DFS-BCG or DFS-BCG(H) are used to perform up to six stimulation stages within a single gas production well, then the total mass of additives injected for the well (excluding proppant) would range from approximately 1,840 kg to 12,000 kg.

Following completion of the stimulation process, a considerable volume of the injected stimulation fluids are recovered upon flowback of the injected fluid. Studies performed by the USEPA (2004) indicated that approximately 60% of the stimulation fluids are recovered in the first three weeks, and total recovery was estimated to be from 68% to 82%. If it is conservatively assumed that 40% of the stimulation fluid volume remains in the formation (this being the “worst case”) this would correspond to 120 to 830 kg per stimulation event, or 740 kg to 5,000 kg per production well where up to six stimulation stages are performed (excluding proppant).

4.0 AQUATIC HAZARD ASSESSMENT

An environmental hazard assessment was undertaken to classify the stimulation chemicals based on persistence (P), bioaccumulation (B) and toxic (T) potential (hereafter referred to as PBT). Using PBT, stimulation chemicals were classified into one of three hazard groups: low, moderate or high. Chemicals classified as high hazard were considered to be chemicals of potential concern (COPC). Identification of a chemical as a COPC did not indicate an unacceptable hazard, nor did it include an evaluation of whether there was a link between source, pathway, and receptor. A high hazard classification indicated the need to evaluate exposure to these chemicals in greater detail. A discussion of possible exposure pathways (to people and the environment) is presented later in Section 2.0 and a qualitative (in the absence of exposure concentrations) characterization of risk is presented in Section 7.0.

The environmental hazard assessment approach developed for this study used national and international guidance for assessment of PBT in the risk assessment, classification, and regulation of chemicals. The guidance used is predominantly focussed on hazard to aquatic receptors. The available guidance for assessment of hazard to terrestrial receptors is somewhat limited. Consequently, in the assessment of environmental hazard, aquatic and terrestrial toxicity were considered separately. This section presents the environmental hazard and includes assessment of toxicity to aquatic receptors. Section 5.0 presents the assessment of toxicity to terrestrial ecological receptors. Section 6.0 presents the human health toxicity assessment.

4.1 Chemical Information Sheets

In order to assess environmental hazard, readily available chemical and physical properties and aquatic ecotoxicological data were collated for the chemicals assessed. This information was compiled into a chemical information sheet for each chemical. The chemical information sheets are presented in APPENDIX E. The data used in the environmental hazard assessment of each chemical, are discussed in the following paragraphs.

4.1.1 Chemical and Physical Properties

Physical and chemical properties that affect the fate and behaviour of chemicals in the environment were used in the assessment of environmental P and B were obtained from the following sources in order of priority:

1) European Chemicals Agency (ECHA).
2) U.S. National Library of Medicine, National Center for Biotechnology Information, PubChem (PubChem).
3) Modelled data from USEPA (2009) EPISUITE™ (Estimation Programs Interface Suite™ for Microsoft® Windows) modelling software (only when data were not available from the SDS or the HSDB); and
4) For data poor chemicals, an internet search for reputable agencies or researchers who may have published data.
5) The Material Safety Datasheet (SDS) provided to Golder by the contractor (provided in APPENDIX B for reference).

USEPA (2009) EPISUITE™ software was developed by Syracuse Research Corporation (SRC) for the USEPA Office of Pollution Prevention and Toxics. EPISUITE™ provides a package of modelling software programs that can estimate physical/chemical, environmental fate and ecotoxicity data for organic chemicals. Inorganic chemicals should not be evaluated using EPISUITE™ because the estimation methods used are developed based on organic chemicals.

In using EPISUITE™, the following limitations for modelling organic chemicals are noted:

1) Chemicals that rapidly hydrolyse are unsuitable to be modelled namely, acid halides[2], isocyanates[3], sulphonyl chlorides[4], siloxanes[5], and alpha-chloro ethers. No chemicals identified in the list of stimulation chemicals considered for this study meeting this description were subject to modelling.
2) Data generated for organic salts may not be reliable, namely cationic salts of Group I, Group II, transition metals, Actinides, and Lanthanides. These should not be profiled because there are not adequate data in the estimation models' databases to predict properties with confidence. Organic salts however of Sodium (Na), Potassium (K), and Ammonium (NH_4^+) may be evaluated reliably. No chemicals identified in the list of the stimulation chemicals considered for this study meeting this description were subject to modelling.
3) Organo-metallic compounds should not be evaluated. No chemicals identified in the list of the stimulation chemicals considered for this study meeting this description were subject to modelling.
4) Highly reactive compounds should not be modelled. No chemicals identified in the list of the stimulation chemicals considered for this study meeting this description were subject to modelling; and
5) High molecular weight compounds with a molecular weight greater than 1000 should not be modelled. No chemicals identified in the list of the stimulation chemicals considered for this study meeting this description were subject to modelling.

The EPISUITE™ estimation programs are simple to use, requiring only one input (e.g., CAS RN or SMILES notation[6]) from the user and a nomination of the program to be used based on the data required by the user. EPISUITE™ includes a database of chemical and physical properties, algorithms, and Quantitative Structure Activity Relationships (QSAR) models with which to estimate parameters. The following programs were used to generate physical and chemical data for this study:

- KOWWIN™ - octanol/water partition coefficient (K_{ow}).
- HENRYWIN™ - Henry's Law Constant.
- BIOWIN™ - Biodegradation rate.
- LEV3EPI™ - Fugacity model to estimate partitioning to soil air, water and sediment.
- KOCWIN™ - Soil organic carbon partition coefficient (K_{oc}); and
- BCFBAF™ - Bioconcentration factor.

[2] Acid halides are organic compounds containing the group -COX where X is a halogen atom (e.g., fluorine, chlorine, bromine, iodine). The inherent reactivity of acid halides precludes their free existence in nature; all are made by synthetic processes.

[3] Isocyanates are salts or esters of isocyanic acid, they are nitrogen based and may be described as neutral derivatives of primary amines. Isocyanates are represented by the general formula RNCO where R typically represents an alkly (a monovalent radical, such as ethyl or propyl, having the general formula CnH2n +1) or aryl (an organic group derived from an aromatic hydrocarbon by removal of one hydrogen), but sometimes is linked to elements such as sulphur (S), silicon (Si), phosphorous (P), nitrogen (N), or the halogens (e.g., fluorine, chlorine, bromine, iodine).

[4] Sulfonyl chlorides have the general formula R-SO_2-Cl which hydrolyse readily and are reactive with alcohols and amines.

[5] Siloxanes may be organic or inorganic and are made up of silicon, oxygen, plus (usually) carbon and hydrogen. They have the structural unit R_2SiO, where R is an alkyl group, usually methyl.

[6] SMILES (**S**implified **M**olecular **I**nput **L**ine **E**ntry **S**ystem) string is a linear notation for chemical structures.

4.1.2 Aquatic Toxicity Information

Acute and chronic aquatic ecotoxicological data were obtained from the following sources in order of priority:

1) USEPA (2009 and 2019) ECOTOXicology Database Version 4.0.
2) European Chemicals Agency (ECHA).
3) U.S. National Library of Medicine, National Center for Biotechnology Information, PubChem (Pubchem).
4) Safety Data Sheets (SDS) provided to Golder under this contract.
5) Australasian Journal of Ecotoxicology; and
6) Hazardous Substances Data Bank (HSDB, a toxicology database on the U.S. National Library of Medicine's Toxicology Data Network.

Where ecotoxicological data were not available for the chemicals of interest or a suitable surrogate, data were modelled using ECOSAR™ software version 1.11 dated July 2012. ECOSAR™ (which stands for Ecological Structure Activity Relationships) estimates the toxicity of chemicals to fish, aquatic invertebrates and microalgae in water. Toxic effect predictions are made using a set of QSARs models. QSARs predict the aquatic toxicity of untested chemicals based on their structural similarity to chemicals for which aquatic toxicity data are available. The toxicity data used to build the QSARs come from a database of publicly available and confidential data submitted to the US EPA New Chemicals Program. The QSARs used in ECOSAR™ correlate a compound's physicochemical properties and its aquatic toxicity within specific chemical classes and applies rules for selecting the appropriate chemical class for the compound. ECOSAR™ generates acute (short-term) toxicity and, when available, chronic (long-term or delayed) toxicity.

In using ECOSAR™, the following limitations are noted:

1) ECOSAR™, is designed to be used by individuals with some knowledge of environmental toxicology and organic chemistry, it is not designed to be used by individuals without experience in these fields.
2) Inorganic chemicals (e.g., sodium chloride, and non-polar inorganics such as titanium dioxide) should not be evaluated using ECOSAR™. No chemicals meeting this description identified in the list of stimulation chemicals considered for this study were subject to modelling.
3) Organo-metallic chemicals[7] should not be evaluated using ECOSAR™. No chemicals meeting this description identified in the list of stimulation chemicals considered for this study were subject to modelling.
4) For chemicals that rapidly hydrolyse or highly reactive chemicals it is suggested that evaluations using ECOSAR™ should take into consideration the degradation products in addition to the parent compounds. As a general rule, where:
   - Half-life < 1 hour, an assessment of degradation products may be recommended.
   - Half-life = 1 hour – 14-days, an assessment of parent and degradation products may be recommended.
   - Half-life > 14-days, an assessment of the parent product may be recommended.
5) Complex salts[8] with a complex organic cation and anion are difficult to model using ECOSAR™. In cases such as these the anion, cation and dissociation products should be taken into consideration. Based on the individual compounds it should be modelled as a single compound (neutralized with both cation and anion attached) or as separate individual compounds (dissociated with no charge). No

[7] Organo-metalls are chemicals that contain carbon bonded to a metal species such as methyl mercury compounds.

[8] Complex salts such as potassium ferricyanide ($K_3Fe(CN)_6$) which consists of a complex ion that does not dissociate in solution, differ from simple inorganic salts such as sodium chloride (NaCl) that readily dissociates in solution.

chemicals meeting this description identified in the list of stimulation chemicals considered for this study were subject to modelling, either as a compounds or as individual components.

6) Compounds with a molecular weight greater than 1,000 should not be evaluated using ECOSAR™. However, many polymers are made up of dimers, trimers and oligomers with a molecular weight of less than 1,000 and therefore the individual components could be assessed using the ECOSAR™ model separately. No chemicals meeting this description identified in the list of stimulation chemicals considered for this study were subject to modelling, either as compounds or as individual components.

7) The ECOSAR™ model does not have the ability to take into consideration molecular conformation, and therefore cannot distinguish between stereoisomers, optical isomers, tautomers, or specific conformations. This is important as three-dimensional molecular properties or molecular conformation can be important as this relates to absorption, binding, and resulting toxicity potential of a chemical; and

8) Chemicals with unknown or variable composition (UVCs, such as oligomers, natural fats, or a product mixture) may have different results using ECOSAR™ depending on the composition assessed with the model. For chemicals such as these the representative structures would need to be identified and noted or all possible compositions would need to be assessed. No chemicals meeting this description identified in the list of stimulation chemicals considered for this study were subject to modelling.

4.2 Hazard Versus Risk

The approach presented in the following paragraphs is an assessment of environmental hazard, rather than environmental risk. Risk assessment of chemicals in the environment is based on a comparison between the levels to which an organism in a particular environmental compartment (e.g. water) is exposed, and a maximum level which an organism can tolerate based on a defined exposure scenario (in an environmental compartment) without significant adverse effect. The environmental hazard assessment presented herein, is not a risk assessment *per se* because it does not consider likely exposure concentrations for most of the stimulation chemicals. A qualitative assessment of the risk will be conducted based on an identification of relevant exposure pathways associated with the stimulation fluid COPC.

Approaches to ranking or screening chemicals for the purposes of assessing relative “hazard” or “risk” can include likelihood and consequence matrices. In these matrices, a chemical may be scored high for consequence (which may be a function of PBT) but low for likelihood (which may be a function of whether the chemical is considered likely to be present in the environment at hazardous concentrations). Overall, such a chemical may then score a relatively lower hazard or risk than would be identified from its consequence (or PBT) score alone. The environmental hazard assessment approach here works on the premise of potential for PBT; that is, the data that may apply to “consequence”. “Likelihood” of exposure was not assessed.

4.3 Hazard Assessment Approach

The environmental hazard assessment approach developed for this study is consistent with national and international guidance for assessment of potential for PBT in the risk assessment, classification, and regulation of chemicals. Physical and chemical properties that affect the fate and behaviour of chemicals in the environment (including degradation rates, partition coefficients, and aquatic ecotoxicological data) were used in assessment of environmental PBT potential.

The Australian National Framework for Chemicals Environmental Management (NChEM) guidance manuals were consulted in preparation of the environmental hazard assessment approach, namely:

- EPHC (2009a). Environmental Risk Assessment Guidance Manual for Industrial Chemicals; and
- EPHC (2009b). Environmental Risk Assessment Guidance Manual for Agricultural and Veterinary Chemicals.

These guidance manuals present the data requirements and methodology for assessment for environmental hazard and risk assessment of industrial and agriculture and veterinary chemicals, consistent with international best practice. NChEM guidance was prepared by the National Environment Protection and Heritage Council (EPHC) for the Department of the Environment, Water, Heritage and the Arts (DEWHA). DEWHA undertakes environmental risk assessments of industrial chemicals for the National Industrial Chemicals Notification and Assessment Scheme (NICNAS) and of agricultural and veterinary chemicals for the Australian Pesticides and Veterinary Medicines Authority (APVMA).

In addition, the following literature was consulted for PBT assessment guidance:

- ANZECC and ARMCANZ (2000). Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand, National Water Quality Management Strategy, Australian and New Zealand Guidelines for Fresh and Marine Water Quality, October 2000.
- ANZG (2018). Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Australian and New Zealand Governments and Australian state and territory governments, Canberra ACT, Australia.
- CCME (2008) Canadian Council of Ministers of the Environment, The National Classification System for Contaminated Sites (NCSCS) Guidance Document.
- Christensen et al. (2003) Assessment Tools under the New European Union Chemicals Policy.
- Environment Canada (2003) Existing Substances Branch Guidance Manual for the Categorization of Organic and Inorganic Substances on Canada's Domestic Substances List, Determining Persistence, Bioaccumulation Potential, and Inherent Toxicity to Non-human Organisms.
- European Commission (2003) Technical Guidance Document on Risk Assessment in support of Commission Directive 93/67/EEC on Risk Assessment for New Notified Substances, Part II Chapter 3 Environmental Risk Assessment.
- ECETOC (2005) Risk Assessment of PBT Chemicals.
- Franke et al. (1994) The Assessment of Bioaccumulation.
- Langley (1993) Refining Exposure Assessment. In: The Health Risk Assessment and Management of Contaminated Sites. Proceeding of the Second National Workshop on the Health Risk Assessment and Management of Contaminated Sites.
- Swann et al. (1983) A rapid method for the estimation of the environmental parameters octanol/water partition coefficient, soil sorption constant, water to air ratio, and water solubility. Residue Reviews; and
- UNECE (2011) Globally Harmonised System (GHS) of Classification and Labelling of Chemicals. Revision 4. Part 4 Environmental Hazards and Annex 9 Guidance on hazards to the aquatic environment.

The above guidance is predominantly focussed on hazard to aquatic receptors. Guidance for assessment of hazard to terrestrial receptors is limited. The following sources were consulted in developing an approach for assessment of hazard to terrestrial receptors (this is discussed later in Section 5.0):

- European Commission (2003) Technical Guidance Document on Risk Assessment in support of Commission Directive 93/67/EEC on Risk Assessment for New Notified Substances, Part II Chapter 3 Environmental Risk Assessment; and
- National Environment Protection Council (NEPC) (2013). National Environment Protection (Assessment of Site Contamination) Amendment Measure.

4.4 Environmental Hazard Classes

The environmental hazard assessment approach presented herein uses several lines of evidence (LOE) that were assessed in a weight of evidence (WOE) framework. Physical, chemical and toxicological parameters selected for assessment of potential for PBT were assigned values that equate to the following hazards:

- High Hazard
- Moderate Hazard; and
- Low Hazard.

Golder has refined this approach on a variety of projects including for assessment of stimulation chemicals. Hazard may be assessed using numeric or non-numeric approaches. Golder's experience using numeric indices is that greater sensitivity (than is possible) in the assessment of hazard is implied when generating statistical averages (e.g., to one or more decimal place). For example, using a numeric score of 1, 2, and 3 for low, moderate, and high hazard respectively for a variety of parameters, average scores of 1.7 or 2.2 could be obtained. These scores imply differences in hazard where none may be determined from the data assessed and the approach. Assessment of hazard via a non-numeric, descriptive approach avoids this and hence a non-numeric approach was used herein.

Hazard was assigned to individual parameters representative of P, B, or T. The LOE were used to assign an overall hazard classification (based on the WOE) for each chemical. There were no minimum data requirements (i.e. in some instances a hazard was evaluated on few data for each of P, B, or T). In order to quantify this uncertainty, a measure of data gaps was calculated for each chemical. In the assessment of T, the highest hazard assigned to either acute or chronic data was adopted as the final hazard classification for T. The approach for assessment of T differed from P and B because some chemicals have few aquatic ecotoxicological data. This resulted in weighting of the assessment towards T and is considered conservative and appropriate for a screening level risk assessment.

Not all the physical and chemical parameters collated for the stimulation chemicals presented in the chemical information sheets (refer to APPENDIX E) were used in the environmental hazard assessment.

The hazard benchmarks set for this study are considered a relative assessment. The benchmarks were assigned with the intent of incorporating the precautionary principle (i.e., designed to be inherently conservative and therefore biased towards capturing, rather than rejecting chemicals that are likely to pose PBT hazard).

The individual hazards assigned to the respective benchmarks for each parameter are presented in Section 4.6.

4.5 Assessment of Organic Versus Inorganic Substances

The approach for the aquatic hazard assessment of inorganic and organic substances differs. The approach for the assessment of inorganic substances[9] was devised based predominantly on guidance published by Environment Canada (2003). Following the Environment Canada (2003) approach, toxicity is considered in conjunction with persistence. The assessment of bioaccumulation potential of inorganic chemicals is more difficult to interpret in hazard assessment and was not included in the approach presented herein.

Non-metal-containing inorganic substances may be assessed following guidance for organic substances.

[9] Inorganic substances may be described as metal-containing inorganic salts, organic-metal salts, and ionizable inorganics

Justification for the hazard assigned to the individual parameters and the adopted ranges are discussed in the following section.

4.6 Environmental Hazard Assessment Parameters

The physical, chemical and aquatic ecotoxicological data collated and assessed in the aquatic environmental hazard assessment are presented in the chemical information sheets (refer to APPENDIX E) and summarised in Table 6 below.

Table 6: Physical, Chemical and Toxicological Parameters Used in Environmental Hazard Assessment

PBT	Applicable to Organic / Inorganic Chemicals	Parameter	Units
Persistence	Inorganic / Organic	Solubility	mg/L
	Organic	Henry's Law constant	atm m3/mol
	Organic	log K_{oc}	L/kg
	Organic	EPISUITE™ Ready biodegradability	Qualitative
	Organic	EPISUTE™ Ultimate Biodegradation (Biowin 3)	Qualitative
	Organic	EPISUTE™ Primary Biodegradation (Biowin 4)	Qualitative
	Organic	EPISUTE™ Anaerobic Biodegradation (Biowin 7)	Qualitative
Bioaccumulation	Organic	BCF	unitless
	Organic	log K_{ow}	unitless
Toxicity	Inorganic / Organic	Aquatic ecotoxicological data for: Plants Invertebrates Fish Acute L(E)C50 Chronic NOEC Chronic LOEC/MATC//EC50	mg/L

The following sections describe in more detail the parameters used, the benchmarks set, and the hazard assigned.

4.6.1 Data Gaps

Where data were unavailable for a chemical, and/or data could not be modelled using EPISUITE™ the parameter was excluded from the environmental hazard assessment. An overall hazard was assigned for each of grouping for P, B and T based on the WOE (i.e., there were no minimum data requirements). In some instances, a hazard was evaluated on few data for each of P, B, or T. Because of this it was necessary to quantify the extent of data gaps. This is expressed as a percentage in the PBT summary in Table C2 (APPENDIX C).

4.6.2 Surrogates

Where data for listed chemicals were unavailable, data for a suitable surrogate chemical were adopted. Surrogate chemicals were selected on the basis of structural similarity (or structure activity relationships, SAR), functional groups present, relevant precursors or breakdown products, data availability, and professional judgement. The approach taken assumes that the chemical and physical parameters of the

surrogate are predominantly the same as the chemical in question. Use of surrogates is supported by relevant guidance (Environment Canada, 2003; NEPC, 2013; and UNECE, 2011) and is considered to be scientifically defensible.

Where chemicals were assessed using a surrogate, this is documented in this report for transparency. Where chemicals could not be assessed using a surrogate, they were not assessed due to insufficient data.

4.6.3 Persistence

The approach for assessment of persistence for inorganic and organic chemicals differs.

Inorganic chemicals were not directly assessed for persistence, although high solubility (particularly compared with toxicity) was considered a potential hazard as this could lead to rapid uptake into organisms. Chemicals that are soluble through dissociation into simple anions and cations have been discussed separately.

Organic chemicals were assessed based on solubility, Henry's Law Constant, K_{oc}, and degradation rates.

4.6.3.1 Solubility

Aqueous solubility is measured in units of mg/L (or g/m^3) at temperatures of 20°C – 25°C. Aqueous solubility is temperature dependent. The solubility of a chemical will influence the rate of migration (or mobility) of that chemical in the environment. An increase in solubility leads to a decrease in adsorption to soil and greater mobility (Langley, 1993). Poor solubility may result in low bioavailability and lower biodegradation rates. A poorly soluble chemical may be considered to have a tendency to persist and therefore have more time to exert a toxic effect. Conversely, high solubility could also imply greater mobility, greater bioavailability and greater hazard. Solubility, rather than effective solubility[10], was adopted in this hazard assessment for simplicity. Effective solubility is a more accurate measure of chemical availability and mobility. However, effective solubility cannot be reliably predicted or modelled and is dependent on the chemical mixture and environmental factors (e.g. pH, temperature, oxidising or reducing conditions, etc). Solubility is a conservative and simple measure of mobility and availability of a chemical in groundwater and hence was used in this hazard assessment.

Organic substances with low water solubility typically have high predicted bioaccumulation factors and / or high log K_{ow} and hence may be considered highly bioaccumulative unless there is evidence to suggest otherwise (Environment Canada, 2003).

Inorganic substances generally need to be dissolved in water to exert deleterious effects (to aquatic receptors) and consequently solubility should be considered in conjunction with aquatic toxicity, as recommended by Environment Canada (2003). Environment Canada (2003) recommends that when the solubility of the substance is greater than the acute toxicity, the substance is likely to pose a hazard. Herein, the lowest acute ecotoxicological endpoint obtained for the chemical of interest was used for data considered in assessment of toxic potential). Where solubility data were not found for the inorganic chemicals considered, solubility was assumed to be greater than acute toxicity. This is conservative and results in a high hazard classification.

Low solubility was signed a high hazard (based on likelihood of persistence and high bioaccumulation tendency) for organic chemicals. Conversely, low solubility was assigned a low hazard for inorganic chemicals. The hazard category benchmarks adopted in this study are summarised in Table 7 and Table 8 for organic and inorganic substances, respectively. These were derived based on professional judgement (noting that the UNECE (2009) consider a substance with a solubility of less than 1 mg/L to be poorly soluble).

[10] Effective solubility is the solubility of a compound that will dissolve from a chemical mixture (e.g., gasoline). The effective solubility of a compound from a chemical mixture is less than its aqueous solubility.

Table 7: Solubility Benchmarks for Organic Substances

Hazard Category	Hazard Symbol	Solubility (mg/L)
High Hazard	●	<10
Moderate Hazard	◖	10 – 100
Low Hazard	○	>100

Table 8: Solubility Benchmarks for Inorganic Substances

Hazard Category	Hazard Symbol	Solubility (mg/L)
High Hazard	●	>10
Moderate Hazard	◖	1 – 10
Low Hazard	○	<1

The benchmarks for the assessment of solubility in conjunction with aquatic toxicity for inorganic chemicals are presented in Table 9. The benchmarks were set following Environment Canada (2003). Because only two categories exist, a moderate hazard is not possible.

Table 9: Benchmarks for Solubility Considered in Conjunction with Acute Toxicity (Inorganic Substances)

Hazard Category	Hazard Symbol	Solubility & Toxicity (mg/L)
High Hazard	●	Solubility > Acute toxicity
Low Hazard	○	Solubility < Acute toxicity

4.6.3.2 Henry's Law Constant

Henry's Law is a partition coefficient which is a measure of the tendency of a substance to partition into air from water at constant temperature and pressure. It can be used as a measure of environmental fate and transport of a substance. Henry's Law Constant is calculated using vapour pressure, molecular weight and water solubility for a chemical and is commonly expressed either as 'dimensionless' (i.e., no units) or in 'dimensions' (i.e., units of atmospheres (atm) m^3/mol or Pa m^3 mol-1). Henry's Law Constant data were used in the environmental hazard assessment even though one of the parameters on which it is based (namely solubility) is assessed and scored separately.

Organic chemicals with a low Henry's Law Constant (i.e., low volatility and high solubility) are likely to be more persistent in the environment. Organic chemicals with a high Henry's Law Constant (i.e., high volatility, low water solubility) are likely to be less persistent in the environment. Organic chemicals with a low Henry's Law Constant were considered to present a greater environmental hazard in this assessment.

Henry's Law Constant benchmarks were assigned based on ranges provided in CCME (2008), Langley (1993) and professional judgement. The benchmarks are summarised in Table 10.

Inorganic chemicals were not assessed using Henry's Law Constant.

Table 10: Benchmarks for Henry's Law Constant

Hazard Category	Hazard Symbol	Henry's Law Constant (atm m3/mol)
High Hazard	●	$<6.1x10^{-09}$
Moderate Hazard	◖	$6.1x10^{-09}$- $6.1x10^{-05}$
Low Hazard	○	$>6.1x10^{-05}$

4.6.3.3 Soil Adsorption Partition Coefficient (K_{oc})

The soil organic carbon-water partitioning coefficient is the ratio of the mass of a chemical that is adsorbed in the soil per unit mass of organic carbon in the soil. It is a measure of the tendency for organic substances to be adsorbed by soil or sediment. K_{oc} values are useful in predicting the mobility of organic contaminants in soil and sediment. Higher K_{oc} values correlate to less mobile organic chemicals while lower K_{oc} values correlate to more mobile organic chemicals. Organic chemicals with lower mobility (greater persistence) are considered in this assessment to be a greater environmental hazard. The benchmarks for K_{oc} used are presented in Table 11. These benchmarks were derived after consideration of information provided in CCME (2008); Langley (1993) and Swann et al. (1983) and professional judgement.

Table 11: Log K_{oc} Benchmarks

Hazard Classification	Hazard Symbol	Log Koc Range (L/kg)
High	●	<3.7
Moderate	◖	2.7-3.7
Low	○	>2.7

4.6.3.4 Biodegradation

Degradation takes into account physical, biological, and chemical changes in a chemical over time (Langley, 1993). Biodegradation is “the process by which organic substances are decomposed by micro-organisms (mainly aerobic bacteria) into simpler substances such as carbon dioxide, water and ammonia” (UN, 1997 cited in OECD, 2010). The rate of biodegradation is generally described as percentage degradation over a period of days (28 days is often the benchmark), but sometimes longer or shorter exposure periods are reported. The longer the time taken for a substance to degrade, the more environmentally persistent that chemical is considered to be. Lower percentages of biodegradation over 28 days were considered to be indicative of higher environmental hazard.

The benchmarks assigned were based on guidance in Environment Canada (2003), UNECE (2011), the European Commission (2003) and professional judgement.

The following biodegradation data were sought:

- Aerobic Ready Biodegradability.
- Ultimate Biodegradation.
- Primary Biodegradation; and
- Anaerobic Biodegradation.

The use of more than one biodegradation measure was to capture appropriate measures of biodegradation for the likely environmental exposures to stimulation chemicals. Summary details of the tests are described below.

i) **Aerobic Ready Biodegradation**. The aerobic ready biodegradability test is considered a stringent test likely to generate slower degradation rates than may actually occur in the natural environment or in a sewage treatment plant. It employs a high concentration of the test chemical and biodegradation rates are measured via non-specific parameters such as dissolved organic carbon, biological oxygen demand, and carbon dioxide production. Ready biodegradability testing is commonly used as the first screen to test for biodegradation potential and employs the use of microorganisms that are not pre-adapted to degradation of the chemical substance. A negative result in a test for ready biodegradability does not necessarily mean that the chemical will not be degraded under relevant environmental conditions;

ii) **Anaerobic Biodegradation**. Anaerobic biodegradation testing is a screening test to measure the potential for biodegradation under anoxic conditions. The test substance (the only source of added organic carbon in the test) is exposed to diluted anaerobically digested sludge. Biodegradability of the test substance is measured via increased headspace pressure resulting from the evolution of carbon dioxide, methane and total inorganic carbon. The test is performed at 35°C to simulate the temperature in heated digesters or anaerobic sludge treatment. This temperature favours anaerobic biodegradation of chemicals with low or moderate toxicity to anaerobic bacteria. On the other hand, because this test uses a high concentration of test substance, negative results may be observed for some chemicals that would otherwise be biodegradable at lower concentrations. Anaerobic biodegradation half-lives were sought on the basis that the groundwater environment is likely to be anaerobic;

iii) **Ultimate Biodegradation**. Ultimate biodegradation[11] testing aims to measure the time taken for a test substance to biodegrade completely into simple molecules e.g. carbon dioxide, biomass, water and other inorganic substances like ammonia; and

iv) **Primary Biodegradation**. Primary biodegradation[12] testing measures the disappearance of the compound as a result of its biotransformation to another product.

A summary of the nominated aerobic ready biodegradation and anaerobic biodegradation benchmarks and the associated hazards assigned are presented in Table 12. These data were generated by EPISUTE™ BIOWIN™ and represent one of two potential outputs and hence a moderate hazard is not possible.

Table 12: Ready Aerobic and Anaerobic Biodegradation Benchmarks

Hazard Classification	Hazard Symbol	Aerobic Ready Biodegradability (EPISUITE™)	Anaerobic Biodegradation (EPISUITE™ BIOWIN 7)
High	●	No	≤0.5 Does not biodegrade fast
Low	○	Yes	≥0.5 Biodegrades fast

A summary of the nominated Ultimate Survey Biodegradation and Primary Biodegradation benchmarks and associated hazards are presented in Table 13. These data were generated using EPISUITE™ and BIOWIN™.

Table 13: Ultimate and Primary Biodegradation Benchmarks

Hazard Classification	Hazard Symbol	Ultimate Survey Biodegradability (EPISUITE™ BIOWIN 3)	Primary Biodegradation (EPISUITE™ BIOWIN 4)
High	●	<2 (2 equates to months, 1 equates to longer than months)	<2 (2 equates to months, 1 equates to longer than months)
Moderate	◖	2 – 3 (2 equates to months, 3 equates to weeks)	2-3 (2 equates to months, 3 equates to weeks)
Low	○	>3 (3 equates to weeks, 4 equates to days, 5 equates to hours)	>3 (3 equates to weeks, 4 equates to days, 5 equates to hours)

4.6.4 Bioaccumulation

Bioaccumulation potential was assessed for organic chemicals only and using two parameters: BCF and log K_{ow}, as discussed below.

[11] Ultimate biodegradation is a measure of inherent biodegradability. Inherent biodegradability is similar to ready biodegradability testing with the exception that a low concentration of the test substance is used with a greater proportion of microorganisms that may be pre-adapted to the test substance. The conditions of an inherent biodegradation test are optimised to achieve rapid biodegradation. Inherent aerobic biodegradation data may over estimate the potential for biodegradation in the natural environment.

[12] Primary biodegradation is a measure of inherent biodegradability.

Bioaccumulation was not assessed for inorganic chemicals because the bioaccumulation of inorganic chemicals is difficult to predict and was considered beyond a screening level risk assessment.

4.6.4.1 Octanol / Water Partition Coefficient (K_{ow})

The octanol-water partition coefficient (K_{ow}) is the ratio of the solubility of a chemical in octanol divided by its solubility in water. It is a measure of the preference for an organic substance to dissolve in an organic solvent or water and is used as a measure of lipophilicity and movement of a substance across a cell membrane. It is usually expressed as Log K_{ow}. It can be used to estimate environmental fate and transport of a chemical.

There is general consensus in the literature that a Log K_{ow} of less than 3.5 represents low or moderate potential to bioaccumulate, and a Log K_{ow} of greater than 3.5 represents an increased potential to bioaccumulate. UNECE (2009) consider that substances with Log K_{ow} less than 4 have no potential to bioaccumulate. UNECE (2009) and CCME (2008) consider that substances with Log K_{ow} greater than 4 have the potential to bioaccumulate. The European Commission (2003) consider that substances with Log K_{ow} greater than 4.5 have the potential to bioaccumulate. The benchmarks used in this study are summarised in Table 14 and were largely based on the classes provided by European Commission (2003), UNECE (2009), CCME (2008) and professional judgment.

Log K_{ow} is assessed for organic chemicals only.

Table 14: Log K_{ow} Benchmarks

Hazard Classification	Hazard Symbol	Log Kow (unitless)
High	●	>5
Moderate	◖	3-5
Low	○	<3

4.6.4.2 Bioconcentration Factor (BCF)

The bioconcentration factor (BCF) is a measure of the tendency for a substance in water to accumulate in organisms, in particular fish. This parameter is an important determinant for uptake into organisms, potential for biomagnification and secondary poisoning (food chain transfer to higher trophic levels). The higher the BCF, the greater the potential for bioconcentration and secondary poisoning. The benchmarks assigned are summarised in Table 15. These benchmarks were assigned after consideration of information provided in ANZECC and ARMCANZ (2000), Franke et al. (1994), European Commission (2003), UNECE (2009) and professional judgment. The benchmarks presented by Franke et al. (1994) were more conservative than those presented by ANZECC and ARMCANZ (2000), the European Commission (2003) and UNECE (2009). As ANZECC and ARMCANZ (2000), European Commission (2003) and UNECE (2011) guidance were prepared with significant peer review by international scientific experts in their development, these guidance frameworks were given precedence over Franke et al. (1994). BCF was assessed for organic chemicals only.

Table 15: BCF Benchmarks

Hazard Classification	Hazard Symbol	BCF (unitless)
High	●	>5000
Moderate	◖	1000 - 5000
Low	○	<1000

4.6.5 Toxicity

There were frequently insufficient data to enable an assessment of both acute and chronic toxicity hence the highest hazard assigned to either the acute or chronic data was adopted as the classification of hazard for toxic (T) potential for the stimulation chemicals. This resulted in weighting of the assessment towards T. This was considered conservative and appropriate for a screening level hazard assessment.

4.6.5.1 Aquatic Ecotoxicology

To assess the toxic (T) potential of the chemicals, readily available acute (i.e., predominantly L(E)C_{50}[13]) and chronic (i.e., NOEC[14], LOEC[15], MATC[16] and non-lethal EC_{50}) data for aquatic organisms were collated.

Chronic aquatic ecotoxicology data are preferred over acute because exposure occurs over a longer time-period, usually during a significant period of the organism's life-cycle or during a sensitive life-stage. However, acute ecotoxicological data dominate in the literature compared to chronic data. Acute toxicity is relevant if the anticipated environmental exposure concentrations are in the acute toxicity concentration range. The receptor groupings considered (plants, invertebrates and fish) and endpoints considered (acute, chronic) were given equal weighting.

As freshwater aquatic organisms were considered the most likely aquatic receptor exposed to stimulation chemicals albeit the likelihood for exposure is low (refer Section 7.0), freshwater ecotoxicological data were used in the assessment of toxic potential. There are generally few aquatic ecotoxicological data available for amphibians and reptiles, and no guidance was found in the international literature on the assessment of hazard for these receptor groups. Hence these receptors groups were excluded from the assessment of T.

The data obtained from USEPA ECOTOX database were screened as follows:

- Endpoints selected included mortality (acute), growth (chronic) and reproduction (chronic) for plants, invertebrates and fish;
- Chronic mortality exposures were not considered.
- Studies longer than 7 d were considered to be chronic (with the exception of microalgae).
- Studies shorter than 24hrs were not considered; and
- L(E)C_x endpoints other than L(E)C_{50} were not considered (namely EC_0, EC_{100}, EC_{10}, EC_{20}, etc).

Although included in the environmental hazard assessment, NOECs are not statistical or empirical point estimates of ecological effect. NOECs are hypothesis-based and reflect the test design (i.e., concentrations of exposure) rather than the dose-response curve. However, NOECs are well documented in the literature and are commonly used in ecological risk assessment and in derivation of risk-based ecological guidelines (preferred endpoints are EC10s (Warne et al. 2018)). Additional chronic endpoints namely LOEC, MATC and EC_{50} were included in the hazard assessment to reduce the uncertainly associated with NOEC data.

Chronic data modelled using ECOSAR™ represent the geomean of NOEC and LOEC endpoints. Because the hazard assessment differentiated between NOEC and LOEC in assessment, these ECOSAR data were not used.

The chronic aquatic ecotoxicology ranges (for plants, invertebrates and fish) were assigned after consideration of information provided in European Commission (2003); UNECE (2009) and professional judgement. As a conservative approach to assessment of T, the lowest chronic effect concentration for each

[13] Lethal (or effect) concentration that kills (or effects) 50% of the test population.

[14] No observed effect concentration.

[15] Lowest observed effect concentration.

[16] Maximum acceptable tolerable concentration.

of NOEC, LOEC/MATC/EC_{50}, and the lowest acute effect concentration for L(E)C_{50} were used. The benchmarks adopted for chronic aquatic toxicological data are summarised in Table 16 and Table 17. The chronic studies represent non-lethal endpoints of growth and reproduction.

Table 16: Chronic Aquatic Toxicity NOEC Benchmarks

Hazard Classification	Hazard Symbol	Chronic Aquatic NOEC (mg/L)
High	●	<0.01
Moderate	◖	0.01 – 0.1
Low	○	>0.1

Table 17: Chronic Aquatic Toxicity LOEC/MATC/EC50 Benchmarks

Hazard Classification	Hazard Symbol	Chronic Aquatic NOEC (mg/L)
High	●	<0.1
Moderate	◖	0.1 – 1
Low	○	>1

The acute aquatic ecotoxicity benchmarks (for plants, invertebrates and fish) were assigned after consideration of information provided in European Commission (2003); UNECE (2005) and professional judgement. The acute aquatic toxicity benchmarks are summarised in Table 18. The acute toxicity studies represent lethal, growth and reproduction endpoints.

Table 18: Acute Aquatic Toxicity L(E)C/50 Benchmarks

Hazard Classification	Hazard Symbol	Acute Aquatic L(E)C50 (mg/L)
High	●	<1
Moderate	◖	1 – 100
Low	○	>100

4.6.6 Environmental Hazard Classification

The environmental hazard classification assigned was based on the WOE for multiple LOE. The classifications were based on the available data, even if there were data gaps. Consequently, a measure of data gaps was assigned to quantify this uncertainty.

It should be noted that T classifications for a number of chemicals were based on modelled, rather than measured data. The modelled ecotoxicological data were from ECOSAR™ (discussed in Section 4.1.2). There is uncertainty associated with modelled data. The one (1) chemical for which modelled toxicological data was used is shown below in Table 19.

Table 19: List of Chemicals Assessed Using Modelled ECOSAR™ Data

Chemical	CAS RN
Amine oxides, cocoalkyldimethyl	61788-90-7

Surrogate chemicals were used for chemicals where the physico-chemical and/or toxicological data were insufficient. The four (4) chemicals assessed using surrogates are presented in Table 20.

Table 20: List of Surrogate Chemicals

Chemical	CAS RN	Surrogate Descriptor
Amides, C18-unsaturated, N,N-bis(hydroxyethyl)	93-83-4	Surrogate for Amides, tall-oil, fatty, N,N-bis(hydroxethyl) (CAS RN 68155-20-4)
Tetra-n-butyl phophonium chloride	2304-30-5	Surrogate for Tributyl tetradecyl phosphonium chloride (CAS RN 81741-28-8)
Rection products of monoethanolamine and boric acid	94095-04-2	Surrogate for Monoethanolamine borate (CAS RN 26038-87-9)
Disodium octaborate tetrahydrate	12008-41-2	Surrogate for Ulexite (CAS RN 1319-33-1)

There was an additional chemical for which physico-chemical and/or toxicological data were insufficient and for which a suitable surrogate could not be found. This chemical is presented in Table 21 below and was not included in the environmental hazard classification assessment.

Table 21: Chemicals Not Assessed

Chemical	CAS RN
Hydroxylpropyl guar	39421-75-5

A further group of four (4) inorganic chemicals presented in Table 22 below were not assessed as these were considered to chemically equivalent to sand and therefore assessed as such.

Table 22: Chemicals Equivalent to Sand

Chemical	CAS RN
Crystalline silica, quartz	14808-60-7
Silica gel	112926-00-8
Aluminium silicate	1302-76-7
Crystalline silica, cristobalite	14464-46-1

Of the thirty-nine (39) stimulation chemicals assessed[17], thirty-four (34) were classified for hazard (excluding the sand compounds). Of these thirty-four chemicals, seventeen (17) were classified low hazard, ten (10) were classified moderate hazard, and seven (7) were classified high hazard. The remaining five (5) chemicals were not subject to PBT assessment as discussed earlier and presented in Table 21 and Table 22.

Five (5) chemicals, hydrochloric acid, sodium carbonate, sodium chloride, sodium hydroxide and sodium iodide were not scored for persistence as these chemicals readily dissociate in the environment. An additional chemical, guar gum was not scored for persistence as it expected to be readily biodegradable based on its composition (a polysaccharide composed of galactomannan).

The stimulation chemical environmental hazard classifications of the thirty-four (34) chemicals are summarised in Table 23, with the detailed PBT values for each chemical provided in Table C2, APPENDIX C.

[17] Excluding hydroxylpropyl guar. Guar gum was assessed

Table 23: Stimulation Chemicals Environmental Hazard Classifications

Rank	Name For Report	CAS RN	Data Gaps %
High	Alcohols, C12-C15, Ethoxylated	68131-39-5	6%
	Surrogate for Amides, tall-oil, fatty, N,N-bis(hydroxyethyl)	93-83-4	11%
	Chlorous acid, sodium salt	7758-19-2	27%
	Disodium octaborate tetrahydrate	12008-41-2	18%
	Sodium bisulfite	7631-90-5	36%
	Sodium iodide	7681-82-5	82%
	Surrogate for Ulexite	12008-41-2	18%
Moderate	Alcohols, C12-16, ethoxylated	68551-12-2	67%
	Amine oxides, cocoalkydimethyl	61788-90-7	33%
	Cinnamaldehyde	104-55-2	33%
	Hydrotreated light petroleum distillate	64742-47-8	17%
	Fatty acids, tall-oil, ethoxylated	61791-00-2	33%
	Glutaraldehyde	111-30-8	11%
	Guar gum	9000-30-0	89%
	Sodium carbonate	497-19-8	64%
	Sodium hydroxide	1310-73-2	82%
	Titanium dioxide	13463-67-7	55%
Low	Acetic acid	64-19-7	33%
	Benzaldehyde	100-52-7	17%
	Citric acid	77-92-9	44%
	Diethylene glycol	111-46-6	39%
	Methanol	67-56-1	17%
	Triethanol amine	102-71-6	22%
	Diethanol amine	111-42-2	17%
	Ethanol	64-17-5	22%
	Sodium polyacrylate	9003-04-7	61%
	Butyl alcohol	71-36-3	28%
	Surrogate for Tributyl tetradecyl phosphonium chloride	2304-30-5	33%
	Surrogate for Monoethanolamine borate	94095-04-2	67%
	Ethylene glycol	107-21-1	22%
	Hydrochloric acid	7647-01-0	82%

Rank	Name For Report	CAS RN	Data Gaps %
	Sodium chloride	7647-14-5	27%
	Aluminium oxide	1344-28-1	82%
	Iron oxide	1309-37-1	73%

4.6.7 Identification of Chemicals of Potential Concern (COPC) to Aquatic Ecosystems

Based on the hazard classification of the stimulation chemicals (as presented in Table 23), the seven chemicals classified as a potential high hazard were considered to be COPC.

The certainty of the hazard classification varies depending on the extent of data gaps and the reliance on modelled data. The percent of data gaps were calculated and are presented in Table 23. The percentage data gaps for the high hazard chemicals ranged from 6% (Alcohols, C12-C15, Ethoxylated) to 82% (Sodium iodide).

4.6.8 Evaluation of Mixture Toxicity

The environmental hazard assessment did not directly consider the combined effects of the stimulation chemicals when present in a mixture. However, the approach of assessing individual chemicals for environmental risk assessment is inherently conservative and designed to over-estimate risk as a precautionary approach and so allow for the potential for some mixture toxicity beyond that exhibited by individual chemicals.

There is a limited, endorsed mixture toxicity assessment guidance in Australia and elsewhere. The Australian National Water Quality Management Strategy (ANZECC & ARMCANZ, 2000 and ANZG, 2018) guidance recommends the use of direct toxicity assessment (DTA) for assessment of mixture impacts on the environment. Direct toxicity assessment (DTA) entails collection of an environmental sample containing the chemical mixture and undertaking ecotoxicological testing (exposing test organisms to the environmental sample and measuring effect). DTA considers the nature of the receiving ecosystem (freshwater or marine), and the potential influence of environmental factors that can modify the effect of the stressor (such as water hardness on metal toxicity). DTA typically involves laboratory-raised cultures of test organisms that broadly represent various trophic levels in a receiving waterbody (e.g., fish, aquatic invertebrates, plants, algae).

The use of a more conservative assessment (screening level assessment) as adopted in this SRA is considered more appropriate than DTA for Santos' SWQ operations, because Santos is not authorised to discharge hydraulic fracturing fluids to a specific environment, and there is a wide diversity of potential receptors and receiving environments within the Santos SWQ Project Area that cannot easily be accommodated by DTA. The individual chemical assessment approach in this SRA is considered appropriate to meet the requirements of mixture toxicity assessment for the EA to ensure the protection of all ecological receptors.

4.7 Exclusions and Limitations

The environmental hazard assessment is a qualitative assessment of environmental hazard. The following limitations with regard to the hazard assessment and source data are noted:

- The approaches consulted for assessment of PBT in devising the environmental hazard assessment approach were predominantly focussed on the assessment of organic chemicals. There was limited guidance for PBT assessment of inorganic chemicals.
- The hazard assessment approach relied in part on professional judgment and the evaluator's subjectivity in designating the parameter ranges for each parameter assessed.

- The assessment did not consider, *inter alia*.
  - Breakdown or reactive products of the chemicals that may pose more or less of an environmental hazard than the parent compound.
  - The quality, adequacy or accuracy of the available information sourced, noting that only sources considered to be reputable were used.
  - Endocrine disruption effects that are not assessed by standard ecotoxicological tests.
- The environmental hazard assessment approach did not adequately assess chemicals which were:
  - Hydrophilic i.e., highly soluble with low K_{ow}. Where aquatic ecotoxicological data were limited for these types of chemicals, toxicity may be underestimated because there is potential for these chemicals to be highly toxic.
  - Poorly biodegradable, of low acute toxicity, but were bioaccumulative (based on the BCF or K_{ow}). These chemicals may exert chronic effects via accumulation in tissues over time.
- The data collated in the chemical information sheets (presented in APPENDIX E) were treated the same regardless of whether the data were measured experimental values or modelled / calculated values.
- It is noted in relation to the aquatic ecotoxicological data:
  - The species *Daphnia magna* are a sensitive species, frequently displaying sensitivity to chemicals orders of magnitude greater than other invertebrate species.
  - The test endpoint description in the (secondary) sources consulted was relied upon although it should be noted that true chronic and acute NOEC, LOEC, MATC and L(E)C50 depend on a variety of factors such as test duration, species tested, stage in the life-cycle, etc. which can only be verified by review of the primary literature.
  - Sources of Australian aquatic ecotoxicological data were consulted but the information was very limited. Furthermore, many species reported in the Australian literature were not necessarily indigenous species; and
  - There were no minimum data requirements (i.e. some chemicals were assessed based on few data for each of P, B, or T). In order to quantify this uncertainty, a measure of data gaps expressed as a percentage is identified in Table 23.

5.0 TERRESTRIAL TOXICITY ASSESSMENT

The previous Section (4.0) presented the assessment of environmental hazard based on P, B and T, where the toxic (T) potential was limited to aquatic receptors. As the following terrestrial receptors (soil microorganisms, plants and animals (vertebrates and invertebrates)) are considered possible or likely receptors[18] that may come into contact with stimulation fluid chemicals, an assessment of hazard to terrestrial receptors was developed in accordance with guidance presented in the following frameworks:

- European Commission (2003) Technical Guidance Document on Risk Assessment in support of Commission Directive 93/67/EEC on Risk Assessment for New Notified Substances, Part II Chapter 3 Environmental Risk Assessment; and
- National Environment Protection Council (NEPC) (2013). National Environment Protection (Assessment of Site Contamination) Amendment Measure.

5.1 Methodology

The methodology for selection, collation and assessment of terrestrial toxicological data for the purposes of assessing potential hazard to terrestrial receptors from the stimulation fluid chemicals is described in the following paragraphs.

Note that the approach for assessment of hazard to terrestrial receptors differs from the assessment of hazard to aquatic receptors presented in Section 4.3. Collation of physico-chemical and toxicological data for PBT hazard assessment (as was done with the aquatic toxicological data) was not undertaken. The available physical, chemical, and toxicological data were not considered sufficiently robust for a PBT assessment. Consequently, the chemicals of concern to terrestrial receptors were identified based on the terrestrial toxicological data. Physico-chemical data were then used to assess the likelihood for environmental exposure (discussed in Section 5.1.2 below). This approach results in a semi-quantitative or qualitative assessment of hazard to terrestrial receptors.

5.1.1 Terrestrial Toxicological Data Sources

Where terrestrial toxicological data are available, this may be limited to results from short-term tests using earthworms and plants, rather than (preferred) long-term test results (European Commission, 2003). Studies that assess effects on soil function are rarely available in the literature, and the potential for food chain transfer (e.g., secondary poisoning via bioaccumulation) is not assessed via ecotoxicological studies. This can pose challenges for development of soil screening criteria protective of terrestrial receptors. To address these data deficiencies, the approach developed was to use QSARs to predict toxicity (using aquatic data), and laboratory mammal toxicological data as lines of evidence to identify COPC for terrestrial receptors. This approach has been adopted in this report based on guidance in the European Commission (2003) and NEPC (2013). However, guidance on assessment of effects on soil function was not found during the preparation of this report.

The European Commission (2003) suggest that the equilibrium partitioning method can be applied to aquatic data to identify a probably no effect concentration (PNEC) for soil organisms. The equilibrium partitioning method uses aquatic toxicological data combined with chemical partitioning properties (between soil and water) and soil density to predict the toxicity to soil organisms. This method cannot replace toxicity data for soil organisms and should only be considered as a screen for identifying substances requiring further testing (EC, 2003). The Amended NEPM (NEPC 2013) similarly recommends the use of the equilibrium partitioning method only where QSARs are unavailable.

[18] Note that the exposure pathway assessment of this report (Section 7.0) lists the sources, pathways of exposure, and receptors that may come into contact with the stimulation fluid chemicals.

The approach adopted was to draw from the large dataset of laboratory mammal (rat, mouse, rabbit) toxicological data and use these animals as surrogates for the potential mammalian terrestrial receptors (e.g., livestock and native mammalian fauna) that may come in contact with stimulation fluid chemicals on or near to a well lease. It is acknowledged that these data are limited in application as they generally comprise acute (LC50) data for receptors that are not of direct interest for exposures of terrestrial receptors in a stimulation risk assessment. Moreover, toxicological data from laboratory mammals are unsuitable surrogates for other terrestrial receptors such as reptiles, birds, invertebrates and plants.

The following sections (5.1.1.1 to 5.1.1.2) list the sources of information and data used to collate and generate terrestrial toxicological data.

5.1.1.1 Toxicological Databases

Laboratory mammalian, earthworm, plant and bird data were sourced from readily available databases and literature. Acute oral LD50 laboratory data for rats, mice and rabbits were selected from sources such as the European Chemicals Agency (ECHA), U.S. National Institute of Medicine (PubChem) and USEPA ECOTOX. The studies used to generate laboratory mammal data are designed with the aim of assessing chemical hazard to human health. Consequently, the relevance of these studies to Australian mammalian receptors is uncertain. Given the paucity of terrestrial toxicological data for the stimulation fluid chemicals on Australian fauna, rabbits and mice were considered as the best surrogates for mammalian receptors potentially present on well leases.

Earthworm data were used where the toxicological endpoint was mortality or reproduction and reported in units of milligrams of chemical per kilogram soil (mg/kg). Earthworm studies with other endpoints (e.g., behaviour) and/or units in other forms (e.g., micro-grams per cm^2) were not considered.

Similarly, plant data were used where the toxicological endpoint (e.g., NOEC) was reproduction or population (e.g., biomass or abundance) and reported in milligrams of chemical per kilogram of soil (mg/kg). Plant studies with other endpoints (e.g., foliar damage) and/or units in other forms (e.g., % or mg/mL of applied solution) were not considered.

5.1.1.2 QSARs

As indicated previously, QSARs are empirical relationships between the toxicity of contaminants to a particular test organism and one or more physicochemical properties of the contaminant (NEPC 2013). QSARs are derived for contaminants with either the same mechanism of action or similar molecular structure (NEPC 2013).

Three QSARs were used to derive additional terrestrial data for this report. NEPC (2010) reference the QSAR of Huzelbos et al. (1991) which predicts the concentration at which 50% growth inhibition (EC50, in units of micro-mol per litre) in lettuce (*Lactuca sativa*) would occur. The equation for the QSAR uses the chemical property log K_{ow} (described in Section 4.6.4.1 and recorded on the chemical information sheets). The QSAR equation of Huzelbos et al. (1991) is:

$$\log EC50 = -0.72 \log K_{ow} + 3.37$$

The Hulzelbos et al. (1991) QSAR was used to predict toxicity of organic chemicals to terrestrial plants, acknowledging that lettuce is not a native flora species, nor of relevance as receptor on a well lease. This QSAR provided the main dataset of terrestrial plant toxicity for the chemicals assessed. It could not be used for inorganic chemicals.

The second QSAR used was that of van Gestel (1992), which predicts the toxicity of earthworms (as the NOEC) in units of mg chemical per kg soil. This QSAR is referenced both by the European Commission (2003) and NEPC (2013) and uses equilibrium partitioning to predict the toxicity of a chemical in soil using

aquatic toxicity data. It is not suitable for chemicals with a log K_{ow} greater than 4 or for chemicals with a specific mode of action (e.g., endocrine disruptors).

The van Gestel (1992) QSAR was used to predict the toxicity of organic chemicals to earthworms and uses soil density (RHO in kg soil per m^3 of soil) and the soil to water partitioning coefficient (K_d in m^3 water per m^3 soil), in combination with the NOEC (in mg/L) for the aquatic environment. The equation is:

$NOEC_{soil} = K_d/RHO_{soil} * NOEC_{water} * 1000$

The soil to water partitioning coefficient (K_d, m^3water/m^3soil) is a function of both the fraction organic carbon content (f_{oc} in kg organic carbon per kg of soil) of soil and the soil organic carbon partitioning coefficient (K_{oc} in L water per kg organic carbon), and the equation is:

$K_d = f_{oc} \times K_{oc}$

An f_{oc} of 0.01 and bulk density of 1.6 g/cm^3 for soil was assumed in the use of this QSAR.

The third QSAR used was that used in the ECOSAR™ modelling programme. The programme uses the log K_{ow} to estimate toxicity (14-day LC50) to earthworms in units of mg/L. The equation is:

Log 14-d LC50 (mmol/L) = - 0.1037 log K_{ow} + 0.4476

The programme converts the units from mmol/L to mg/L. ECOSAR™ was used to estimate the toxicity of the stimulation fluid chemicals to earthworms.

5.1.2 Use of Physico-chemical Data

Following guidance in NEPC (2013), the relative importance of an exposure pathway to a terrestrial receptor can be determined by assessment of the chemicals-specific properties, and the soil-specific properties that affect chemical bioavailability and environmental fate. Some physicochemical properties of chemicals, for example, partitioning between octanol and water (K_{ow}), partitioning from soil to water (K_d), and volatility (using Henry's law constant (K_H)), can be used to predict the most important exposure pathways for a chemical in terrestrial environments. Organic and inorganic chemicals have different physicochemical properties that control their environmental fate. Consequently, different methods apply to assessment of organic vs. inorganic chemical exposures in terrestrial environments.

The environmental fate of organic chemicals is largely controlled by the following physicochemical properties:

- Half-life (t ½), Table 24.
- Henry's Law Constant (K_H), Table 25; and
- The octanol-water partition coefficient (K_{ow}) which, in general, determines a chemicals potential to cause secondary poisoning.

5.1.2.1 Half-life

The half-life (t½) of a chemical is a measure of persistence (P) in the environment. It represents the time taken for 50% of the chemical to be lost from the environment. The loss may occur through biodegradation (microbial mediated degradation) or abiotic pathways (hydrolysis, oxidation, reduction, etc.). The more persistent a contaminant in the environment (that is, larger t½), the longer is the potential exposure time of species to the contaminant and the more deleterious the effects that could occur (NEPC 2013).

Table 25 (taken from NEPC 2013) provides benchmarks for assessment of persistence in terrestrial ecosystems using half-life.

Table 24: Half Life Benchmarks

Classification	T ½ (Days)
Degrades Fast	<22.5
Degrades Moderately Fast	22.5 – 45
Degrades Slow	>45

5.1.2.2 Henry's Law Constant

Henry's law constant (K_H) is a measure of the volatility of a chemical. The higher the volatility (or value of K_H) the more of the contaminant will volatilise and be found in the soil air spaces and in the atmosphere. K_H is a temperature-dependent constant. Vapour transport for many contaminants may constitute an important pathway of loss and exposure to organisms (NEPC 2010). Together with half-life (t ½) of the chemical, K_H was used to assess the potential for transfer and persistence of the chemical in the soil.

NEPC (2013) have provided benchmarks for assessment of volatility of chemicals in terrestrial ecosystems. This is reproduced in Table 25 below.

Table 25: Henry's Law Constant Benchmarks

Classification	Henry's Law Constant (dimensionless)
Highly volatile (H)	>2.5 x 10^{-3}
Moderately volatile (M)	2.5 x 10^{-7} - 2.5 x 10^{-3} *
Not volatile (L)	< 2.5 x 10^{-7}

* It is noted that NEPC (2013) provides a range for moderately volatile of 2.5x10^{-7} to 2.5x10^{-5}, leaving two orders of magnitude (2.5x10^{-5} to 2.5x10^{-3}) unclassified. It was assumed that this was an error and the moderately volatile range has been extended from 2.5x10^{-5} to 2.5x10^{-3}.

5.1.2.3 Octanol-Water Partition and Organic Carbon-water Coefficient

The octanol-water partition coefficient (K_{ow}) is the ratio of the concentration of a chemical that is dissolved in n-octanol to that dissolved in water at equilibrium and at a specified temperature. It is used to estimate the potential for chemicals to accumulate in tissue, both plant and animal (NEPC, 2013).

Chemicals with high log K_{ow} values are more likely to accumulate in plants and soil invertebrates than chemicals with low K_{ow} values. If further magnification of these chemicals occurs in the food chain, a predator might experience toxicity while its prey does not. This effect is known as secondary poisoning. Chemicals with log K_{ow} values below 3 were not considered to biomagnify. Chemicals with log K_{ow} values greater than 4 were considered to be highly fat soluble and lipophilic, and therefore posing the potential to biomagnify and result in secondary poisoning.

For the purpose of this report, and consistent with NEPC (2013), the log K_{ow} values of chemicals were divided into two classes. These were:

- Low, log K_{ow} <4: the chemical has a low potential to biomagnify.
- High, log K_{ow} ≥ 4: the chemical has a high potential to biomagnify.

5.1.3 Summary of Approach

In summary, toxicological data, as guidelines, as measured endpoints (e.g., LD50) or based on measurement data (e.g. PNEC) or as modelled data from QSAR were collated in a step-wise process. Figure 1 indicates that steps followed for the collection of terrestrial toxicological data.

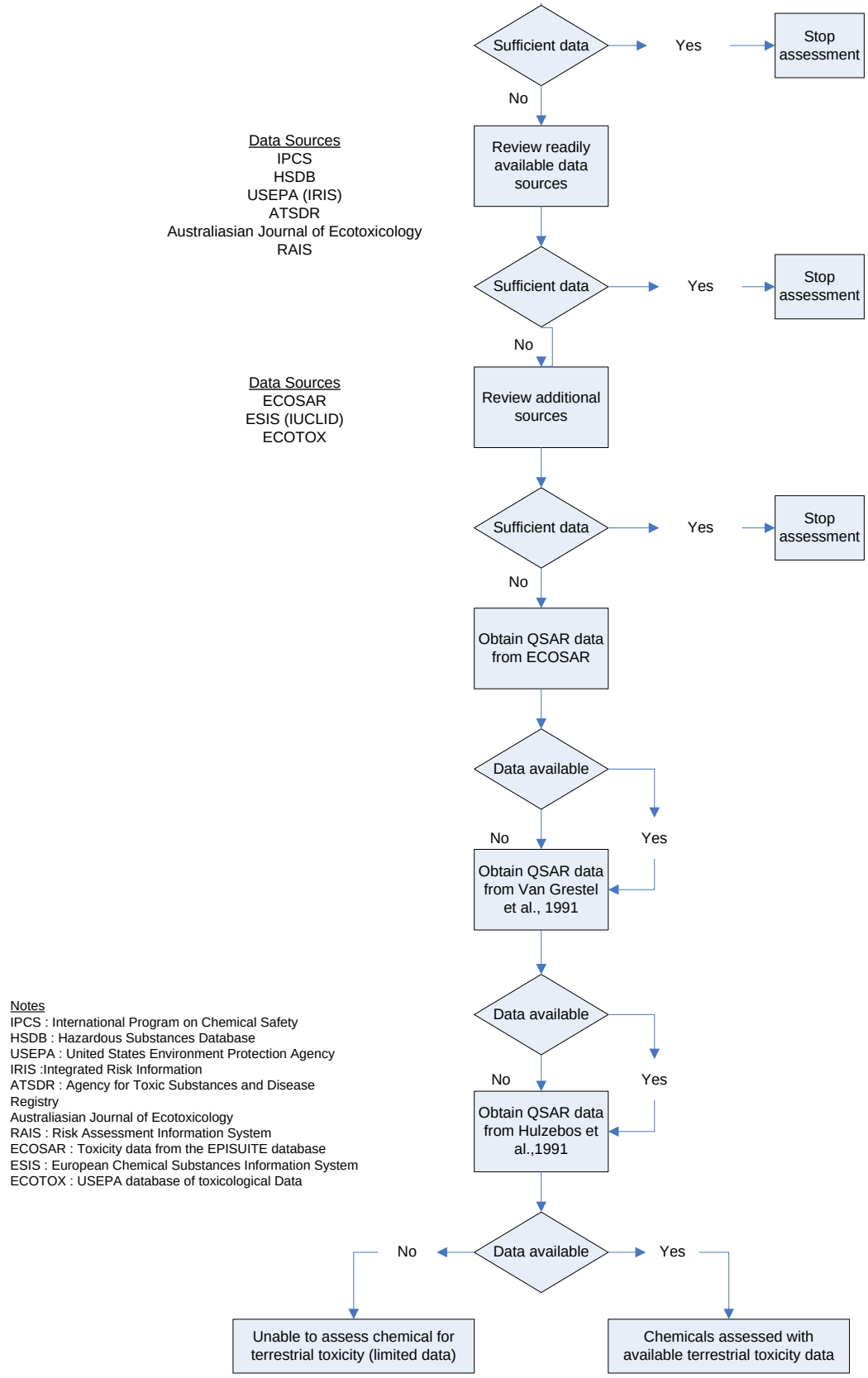

Figure 1: Approach Used for Collation and Generation of Terrestrial Toxicological Data

5.2 Results

Out of the thirty-nine (39) chemicals assessed (one (1) chemical was not assessed due to insufficient data and four (4) were not assessed because they were considered to be sand, refer to Table 21 and Table 22 in Section 4.6.6). In addition to the chemicals listed in Table 21 and Table 22, eight chemicals (aluminium oxide, chlorous acid sodium salt, hydrochloric acid, iron oxide, sodium chloride, sodium hydroxide, sodium iodide and titanium dioxide) were unable to be assessed for terrestrial toxicity due to lack of available data. It is noted that the chemicals unable to be assessed comprise inorganics for which bioaccumulation is unlikely to be of concern. In addition, most of these chemicals will dissociate in the environment to anions and cations.

5.2.1 Mammalian Acute Oral LD50

Acute oral LC50 data for mammals were found for twenty-five (25) of the chemicals. The lowest LD50 value for rats, mice and rabbits was selected and are presented in Table 26.

5.2.2 QSAR data

The lettuce EC50 of Huzelbos et al. (1991) was used to predict plant toxicity for fourteen (14) of the organic chemicals. Whilst the EC50 for this QSAR reports in micromole per litre, the units were not altered as the output was used as a process to rank chemicals against each other, not as an absolute measure of toxicity. Of the fourteen (14) chemicals assessed it should be noted that eleven (11) were derived using a log Kow < 1 which reduces the reliability of the outcome (as indicated in Huzelbos et al. 1991). As a result, these eleven compounds were not used in determining the final hazard assessment. The results of this QSAR are also shown in Table 26.

The QSAR of van Gestel (1992) was used to predict soil invertebrate toxicity for fourteen (14) organic chemicals. The results of this QSAR are also shown in Table 26.

The earthworm QSAR of the ECOSAR programme in EPISUITE was used to predict toxicity to earthworms of seventeen (17) chemicals. The results of this QSAR are shown in Table 26.

5.2.3 Summary of Toxicological Data

A summary of the terrestrial toxicological data (including measured and modelled) collated is presented in Table 26 below.

Table 26: Summary of Terrestrial Toxicological Data

Chemical	CAS RN	EC/LC50 Earthworm[1] (QSAR) (mg/L)	Lowest LD50 mammals (mg/kg/bw)	EC50[2] lettuce (QSAR) (mg/L)	LC50 Soil invertebrate[3] (QSAR) (µg/kg)
Acetic acid	64-19-7	1649	600[4]	0.210*	9.3
Alcohols, C12-C16, Ethoxylated	68551-12-2		4500[4]		977120
Amine oxides, cocoalkydimethyl	61788-90-7		846[5]		
Benzaldehyde	100-52-7		27.8[5]	0.245	
Cinnamaldehyde	104-55-2		200[6]	0.265	46.7
Citric acid	77-92-9	8030	3000[4]	0.874*	27500
Diethylene glycol	111-46-6	423	3300[6]	0.470*	31250
Methanol	67-56-1	105	5628[6]	0.126*	231
Triethanolamine	102-71-6		2200[7]	0.610*	29375
Diethanolamine	111-42-2		1100[8]	0.462*	25
Ethanol	64-17-5	134	2000[8]	0.167*	1800
Hydrotreated light petroleum distillate	64742-47-8	108	>5000[8]		
Sodium polyacrylate	9003-04-7		>1000[9]		
Alcohols, C12-C15, Ethoxylated	68131-39-5		>5000[8]		
Surrogate for Amides, tall-oil, fatty, N,N-bis(hydroxyethyl)	93-83-4		10000[8]		
Fatty acids, tall-oil, ethoxylated	61791-00-2	351	10000[10]		
Butyl alcohol	71-36-3	170	1200[8]	0.196	28779
Surrogate for Tributyl tetradecyl phosphonium chloride	2304-30-5	162	300[8]	1.091*	739556
Glutaraldehyde	111-30-8		27[11]	0.363*	2.3
Surrogate for Monoethanolamine borate	94095-04-2		2000[8]	1.132*	2957
Guar gum	9000-30-0		7060[12]		
Ethylene glycol	107-21-1	232	4000[13]	0.270*	100
Aluminium oxide	1344-28-1				
Chlorous Acid, Sodium Salt	7758-19-2				
Disodium Octaborate Tetrahydrate	12008-41-2		2550[8]		

Chemical	CAS RN	EC/LC50 Earthworm[1] (QSAR) (mg/L)	Lowest LD50 mammals (mg/kg/bw)	EC50[2] lettuce (QSAR) (mg/L)	LC50 Soil invertebrate[3] (QSAR) (µg/kg)
Hydrochloric Acid	7647-01-0				
Iron oxide	1309-37-1				
Sodium bisulfite	7631-90-5		1420[8]		
Sodium Carbonate	497-19-8	194			
Sodium Chloride	7647-14-5				
Sodium Hydroxide	1310-73-2				
Sodium Iodide	7681-82-5				
Titanium dioxide	13463-67-7				
Surrogate for Ulexite	12008-41-2		2550[8]		

1 ECOSAR (2012)
2 Huzelbos et al. (1991)
3 van Gestel (1992)
4 International Uniform Chemical Information Database (IUCLID) (2012)
5 International Program for Chemical Safety (INCHEM) (2012)
6 Hazardous Substances Data Bank (HSBD) (2012)
7 U.S. National Institute of Medicine PubChem (PubChem) (2020)
8 European Chemical Agency (ECHA) (2020)
9 European Human and Environmental Risk Assessment Program (HERA) (2014)
10 European Chemical Agency (ECHA) (2018)
11 European Chemical Agency (ECHA) (2019)
12 USEPA Federal Register (FR) (2011)
13 ATSDR 2010 US Agency for Toxic Substances and Disease Registry (ATSDR) (2010)
* based on a log Kow of <1.

5.3 Hazard Assessment

5.3.1 Toxicological Data

Examination of the data in Table 26 above does not provide consistent findings between data sources for highest hazard chemicals.

For the organic chemicals, for which the most data are available, the three most hazardous chemicals using the different techniques are shown in Table 27 below:

Table 27: Highest Hazard Organic Chemicals for Terrestrial Receptors Using the Different Datasets

Mammalian LD50 data	Lettuce QSAR (Huzelbos et al. 1991)*	Invertebrate QSAR (van Gestel 1992)	Earthworm QSAR (EPISUITE)
Glutaraldehyde	Butyl alcohol	Glutaraldehyde	Methanol
Benzaldehyde	Benzaldehyde	Acetic acid	Hydrotreated light petroleum distillate
Cinnamaldehyde	Cinnamaldehyde	Diethanolamine	Ethanol

*Excluding data for those chemicals with LogKow<1

On the basis of Table 27, nine organic chemicals: glutaraldehyde, benzaldehyde cinnamaldehyde, butyl alcohol, acetic acid, diethanol amine, methanol, ethanol and hydrotreated light petroleum distillate have the highest toxicity to terrestrial plants and invertebrates. These chemicals were assessed for persistence and bioaccumulation using the physico-chemical data described in Section 5.1.2 and are discussed further in Section 5.3.2.

Data for the inorganic chemicals were limited. The three QSARs could not be used. NEPC (2013) provides only limited discussion on how the environmental fate and persistence of inorganic substances should be assessed. Further assessment of the hazards of the inorganic chemicals to terrestrial receptors has not been undertaken. The three highest hazard inorganic chemicals ranked using the mammalian LD50 data are:

- Sodium carbonate.
- Disodium carbonate tetrahydrate; and
- Sodium bisulfite.

5.3.2 Persistence and Bioaccumulation of the Organic Chemicals

The nine high hazard organic chemicals identified in Section 5.3.1 were classified based on the half-life as described in Section 5.1.2.1. Glutaraldehyde, benzaldehyde and cinnamaldehyde were the most persistent with moderate half-lives. Butyl alcohol, acetic acid, diethanolamine, methanol, ethanol and hydrotreated light petroleum distillate were the least persistent with fast half-lives (Table 28).

Table 28: Soil Half-life (t ½) Classification for High Hazard Organic Chemicals

Chemical	CAS RN	Half-life in Soil (days)	Half-life in Soil (t ½) Classification
Glutaraldehyde	111-30-8	30	Moderate
Benzaldehyde	100-52-7	30	Moderate
Cinnamaldehyde	104-55-2	30	Moderate
Butyl alcohol	71-36-3	17.3	Fast
Acetic acid	64-19-7	17.3	Fast

Chemical	CAS RN	Half-life in Soil (days)	Half-life in Soil (t ½) Classification
Diethanolamine	111-42-2	17.3	Fast
Methanol	67-56-1	17.3	Fast
Ethanol	64-17-5	17.3	Fast
Hydrotreated light petroleum distillate	64742-47-8	17.3	Fast

The nine high hazard organic chemicals identified in Table 28 were classified based on the Henry's Law constant benchmarks presented in Section 5.1.2.2; the results are summarised in Table 29. Diethanolamine was classified as low volatility, and is therefore considered to be likely to persist longer than the other organic chemicals. Glutaraldehyde, benzaldehyde, cinnamaldehyde, butyl alcohol, acetic acid, methanol and ethanol were classified as moderately volatile (M), and hydrotreated light petroleum distillate were classified as having the highest volatility (H) and therefore are the least persistent (Table 29).

Table 29: Henry's Law Constant Classification for High Hazard Organic Chemicals

Chemical	CAS RN	Henry's Law (atm m^3/mol at 25°C)	Henry's Law (Dimensionless)	Henry's Law Constant Classification
Glutaraldehyde	111-30-8	1.10E-07	4.51E-06	Moderately volatile
Benzaldehyde	100-52-7	2.60E-05	1.07E-03	Moderately volatile
Cinnamaldehyde	104-55-2	3.50E-06	1.43E-04	Moderately volatile
Butyl alcohol	71-36-3	9.99E-06	4.09E-04	Moderately volatile
Acetic acid	64-19-7	1.00E-07	4.10E-06	Moderately volatile
Diethanolamine	111-42-2	3.90E-11	1.60E-09	Low volatility
Methanol	67-56-1	4.55E-06	1.86E-04	Moderately volatile
Ethanol	64-17-5	5.76E-06	2.36E-04	Moderately volatile
Hydrotreated light petroleum distillate	64742-47-8	9.35E-00	3.83E+02	Highly volatile

Based on the octanol-water partitioning coefficient classification in Section 5.1.2.3, hydrotreated light petroleum distillate was classified as high potential to biomagnify. The remaining eight chemicals are considered to have low potential for biomagnification (refer to Table 30).

Table 30: Low Kow Classification for High Hazard Chemicals

Chemical	CAS RN	Log Kow	Potential to Biomagnify
Glutaraldehyde	111-30-8	-0.36	Low
Benzaldehyde	100-52-7	1.48	Low
Cinnamaldehyde	104-55-2	1.90	Low
Butyl alcohol	71-36-3	1.00	Low
Acetic acid	64-19-7	-0.17	Low

Chemical	CAS RN	Log Kow	Potential to Biomagnify
Diethanolamine	111-42-2	-1.43	Low
Methanol	67-56-1	-0.77	Low
Ethanol	64-17-5	-0.35	Low
Hydrotreated light petroleum distillate	64742-47-8	6.10	High

5.3.3 Identification of Terrestrial Chemicals of Potential Concern (COPC)

Using the three physico-chemical measures in combination it was possible to identify the COPC to terrestrial receptors posing a potential high hazard (see Table 31).

Table 31: Henry's Law Constant Classification for High Hazard Organic Chemicals

Chemical	CAS RN	Half-life in Soil (t ½) Classification	Potential to Biomagnify	Henry's Law Constant Classification	Primary Exposure Route
Glutaraldehyde	111-30-8	Moderate	Low	Moderately volatile	Direct toxicity
Benzaldehyde	100-52-7	Moderate	Low	Moderately volatile	Direct toxicity
Cinnamaldehyde	104-55-2	Moderate	Low	Moderately volatile	Direct toxicity
Butyl alcohol	71-36-3	Fast	Low	Moderately volatile	Direct toxicity
Acetic acid	64-19-7	Fast	Low	Moderately volatile	Direct toxicity
Diethanolamine	111-42-2	Fast	Low	***Low volatility***	Direct toxicity
Methanol	67-56-1	Fast	Low	Moderately volatile	Direct toxicity
Ethanol	64-17-5	Fast	Low	Moderately volatile	Direct toxicity
Hydrotreated light petroleum distillate	64742-47-8	Fast	***High***	Highly volatile	Direct toxicity

Cells in bold, underline and italics = Classified as persistent or possessing a high potential to biomagnify.

The organic chemicals classified as high hazard in Section 5.3.1 were assessed according to their toxicological and physio-chemical properties. The following organic chemicals were assessed to have the potential to pose a higher environmental hazard relative to the other chemicals assessed based on persistence and potential to biomagnify:

- Diethanolamine (low volatility); and
- Hydrotreated light petroleum distillate (high potential to biomagnify)

Diethanol amine has low volatility but it does not persistent in the soil and does not biomagnify. Hydrotreated light petroleum distillate has a high potential to biomagnify but it does not persist in the environment based on its fast half-life and high volatility. Therefore, although these chemicals appear to pose a higher hazard than others, their risk profile to terrestrial receptors is relatively low.

The remaining chemicals were considered likely to degrade quickly or moderately quickly and/or have a high or moderate volatility. Hence, whilst direct toxicity to terrestrial receptors may occur from exposure to these chemicals either after a spill or breach of containment, or from direct exposure via accidental entry into a panel tank (refer Section 2.1.1); effects are unlikely to persist over time.

5.4 Limitations and Uncertainties

The terrestrial environmental hazard assessment is a relative assessment and not a comprehensive evaluation of environmental hazards. The following limitations with regard to the terrestrial hazard assessment and source data were noted:

- Sources of Australian terrestrial ecotoxicological data were consulted but the information was limited. No terrestrial ecotoxicological data on the assessed chemicals were available for Australian birds, mammals, reptiles or flora.
- The terrestrial toxicological data used in this report do not include endpoints that assess effects on soil function or secondary poisoning via bioaccumulation in the food chain. Assessment of impacts via secondary poisoning has been assessed qualitatively from the chemical-specific physical and chemical data.
- The terrestrial toxicity assessment was largely based on modelled data of lettuce and earthworm that may not be receptors present in soil on well leases. Modelled data introduces greater uncertainty compared to use of measured data.
- The effects of exposure to the inorganic chemicals identified as posing a higher hazard relative to other chemicals could not be fully assessed.
- The terrestrial toxicity assessment identifies chemicals with the highest hazard relative to the chemicals assessed. Actual hazard is based on the exposure concentration and exposure scenario, as discussed in Section 2.0.
- Toxicological data were obtained for surrogates for a number of chemicals; and
- The data collated in the chemical information sheets (presented in APPENDIX E) were treated the same regardless of whether the data were measured experimental values or modelled / calculated values.

6.0 HUMAN HEALTH TOXICITY ASSESSMENT

6.1 Objective

As discussed in Section 4.2, the assessment of toxicity represents an assessment of hazard rather than risk. In terms of elements of the risk assessment process, the hazard assessment identifies a potential due to intrinsic properties of the chemical of interest, the exposure assessment provides information on the likelihood of the hazard being realised, and the risk characterisation provides a qualitative or semi-quantitative measure of the potential for the hazard to be realised.

The aim of the hazard assessment is therefore to provide a qualitative hazard ranking of chemicals based on human health toxicity and other hazardous endpoints to identify COPC. Further evaluation of the risk posed by the COPC is provided with an evaluation of exposure pathways. There are qualifiers related to the hazard ranking process. These are summarised in the concluding comments of each human health hazard profile presented in APPENDIX D

The end result of the human health hazard assessment is to provide direction for the mitigation of environmental and occupational health hazards that have the potential to be realised. This may be achieved by suitable management measures or in some cases, additional investigations (e.g., sampling and analytical programs and further risk assessment).

6.2 Historical Human Health Hazard Ranking

Human health hazard ranking may adopt a variety of approaches depending on the project or site-specific needs. A variety of hazard ranking or chemical screening methods are available in the published, peer-reviewed literature. Some of these methods are described in the following paragraphs.

Pennington and Bare (2001) described two methods developed by the US EPA: the Waste Minimisation Prioritization Tool (WMPT); and the Toxic Equivalency Potential (TEP). The WMPT examines screening in terms of key physical-chemical properties and includes measures for persistence, bioaccumulation and toxicity (PBT) that are calculated. Each PBT measure is scored to provide a single measure of relative concern. TEPs evaluate chemical fate, multi-pathway exposure and toxicity using a model-based approach. The TEP approach was considered by the authors to represent a less subjective and thus improved approach. TEPs are based on a generic version of CalTox - an integrated multimedia fate, multi-pathway exposure and toxicity model initially developed for human health risk assessments. The authors further stated that "*in typical applications and given the currently available transformation data, neither approach should be used to provide insights beyond a qualitative basis such as high, medium and low concern*" (p 910).

Pittinger *et al*. (2003) described seven discrete hazard and risk assessment tools and proposed a systematic framework to assist users in selecting the appropriate tool for a given application. The framework used a hazard-risk continuum with varying amount and specificity of data requirements. The continuum commenced with toxicity and physical-chemical properties on the hazard end and progressed to site-specific risk assessment. Pittinger et al. (2003) discussed approaches from:

- The American Industrial Health Council (AIHC).
- European Risk Ranking Method (EURAM).
- US Chemical Hazard Evaluation for Management Strategies (CHEMS-1).
- US Risk Screening Environmental Indicators.
- US EPA Clusters Scoring System for particular tasks.
- Exposure, Fate Assessment Screening Tool (E-FAST) used in US EPA's New Chemicals Program; and
- The OECD's "Tools for R&D Screening" which is part of the OECD's Chemical Risk Management Program.

Logue et al., (2011) published an approach that used indoor air exposure data and air guidelines to rank 267 chemicals. Thirty-one chemicals were identified as posing hazards with nine as priority pollutants. Dunn (2009) presented an approach for a relative risk ranking of select substances on the Canadian National Pollutant Release Inventory using the CHEMS-1 model listed by Pittinger et al. (2003) discussed above.

OECD (2001) published an initial approach to a harmonised integrated classification system for human health and environmental hazards of chemical substances and mixtures was updated to a Globally Harmonised System of Classification and Labelling of Chemicals (GHS) in 2003, with subsequent updates in 2005, 2007, 2009 and then in 2011 (UNECE, 2011). These guidelines provide categorisation across ten toxicity parameters and provide specific guidance for separation into those categories based on available toxicological data. The approach ranks within the respective categories but not across the toxicological parameters.

While the paper by Dunn (2009) highlights the use of CHEMS-1 in the Canadian approach to the National Pollutant Release inventory, the model does not include some elements that have more recently been included in evaluations by agencies such as the US EPA Design for the Environment (DfE). DfE focuses on the principles of green chemistry and applies these principles to work towards the replacement of hazardous chemicals by safer chemicals and considers a broader range of variables.

Recent green chemistry initiatives such as "*The Green Screen for Safer Chemicals*" (Clean Production Organisation, 2009) provide comprehensive ranking approaches embodying health risk assessment principles with the objectives of achieving safer chemical use. These approaches integrate data and categorisations from the following environment agencies: US EPA, the European Union/Commission (EU), United Nations Economic Commission for Europe (UNECE) GHS, International Agency for Research on Cancer (IARC), and US National Toxicology Program (NTP) sources to establish Very High (VH), High (H), Moderate (M), and Low (L) categories. The basis of these evaluations is to produce an overall categorisation into four benchmarks with 'Benchmark 4' reflecting a preferred safer chemical – a "green" objective. While the green chemistry initiative objectives differ somewhat from the objectives of the stimulation hazard ranking described in this report, the basis to the use of data reflects current approaches in hazard categorisation and includes toxicological parameters drawn from the UN GHS, IARC and other reputable sources. The stimulation hazard approach also includes a consideration of endocrine disruptor potential and physical hazards such as explosive capability and flammability. The approach has been employed with suitable adjustments for human health hazard ranking of stimulation chemicals. This is discussed in the following sections.

6.3 Historical Hazard Assessment and Ranking Methodology

The literature described above presented a variety of models and approaches to hazard rank chemicals. There is no one model or approach that is ideally suited to assess the potential environmental distribution, potential for human exposure, and subsequent hazard of stimulation chemicals.

Golder has structured an approach which integrates a number of the above methods to assess and rank hazards to humans exposed to stimulation chemicals. The approach is summarised as follows:

1) The inventory of stimulation chemicals was reviewed and all substances with reported CAS numbers collated. Those with no CAS numbers were separated into a "*Separate listing for review*" and additional information sought;

2) All substances with CAS numbers were reviewed to determine listing on Safework Australia's Hazardous Substances Information System (HSIS). Safework Australia's HSIS reports chemicals that have been reviewed under the National Occupational Health and Safety Commission (NOHSC, 2004) "*Approved Criteria for Classifying Hazardous Substances, 3rd Edition*" and/or have National Exposure Standards declared under the Adopted National Exposure Standards for Atmospheric Contaminants in the Occupational Environment [NOHSC:1003(1995)]. These classifications are based on a range of toxicological properties consistent with international approaches used in hazard ranking and health risk assessment.

3) Compositional data from SDSs were not used as a screening process in this instance because of the potential for low percentage substances to alter in availability due to environmental fate and transport processes. This is in contrast to occupational settings and product use where exposure controls and chemical alteration are limited compared with environmental settings. The issue of mass input into the environment as an index of potential exposure was considered at the end of the ranking process for each health hazard profile.

4) Data for all substances was collated based on the following variables:

    a. Carcinogenicity
    b. Mutagenicity/Genotoxicity
    c. Reproductive toxicity
    d. Developmental toxicity/Teratogenicity
    e. Endocrine disruption
    f. Neurotoxicity
    g. Acute toxicity (oral, dermal or inhalation)
    h. Corrosion/irritation of the skin or eye
    i. Sensitisation of the skin or respiratory system
    j. Immune system effects
    k. Systemic toxicity/Organ effects
    l. Flammable potential
    m. Explosive potential.

5) Thresholds were employed based on a combination of EU, IARC, US EPA, US NTP and the UNECE GHS approaches for hazard characterisation consistent with the ““*Green Screen for Safer Chemicals*”.

6) It should be noted that the “*Green Screen for Safer Chemicals*” (described in the previous section) includes an evaluation of persistence, bioaccumulation and aquatic toxicity (PBT). Rather than use the classification outlined in the “*Green Screen for Safer Chemicals*” the PBT analysis described in Section 4.6 has been used for consistency. This is appropriate as the evaluation is a comprehensive assessment of multiple parameters. In addition the classification of high, medium and low categories in Section 4.6 utilises more conservative thresholds for the hazard cut offs than presented in the “*Green Screen for Safer Chemicals”*. Finally, the classification scheme in Section 4.6 does not differentiate within hazard classifications (such as use a ‘Very High’ grouping adopted in the human health assessment), rather any chemical classified as posing a ‘High Hazard’ is considered a COPC. The Very High grouping in “*Green Screen for Safer Chemicals*” relates only to the PB assessment, as such this grouping has not been used in this assessment.

7) These thresholds allowed data to be ranked into strata of High, Moderate and Low concern and numerically converted as follows.

    a. High = 3
    b. Moderate = 2
    c. Low = 1

    Values were then averaged based on the available data that generated each score. This ensured scores were not biased by the amount of data for any one chemical, e.g. ten sets of data, the total was divided by ten, four sets of data, the total score was divided by 4, etc; and

8) The values were then converted into a qualitative expression of hazard described as Low (1), Low to Moderate (1-2), Moderate (2), Moderate to High (2-3) and High (3). These hazard classes were designed to reflect a relative ranking and were further qualified in terms of key hazards and potential scenarios requiring consideration. The latter was provided in a concluding section with summary comments for the

human health hazard profiles developed. The summary comments to each profile placed the health hazard ranking in perspective.

The application of this approach is iterative and subject to further refinement should additional information and or methodologies become available. As new information becomes available these rankings may be subject to change. As a consequence, the human health hazard evaluation presents uncertainty for each chemical assessed, expressed as a percentage. The percentage is calculated based on the data availability across the 13 hazard categories investigated. The percentage uncertainty is not a measure of data quality, but data availability.

Further discussion of these parameters is provided in the Section 4.0 including the threshold values used for each parameter.

6.4 Human Health Hazard Assessment Parameters

A description of each parameter is provided below, along with the threshold values for each parameter as presented in the "*Green Screen for Safer Chemicals*". The threshold values for these parameters as presented in the "*Green Screen for Safer Chemicals*" are drawn from the following sources:

- EU's recently enacted chemicals policy legislation (Registration, Evaluation and Authorization of Chemicals–REACH) (EU 2006).
- UNECE (2011) Globally Harmonized System of Classification and Labelling of Chemicals (GHS). Fourth revised edition. United Nations, New York and Geneva.
- The International Agency for Research on Cancer (IARC) monographs on Carcinogens, available at http://monographs.iarc.fr.
- US Environmental Protection Agency, Design for Environment Program. (USEPA DfE) 2005. Environmental Profiles of Chemical Flame-Retardant Alternatives for Low-Density Polyurethane Foam.
- US Department of Health and Human Services, Public Health Service, National Toxicology Program (US NTP). 2005. Report on Carcinogens, Eleventh Edition.
- State of California, Environmental Protection Agency, Office of Environmental Health Hazard Assessment. 2006. Chemicals Known to the State to Cause Cancer or Reproductive Toxicity.
- Japan Ministry of Environment. 1998. Endocrine Disrupting Chemicals Database, Table of Chemicals Suspected of Having Endocrine Disrupting Effects; and
- US Department of Labour Occupational Safety and Health Administration (OSHA) List of OSHA carcinogens.

6.4.1 Acute Toxicity

Acute toxicity refers to the occurrence of adverse effects following exposure to a single dose of a substance or multiple doses within a 24-hour period (OECD 2009). In toxicity studies acute effects are often characterised by lethality, commonly reported in lethal dose or concentration at which 50% of the animals tested die (LD50 or LC50). Non-lethal acute effects are sometimes included. Routes of administration commonly used are the oral, dermal and inhalation pathways. The threshold values for acute toxicity are presented in Table 32.

Table 32: Acute Toxicity (Oral, Dermal or Inhalation) Threshold Values

High	Medium	Low
■ LD50 <50 mg/kg bodyweight (oral) ■ LD50 <200 mg/kg bodyweight (dermal) ■ LC50 <500 ppm (gas) ■ LC50 <2.0 mg/l (vapour) ■ LC50 <0.5 mg/l (dust or mist) ■ US EPA Extremely Hazardous Substance List ■ GHS Category 1 or 2	■ LD50 50-2000 mg/kg bodyweight (oral) ■ LD50 200-2000 mg/kg bodyweight (dermal) ■ LC50 500-5000 ppm (gas) ■ LC50 2-20 mg/l (vapour) ■ LC50 0.5-5 mg/l (dust or mist) ■ GHS Category 3 or 4	No basis for concern identified

6.4.2 Corrosion/Irritation of the Skin or Eye/s

Skin corrosion is the production of irreversible damage to the skin namely, visible necrosis through the epidermis and into the dermis following the application of a substance for up to four hours (OECD, 2009). Corrosion is often indicated by ulcers and bleeding and after 14 days discolouration of the skin, alopecia and scars. Skin irritation is the production of reversible damage to the skin following application of a substance (OECD, 2009).

Serious eye damage (i.e. corrosion) is indicated by tissue damage of the eye or serious physical decay of vision following application of the anterior surface of the eye which is not fully reversible within 21 days (OECD, 2009). Eye irritation is indicated by changes in the eye following application of the anterior surface of the eye which is fully reversible within 21 days (OECD, 2009).

The threshold values for corrosion/Irritation of the skin or eye are presented in Table 33.

Table 33: Corrosion/Irritation of the Skin or Eye Threshold

High	Medium	Low
■ Evidence of irreversible effects in studies of human populations ■ Weight of evidence of irreversible effects in animal studies ■ GHS Category 1 (skin or eye)	■ Evidence of reversible effects in humans or animals ■ GHS Category 2 or 3 — skin irritation ■ GHS Category 2A or 2B — eye	■ No basis for concern identified

6.4.3 Sensitisation of the Skin or Respiratory System

A respiratory sensitiser is a substance that will lead to hypersensitivity of the airways following inhalation of the substance (OECD, 2009). A skin sensitizer is a substance that will lead to an allergic response following skin contact (OECD 2009).

The threshold values for sensitisation of the skin or respiratory system are presented in Table 34.

Table 34: Sensitisation of the Skin or Respiratory System Threshold

High	Medium	Low
■ Evidence of adverse effects in humans; ■ Weight of evidence demonstrates potential for adverse effects in humans ■ GHS Category 1 – (skin or respiratory) ■ Positive responses in predictive Human Repeat ■ Insult Patch Tests (HRIPT) (skin)	■ Suggestive animal studies of adverse effects ■ Analogue data ■ Chemical class known to produce toxicity	■ No basis for concern identified

6.4.4 Carcinogenicity

A carcinogen is a substance or a mixture which induces cancer or increases its incidence. The classification of a substance or mixture as a carcinogenic hazard is based on its inherent properties and does not provide information on the level of human cancer risk which the use of a substance may represent (OECD, 2009).

The threshold values for carcinogenicity are presented in Table 35.

Table 35: Carcinogenicity Thresholds

High	Medium	Low
■ Evidence of adverse effects in humans ■ Weight of evidence demonstrates potential for adverse effects in humans ■ NTP known or reasonably anticipated to be human carcinogen ■ OSHA carcinogen ■ California Prop 65 ■ IARC Group 1 or 2A ■ EU Category 1 or 2 ■ GHS Category 1A or 1B	■ Suggestive animal studies of adverse effects ■ Analogue data ■ Chemical class known to produce toxicity ■ IARC Group 2B ■ EU Category 3 ■ GHS Category 2	■ No basis for concern identified ■ IARC Group 3 or 4

6.4.5 Developmental Toxicity

Developmental toxicity refers to the *in-utero* effects such as death, malformations, functional deficits and developmental delays (enHealth, 2004). It can also include delayed toxicity associated with epigenic effects during the sensitive phases of foetal development.

The threshold values for developmental toxicity are presented in Table 36.

Table 36: Developmental Toxicity Threshold

High	Medium	Low
■ Evidence of adverse effects in humans ■ Weight of evidence demonstrates potential for adverse effects in humans ■ NTP Center for the Evaluation of Risks to Human Reproduction ■ California Prop 65	■ Suggestive animal studies of adverse effects ■ Analogue data ■ Chemical class known to produce toxicity	■ No basis for concern identified

6.4.6 Mutagenicity/Genotoxicity

Mutagenesis occurs when chemicals cause changes in the genetic material which can be transmitted during call division (Davis et al., 1994). The OECD (2009) indicates a mutagen is a chemical that may cause mutations in the germ cells of humans that can be transmitted to the progeny. A mutation is defined as a permanent change in the amount or structure of the genetic material in a cell. The more general terms genotoxic and genotoxicity apply to agents or processes which alter the structure, information content or segregation of deoxyribonucleic acid (DNA) (OECD, 2009).

The threshold values for mutagenicity and genotoxicity are presented in Table 37.

Table 37: Mutagenicity/Genotoxicity Thresholds

High	Medium	Low
■ Evidence of adverse effects in humans ■ Weight of evidence demonstrates potential for adverse effects in humans ■ EU Category 1 or 2 ■ GHS Category 1A or 1B	■ Suggestive animal studies of adverse effects ■ Analogue data ■ Chemical class known to produce toxicity ■ EU Category 3 ■ GHS Category 2	■ No basis for concern identified

6.4.7 Reproductive Toxicity

Reproductive toxicity includes adverse effects on sexual function and fertility in adult males and female as well as developmental toxicity in the offspring (OECD, 2009). This may include effects on mating behaviour, gonadal function, oestrous cycling, conception, implantation, parturition and lactation (Draft enHealth, 2010). The threshold values for reproductive toxicology are presented in Table 38.

Table 38: Reproductive Toxicity Thresholds

High	Medium	Low
■ Evidence of adverse effects in humans ■ Weight of evidence demonstrates potential for adverse effects in humans ■ NTP Centre for the Evaluation of Risks to Human Reproduction ■ California Prop 65 ■ EU Category 1 or 2 ■ GHS Category 1A or 1B	■ Suggestive animal studies of adverse effects ■ Analogue data ■ Chemical class known to produce toxicity ■ EU Category 3 ■ GHS Category 2	■ No basis for concern identified

6.4.8 Neurotoxicity

Neurotoxicity refers to any adverse effects on the structure or functional integrity of the developing or adult nervous system. Neurotoxic effects may involve a spectrum of biochemical, morphological, behavioural, and physiological abnormalities whose onset can vary from immediate to delayed following exposure to a toxic substance, and whose duration may be transient or persistent (US Department of Food and Drug Administration, 2000).

The threshold values for neurotoxicity are presented in Table 39.

Table 39: Neurotoxicity Thresholds

High	Medium	Low
■ Evidence of adverse effects in humans ■ Weight of evidence demonstrates potential for adverse effects in humans	■ Suggestive animal studies of adverse effects ■ Analogue data ■ Chemical class known to produce toxicity	■ No basis for concern identified

6.4.9 Endocrine Disruption

Endocrine disruptors are chemicals that may interfere with the body's endocrine system and produce adverse developmental, reproductive, neurological, and immune effects (OECD, 2009).

The threshold values for endocrine disruption are presented in Table 40.

Table 40: Endocrine Disruption Thresholds

High	Medium	Low
■ Evidence of adverse effects in humans ■ Weight of evidence demonstrates that mechanisms of action lead to adverse effects	■ Suggestive animal studies of adverse effects ■ Analogue data ■ Chemical class known to produce toxicity ■ EU Draft List - Category 1 or 2 ■ Japanese list	■ No basis for concern identified

6.4.10 Systemic Toxicity/Organ Effects

This relates to substances that produce specific non- lethal organ toxicity arising either from a single or repeated dose. All significant health effects that can impair function, reversible and irreversible, immediate and/or delayed are included (OECD, 2009).

The threshold values for systemic toxicity / organ effects are presented in Table 41.

Table 41: Systemic Toxicity Thresholds

High	Medium	Low
■ Evidence of adverse effects in humans ■ Weight of evidence demonstrates potential for adverse effects in humans ■ GHS Category 1 — organ/systemic toxicity following single or repeated exposure	■ Suggestive animal studies of adverse effects ■ Analogue data ■ Chemical class known to produce toxicity ■ GHS Category 2 or 3 single exposure ■ Category 2 repeated exposure	■ No basis for concern identified

6.4.11 Immune System Effects

The threshold values for immune system effects are presented in Table 42.

Table 42: Immune System Effect Thresholds

High	Medium	Low
■ Evidence of adverse effects in humans Weight of evidence demonstrates potential for adverse effects in humans	■ Suggestive animal studies of adverse effects ■ Analogue data ■ Chemical class known to produce toxicity	■ No basis for concern identified

6.4.12 Explosive Potential

An explosive substance is a solid or liquid which is capable by chemical reaction of producing gas at such high temperature and pressure and at such a speed as to cause damage to the surroundings (OECD, 2009).

The threshold values for explosive potential effects are presented in Table 43.

Table 43: Explosive Potential Threshold Values

High	Medium	Low
■ GHS Category: Unstable Explosives or Divisions 1.1, 1.2 or 1.3	■ GHS Category: Divisions 1.4, 1.5	■ No basis for concern identified

6.4.13 Flammable Potential

A flammable liquid has a flash point of not more than 93˚C (OECD, 2009). A flammable solid is readily combustible or may cause or contribute to fire through friction. A readily combustible solid is a powdered, granular or pasty substance which is dangerous if it can be ignited by brief contact with an ignition source and the flame spreads rapidly (OECD, 2009).

The threshold values for flammable potential effects are presented in Table 44.

Table 44: Flammable Potential Thresholds

High	Medium	Low
■ GHS Category 1 - Flammable Gases ■ GHS Category 1 - Flammable Aerosols ■ GHS Category 1 or 2 — Flammable Liquids	■ GHS Category 2- Flammable Gases ■ GHS Category 2- Flammable Aerosols ■ GHS Category 3 or 4 — Flammable Liquids	■ No basis for concern identified

6.5 Historical Human Health Hazard Ranking

6.5.1 Process of Hazard Review

As an initial assessment of hazard, all chemicals listed in Table 4 were queried via the SafeWork Australia Hazardous Chemical Information System (HCIS) to determine if they were classified as "*hazardous*"" based on the in accordance with the Globally Harmonized System of Classification and Labelling of Chemicals (GHS) 3rd revised edition. The GHS classifications are based on a range of toxicological properties consistent with approaches used in hazard ranking and health risk assessment. A limitation of this initial search is that although the HCIS database includes over 5,000 substances, only substances that have been assessed and subsequently classified as hazardous are included. Absence of a chemical from the database does not imply a chemical is non-hazardous. The listings are summarised in Table 45. Of the total of 39 substances reviewed in this report, 26 were listed, 13 were not listed.

Table 45: Hazardous Chemical Information System Listing

Chemical Name	CAS RN	HCIS
Acetic acid	64-19-7	Listed
Alcohols, C12-16, ethoxylated	68551-12-2	Listed*
Amine oxides, cocoalkyldimethyl	61788-90-7	Not Listed
Benzaldehyde	100-52-7	Listed
Cinnamaldehyde	104-55-2	Listed*
Citric acid	77-92-9	Listed
Diethylene glycol	111-46-6	Listed
Methanol	67-56-1	Listed
Triethanol amine	102-71-6	Listed
Diethanol amine	111-42-2	Listed
Ethanol	64-17-5	Listed
Hydrotreated light petroleum distillate	64742-47-8	Listed

Chemical Name	CAS RN	HCIS
Sodium polyacrylate	9003-04-7	Not Listed
Alcohols, C12-C15, ethoxylated	68131-39-5	Listed
Amides, tall-oil fatty, N,N-bis(hydroxyethyl)	68155-20-4	Not Listed
Fatty acids, tall-oil, ethoxylated	61791-00-2	Not Listed
Butyl alcohol	71-36-3	Listed
Tributyl tetradecyl phosphonium chloride	81741-28-8	Listed
Glutaraldehyde	111-30-8	Listed
Monoethanolamine borate	26038-87-9	Listed
Guar gum	9000-30-0	Not Listed
Ethylene glycol	107-21-1	Listed
Aluminium oxide	1344-28-1	Not Listed
Chlorous Acid, sodium Salt	7758-19-2	Listed*
Disodium octaborate tetrahydrate	12008-41-2	Listed*
Hydrochloric acid	7647-01-0	Listed
Iron oxide	1309-37-1	Not Listed
Sodium bisulfite	7631-90-5	Listed
Sodium carbonate	497-19-8	Listed
Sodium chloride	7647-14-5	Not Listed
Sodium hydroxide	1310-73-2	Listed
Sodium iodide	7681-82-5	Not Listed
Titanium dioxide	13463-67-7	Not Listed
Ulexite	1319-33-1	Listed
Hydroxylpropyl guar	39421-75-5	Not Listed
Aluminium silicate	1302-76-7	Not Listed
Crystalline silica, cristobalite	14464-46-1	Listed
Crystalline Silica, quartz	14808-60-7	Listed
Silica Gel	112926-00-8	Not Listed

Note:" * "These chemicals have been added to the HCIS since the previous search of the database (formerly the Hazardous Substances Information System HSIS) Golder conducted in 2012.

Of the chemicals listed in Table 45, two chemicals have not been assessed or considered further in this report:

- Sodium chloride (7647-14-5) is a naturally occurring ubiquitous salt and not considered to be a hazardous substance

- Hydroxylpropyl guar (39421-75-5) which has been considered to be sufficiently addressed by the assessment of guar gum (9000-30-0).

Readily available human health toxicity and hazard data were collated from the following online data bases:

- Safework Australia sources, specifically the Hazardous Chemical Information System (HCIS).
- National Industrial Chemicals Notification and Assessment Scheme (NICNAS)
- World Health Organisation (WHO) sources such as International Program of Chemical Safety (IPCS) INCHEM, including Concise International Chemical Assessment Documents (CICADS) and Environmental Health Criteria (EHC) monographs.
- European Chemicals Agency (ECHA) REACH registration dossiers
- United States sources such as:
  - United States National Medical Library of Medicine Toxicology (Toxnet) and Hazardous Substances Data Bank (HSDB).
  - United States Environmental Protection Agency (US EPA) Integrated Risk Information System (IRIS).
  - Agency for Toxic Substances and Disease Registry (ASTDR) toxicological profiles; and
  - Risk Assessment Information System (RAIS).

If no information was available from these databases then the search was extended to access other sources of toxicity information, preference was given to peer-reviewed data.

Toxicity information for each parameter was then categorised as High, Medium or Low concern according to the thresholds described in Section 4.6. The categories were numerically converted as follows:

- High = 3
- Moderate to High = 2-3
- Moderate = 2
- Low to Moderate = 1-2
- Low = 1

The scoring system is semi-quantitative in that scores are assigned to ranges for a particular parameter. The scores are largely assigned using some quantitative data and professional judgement following consideration of the guidance from the ranking thresholds specified for each parameter. In order to provide some measure to the availability of data an estimation of uncertainty was presented by calculating the percentage of parameters for which data were available, e.g. if data for 2 parameters only were obtained, this represented 2/13 or 15%. This allowed some appreciation of data gaps that, if available, may alter the estimated hazard assessment.

6.5.2 Surrogate Selection

Surrogates compounds were selected consistent with the approach described in Section 4.6.2. Where chemicals were assessed using a surrogate, this is documented in this report for transparency. Where chemicals could not be assessed using a surrogate, they were not assessed due to insufficient data. In total nine surrogates were employed for all the substances considered in this assessment. These are presented in Table 46.

Table 46: Surrogates Used in Human Health Hazard Evaluation

Chemical	CAS No	Surrogate Descriptor
Kaolin	1332-58-7	Surrogate for aluminium silicate

Chemical	CAS No	Surrogate Descriptor
Amides, C18-unsaturated, N,N-bis(hydroxyethyl)	93-83-4	Surrogate for Amides, tall-oil, fatty, N,N-bis(hydroxethyl) (CAS RN 68155-20-4)
Tetra-n-butyl phophonium chloride	2304-30-5	Surrogate for Tributyl tetradecyl phosphonium chloride (CAS RN 81741-28-8)
Rection products of monoethanolamine and boric acid	94095-04-2	Surrogate for Monoethanolamine borate (CAS RN 26038-87-9)
Disodium octaborate tetrahydrate	12008-41-2	Surrogate for Ulexite (CAS RN 1319-33-1)

6.5.3 Human Health Chemicals of Potential Concern (Historical Assessment Method)

The evaluation process detailed above provided a relative ranking of human health hazard scores to enable a prioritization of COPC to be made. On this basis, chemicals ranged from a hazard score of 1.0, representing classification of "*no cause for concern*" to those considered "*Moderate to High*" cause for concern. The data completeness ranged from 31% to 100%. This data completeness measures provides some confidence in the ranking such that where data are limited there is a greater possibility that the hazard profile may change with increase information.

A summary of the available human health hazard information for each chemical is presented in the Health Hazard Profiles for each substance in APPENDIX D.

The selection of a chemical as a COPC does not indicate an unacceptable risk (which is reflection of the realisation of a hazard); rather it indicates that potential exposures to these chemicals should be evaluated in greater detail to ascertain if they may present an unacceptable risk. Furthermore, adverse health effects are a reflection of intrinsic chemical or physical toxicity, the physico-chemical parameters of the substance concerned, and the exposure setting and affected populations. Subsequently, it is not possible within a numerical ranking system to capture all possible exposure settings that may apply with product use and the possible chemical exposures. Consequently, qualitative comments have been provided for each of the ranked chemicals as concluding summary comments. These qualifying comments should be read and understood. These are presented in the human health profiles in APPENDIX D.

The recognition of human health hazards provides a basis to assigning public health protection measures to ensure exposures to substances identified as having intrinsic toxic effects are adequately controlled. Public health protection may be differentiated between occupational health and environmental health where the former involves workers and respective legislative requirements and the latter involves the general community sector. Of the 64 substances that were examined, 44 substances recorded hazard scores greater than 1.0 and these substances are have been the subject of further comment in Table 47. This table presents the substances, their hazard score, and indication of persistence and key hazard determinants and potential areas of concern. The latter provides direction on the differentiation of occupational health and environmental health concerns and provides further focus on hazard mitigation measures including assessment.

The assessment of human health hazards has been undertaken on individual substances. Assessment of the combined effects of the constituents (when present in a mixture) was outside the scope of this assessment.

Table 47: Summary of Human Health Hazard Classification and Potential Outcomes (Historical Assessment Method)

Substance	CAS No	Environmental Behaviour	Key Determinants and Potential Hazard Outcomes
Moderate to High Hazard			
Methanol	67-56-1	Dilution/biodegradation/volatile	Occupational exposure concerns – volatile and flammable/explosive.
Sodium iodide	7681-82-5	Dilution/dissociation/persistence	Occupational irritant. Toxicity concerns of iodine warrant both occupational and environmental exposure assessment.
Acetic acid	64-19-7	Dilution/dissociation/biodegradation	Concentrated form is an occupational hazard. Flammable and explosive.
Moderate Hazard			
Crystalline silica, quartz	14808-60-7	Dilution/Persistence	Occupational respiratory effects (cancer, silicosis)
Sodium carbonate	497-19-8	Dilution/dissociation	Occupational irritant and sensitiser – product and concentrated solutions are alkaline. May increase alkalinity of environmental waters.
Crystalline silica, cristobalite	14464-46-1	Dilution/Persistent	Occupational respiratory effects (cancer, silicosis)
Low to Moderate Hazard			
Chlorous acid, sodium salt	7758-19-2	Dilution/degradation	Occupational hazard – suspect mutagen and irritant. Developmental toxicity concerns (female workers).
Sodium hydroxide	1310-73-2	Dilution/dissociation	Occupational hazard - highly corrosive to skin, eyes and mucous membranes. May increase alkalinity in environmental waters.
Hydrochloric acid	7647-01-0	Dilution/dissociation	Occupational hazard – irritant, corrosive and necrotic to lung, eyes, skin and mucous membranes. May increase acidity of environmental waters.
Citric acid	77-92-9	Dilution/dissociation	Occupational hazard – skin and eye irritant. May contribute to elevations in acidity of environmental waters.
Low to Moderate Hazard (cont.)			
Disodium octaborate tetrahydrate	12008-41-2	Dilution/dissociation/persistence	Occupational and environmental hazard – reproductive (males and females) and developmental toxicity (female workers). May elevate boron levels in environmental surface waters.

Substance	CAS No	Environmental Behaviour	Key Determinants and Potential Hazard Outcomes
Aluminium oxide	1344-28-1	Dilution/persistence	Occupational and environmental hazard. Respiratory irritant and neurotoxin. May elevate aluminium levels in environmental waters.
Benzaldehyde	100-52-7	Dilution/biodegradation	Occupational and environmental hazard – irritant and evidence of acute and chronic toxicity. Environmental concentrations require evaluation. Flammable.
Cinnamaldehyde	104-55-2	Dilution/biodegradation	Occupational hazard – skin and eye irritant and sensitiser. Low toxicity.
Diethylene glycol	-	Dilution/biodegradation	Occupational hazard – skin and eye irritant. Low toxicity based on available information.
Surrogate for aluminium silicate	1302-76-7	Dilution/Persistent	Occupational respiratory particulate hazard. Limited evidence of developmental toxicity (by ingestion),
Amine oxides, cocoalkyldimethyl	61788-90-7	Dilution/readily biodegradation	Occupational hazard - skin, eye and respiratory irritant.
Low to Moderate Hazard (cont.)			
Iron oxide	1309-37-1	Limited mobility as not soluble in water but the ferric cation will persist	Occupational inhalation hazard and skin irritant and sensitiser. Low oral toxicity. May result in elevations of iron levels in environmental waters.
Alcohols, C12-16, ethoxylated	68551-12-2	Dilution/biodegradation	Occupational hazard – skin and eye irritant. Low toxicity. Volatile.
Titanium dioxide	13463-67-7	Dilution/Persistence	Occupational hazard – eye and respiratory irritant. Pulmonary effects from particulate inhalation. Low oral toxicity.

6.6 New Hazard Assessment Approach (IMAP Framework)

In addition to the chemicals assessed under the above described historical 'high-moderate-low' hazard ranking system, eight new chemicals were assessed using the following approach which is based on the Inventory Multi-tiered Assessment and Prioritisation (IMAP) Framework recently published by the National Industrial Chemicals Notification and Assessment Scheme (NICNAS, 2013). This framework has been designed to enable prioritisation of chemicals by hazard, exposure and use in the community for the purposes of national chemical assessment programs. This involves hazard bands, exposure bands and five broad categories: cosmetic, domestic, commercial, site-limited and non-industrial. The exposure assessment considers volumes and uses multipliers in conjunction with the hazard assessment to provide the risk characterisation for prioritisation and subsequent national assessment of the chemical. Integral to this process is review of international classifications and assessments following the prioritisation process with further increasingly detailed Tier I, Tier II and Tier III assessments.

The IMAP Framework for hazard assessment uses a hierarchy of indicators developed and agreed by the Human Health Expert Working Group (HHEWG) which reflects the following weighting:

- Carcinogenicity, Genotoxicity, Reproductive/developmental toxicity, Endocrine disruption, Neurotoxicity
- Acute toxicity
- Repeat dose toxicity
- Sensitisation
- Irritation.

This facilitates a Hazard Banding which is structured across five bands from Hazard Band 4 (highest) to Hazard Band 0 (lowest). The approaches employed within the IMAP framework adopt global harmonisation practices for classification and labelling of chemicals with assessment thresholds consistent with the previous historical approach used. The major difference is the national weighting applied for the above specific toxicological parameters.

The following chemicals have been assessed using the above approach. The results of which are included in APPENDIX D and summarised in Table 48.

- Ethylene Glycol
- Sodium bisulfite
- Triethanolamine
- Diethanolamine
- Ethanol
- Hydrotreated light petroleum distillate
- Sodium polyacrylate
- Alcohols, C12-C15, ethoxylated
- Amides, tall-oil fatty, N,N-bis(hydroxyethyl)
- Fatty acids, tall oil, ethoxylated
- Butyl alcohol
- Tributyl tetradecyl phosphonium chloride
- Glutaraldehyde
- Monoethanolamine borate

- Guar gum
- Ulexite
- Silica gel.

It should be noted that the IMAP framework has not been employed for the balance of chemicals, and so no change is reflected in previous chemical assessments.

Table 48: Summary of Human Health Hazard Classification and Potential Outcomes (as per the IMAP Framework Ranking Approach)

Substance	CAS No	IMAP Hazard Ranking	Environmental Behaviour	Key Determinants and Potential Hazard Outcomes
Sodium bisulfite	7631-90-5	3	Readily dissociates / dilutes in waters. Oxides of sulphur may be produced from the bisulphite anion.	Low order of toxicity. Rating reflects the hypersensitivity responses to sulphur and oxides of sulphur for sensitive populations (common) Concerns thus limited to occupational setting as sulphur (as oxide) is expected to be distributed (e.g. to atmosphere) within the environmental setting.
Ulexite	1319-33-1	4	Slightly soluble. The surrogate for ulexite, disodium octaborate is converted to boric acid and disodium borate in water. Unlikely to bioaccumulate.	Potential to cause reproductive toxicity (infertility) and its potential for damaging the unborn child. In aqueous solutions sodium borates are likely to convert to boric acid/borate and at physiological and acidic pH, predominately exist as un-dissociated boric acid. Based on this, the potential human toxicity of ulexite can be based on boric acid. The reproductive toxicity of boric acid and its salts occurs at high doses via the oral route. It is unlikely to present a reproductive toxicity hazard via skin contact and when inhaled as dust below the occupational exposure limit.
Triethanolamine	102-71-6	2	Highly soluble, readily biodegradable with a low to moderate potential to bioaccumulate	Triethanolamine has a low order of acute and chronic toxicity. It is classified as a skin sensitiser and eye irritant. It is not genotoxic, carcinogenic, or toxic to development or the reproductive system.
Amides, tall-oil fatty, N,N-bis(hydroxyethyl)	68155-20-4	2	Readily biodegradable in soil, potential to persist and bioaccumulate	Based on chronic dermal exposure and being an eye and skin irritant.
Ethylene Glycol	107-21-1	3	Rapid degradation following dilution.	Ethylene glycol exhibits a diverse range of adverse toxicological outcomes in animal studies including reproductive, developmental and teratogenic effects and renal effects after chronic exposure, although it is not considered highly acutely toxic via the oral, dermal and inhalation pathways. In humans it is considered to be acutely toxic. Furthermore, while ECHA has not classified ethylene glycol as a reproductive toxicant, ATSDR (2010) highlight the developmental toxicity of ethylene glycol in animals.
Diethanolamine	111-42-2	3	Highly soluble, readily biodegradable with a low to moderate potential to bioaccumulate.	Based on carcinogenic and reproductive toxicity potential. Diethanolamine was assigned Group 2B by IARC indicating it is possibly carcinogenic to humans and it is classified by the ECHA dossier as Category 2 for reproductive toxicity (H361). The ECHA dossier also classifies diethanolamine for chronic (repeated dose) oral toxicity and as irritating to the skin and highly irritating to the eyes. Diethanolamine is considered to

Substance	CAS No	IMAP Hazard Ranking	Environmental Behaviour	Key Determinants and Potential Hazard Outcomes
				have moderate acute oral toxicity and low toxicity following inhalation exposure. It is considered to be not sensitising to the skin.
Fatty acids, tall-oil, ethoxylated	61791-00-2	2	Likely to persist in soils, immobile in water with a potential to bioaccumulate	Based on the potential for it to be sensitising to skin. Although it is noted that sensitising test produced mixed results. Fatty acids, tall-oil, ethoxylated has low oral acute and chronic toxicity.
Ethanol	64-17-5	1	Highly soluble, readily biodegradable with a low potential to bioaccumulate.	Based on being an eye irritant. This ranking is based on the exclusion of data specific to extremely high exposure to ethanol, as observed for consumption of alcoholic beverages. Adverse effects for several endpoints (carcinogenicity, mutagenicity/genotoxicity, reproductive/developmental toxicity and chronic toxicity) were observed at high dose rate. However, these dose rates are not considered relevant when considering industrial uses and potential occupational exposure.
Sodium polyacrylate	9003-04-7	3	Highly soluble in water.	Based on the potential effects of inhalation of the respirable dust of the polymer. It is noted that this is based upon a no observed effect concentration, which was the highest concentration in a study. Given the limited information, it is concluded that there is the potential for toxicity effects due to chronic inhalation of respirable dust. Potential inhalation exposures would require management.
Butyl alcohol	71-36-3	3	Highly soluble, readily biodegradable with a low potential to bioaccumulate.	Because it is corrosive to the eyes, causing serious and irreversible eye damage (classified as Category 1, H318: “Causes serious eye irritation”). It is also a skin irritant (classified as Category 2, H315: Causes skin irritation). As typical of alcohols, butyl alcohol can result in transient effects on the central nervous systems (CNS) consistent with general impairments of neurological and behavioural functions (drowsiness and dizziness). As such, butyl alcohol is also classified as specific target organ toxicity (STOT) Single Exposure Category 3 (H335: May cause respiratory irritation/ H336: May cause drowsiness or dizziness), and is also classified for acute oral toxicity as Category 4 (H302: Harmful if swallowed).
Tributyl tetradecyl phosphonium chloride	81741-28-8	3	Insoluble in water, readily biodegradable with a low potential to bioaccumulate	Due to acute inhalation and dermal toxicity, and corrosivity to skin and eyes. It is considered fatal if inhaled, toxic following contact with the skin and harmful if shallowed. It is also considered corrosive to the skin and eyes and sensitising to the skin. Data is lacking for the assessment of the chronic toxicity, reproductive toxicity and respiratory sensitization potential of tetrabutylphosphonium chloride.

Substance	CAS No	IMAP Hazard Ranking	Environmental Behaviour	Key Determinants and Potential Hazard Outcomes
Guar gum	9000-30-0	3	Insoluble in water, biodegradable and unlikely to bioaccumulate	Based on reported occupational asthma suggestive of Type 1 hypersensitivity responses while dermal and eye irritancy is the other main consideration. The potential for dust generation with such a product may result in both of these adverse outcomes under conditions of occupational exposure and subsequently warrant management measures. In addition, as the product is an organic dust, ignition and explosion are further concerns related to worker safety during on-site use of this product during chemical stimulation activities.
Hydrotreated light petroleum distillate	64742-47-8	3	Insoluble in water, readily biodegradable with a low potential to bioaccumulate	Based on a classification of Aspiration Hazard – Category 1; H304 (May be fatal if swallowed and enters airways). In addition, Kerosines are classified as Skin Irritation Category 2 (H315), irritating to the skin, and have the hazard statement AUH066 (Repeated exposure may cause skin dryness and cracking). Other than these hazards, studies reported low acute and chronic toxicity via the oral, dermal and inhalation route.
Alcohols, C12-C15, ethoxylated	68131-39-5	1	Volatile, low potential to bioaccumulate	Reflects a low order of acute toxicity and its associated irritant properties, the latter of greater concern for the occupational setting. Overall, alcohols, C10-16, ethoxylated, propoxylated, exhibit a lack of carcinogenic, genotoxic, reproductive and developmental toxicities with the latter only evidenced at maternally toxic doses. It is not considered a sensitiser.
Glutaraldehyde	111-30-8	3	Insoluble in water, readily biodegradable with a low potential to bioaccumulate	Based on the potential for it to be corrosive to the skin and eyes, a respiratory sensitiser and acutely toxic via the oral route of exposure.
Monoethanolamine borate	26038-87-9	4	Soluble, biodegradable and unlikely to bioaccumulate	Based on potential reproductive and developmental toxicity, Safe Work Australia (2020) has classified Monoethanolamine borate as Category 1B for reproductive and developmental toxicity (H360FD May damage fertility. May damage the unborn child). This is based on the classification of sodium borate, anhydrous (CAS No. 1330-43-4), tetraboron disodium heptaoxide, hydrate (CAS No. 12267-73-1) and orthoboric acid, sodium salt (CAS No. 13840-56-7) as Category 1B and the recommendation by NICNAS to extent this classification to the group (‘salts of boric acid’).

Substance	CAS No	IMAP Hazard Ranking	Environmental Behaviour	Key Determinants and Potential Hazard Outcomes
Silica gel	112926-00-8	0	Porous and water absorbing. Chemically stable (unlikely to react with other substances in the environment).	Amorphous silica is chemically and biologically inert when ingested in any of its many physical forms such as amorphous siliceous earth (diatomaceous earth, diatomite, kieselguhr) or colloidal silica gels and is not classifiable as to its carcinogenicity to humans. SAS is not considered as having acute or chronic health effects when administered via oral, dermal and inhalation exposure pathways nor as having any reproductive, development/teratogenicity and mutagenicity/genotoxicity effects. SAS is not classified as a skin sensitiser nor does it cause irreversible irritation of the skin or eye. For this reason it is categorized as Hazard Band 0. Safe Work Australia has listed amorphous silica as a hazardous substance under the respective legislation and developed an exposure standard for amorphous silica dust which is the generic standard for dusts. Due to its low solubility, amorphous silica in aqueous solution and as introduced during chemical stimulation activities would settle into soils and sediments and become indistinguishable from those materials. The principle hazard is subsequently the generation of dusts under occupational settings which require management.

6.7 Uncertainty Analysis and Concluding Comments

The evaluation of the hazards presented in Table 48is based on the available data obtained from the selected sources presented in Section 6.5. As a consequence, the hazard evaluation is limited to the quantity and quality of information available in those sources. An assessment of the quality of the available data is beyond the scope of this report. In the absence of verifying the data by going to the primary literature sources, the selection of data for use in the assessment has been confined to established, robust and reputable sources such as NICNAS, EU, IARC, WHO and US EPA where available. As new toxicological data are generated and become available in the published literature, the information presented in this hazard evaluation and the associated conclusions may be subject to change. Specific areas where such information is being generated include the areas of endocrine disruptors and nanotoxicity. The latter has at this stage not been a focus of these current evaluations due to the paucity of available peer-reviewed information but may be required as new information becomes available.

The hazard evaluation for human health suggests that the dominant concerns are related to occupational hazards such as carcinogenicity, silicosis, skin, eye and respiratory irritancy or corrosivity and sensitisation. In some cases, physical hazards of flammability and explosion prevail and are identified in this report. While extensive dilution of the stimulation chemicals is anticipated such that exposure concentrations will be much reduced compared to concentrations injected into the well, and in flowback fluid, there are a number of environmental hazards that are suggested from this human health evaluation. These include the potential for:

- Residual elevation of organic moieties. e.g. some salts have an organic part that will be present following dissociation that may increase in environmental waters.
- Changes in pH of environmental waters due to alkaline or acidic components.
- Elevations of certain metal concentrations in environmental waters.
- Some additives to exert endocrine disruption effects.
- Certain inorganic substances to generate atmospheric particulates that may impact nearby communities; and
- Volatile components to comprise nuisance or irritant effects should atmospheric concentrations be elevated in close proximity to communities.

These environmental hazards may be assessed further, and/or managed as required.

7.0 RISK CHARACTERISATION

Risk characterisation is the final step in a risk assessment process. It traditionally involves the incorporation of the exposure assessment and toxicological dose-response data. In this qualitative risk assessment, the process has embodied a hazard assessment and discussion of potential exposure pathways as part of a qualitative assessment of risk.

7.1 Discussion of Hazard Assessment

A hazard assessment of the chemicals used in the stimulation process by Santos contractor Halliburton have been assessed through the evaluation of persistence, bioaccumulation and aquatic toxicity (PBT) for aquatic receptors, terrestrial toxicity, and human health toxicity including physical hazards such as fire and explosion. The review of hazards is qualitative in that it has provided a relative ranking of chemicals considered to represent a high, moderate or low hazard in respect to the ecological or human health end points.

It should be noted that the selection of a substance as a COPC does not indicate an unacceptable risk; rather it indicates that potential exposures to these chemicals should be evaluated in greater detail to assess whether they might present an unacceptable risk. Further assessment usually entails evaluation of likely environmental concentrations and refinement of the exposure assessment.

The hazard assessment incorporates the assessment of toxicity and is based on the assumption that the pure substance is present; this is not true of either the stimulation fluid or the resultant concentration in the environment. The concentration of chemicals in the stimulation fluid during a release into the environment is expected to be less than the starting concentration calculated in the mass balance. The concentrations are expected to be reduced due to chemical processes during the stimulation process that result in transformation of the chemicals to simpler end products. In addition, chemicals will be subject to degradation, dispersion and adsorption all of which will result in attenuation of chemical concentrations with distance from the radius of stimulation.

7.1.1 Aquatic and Terrestrial Assessment

Based on the hazard classification of the stimulation chemicals (as presented in Table 4), the seven chemicals classified as a high hazard for aquatic receptors were considered to be COPC and these were alcohols, C12-C15, ethoxylated; surrogate for amides, tall-oil, fatty, N,N-bis(hydroxyethyl); chlorous acid, sodium salt; disodium octaborate tetrahydrate, sodium bisulfite, sodium iodide and surrogate for ulexite.

The certainty of the hazard classification varies depending on the extent of data gaps and the reliance on modelled data. The percent of data gaps were calculated and are presented in Table 23. The percentage data gaps for the high hazard chemicals ranged from relatively low (Alcohols, C12-C15, Ethoxylated) to relatively high (Sodium iodide).

In terms of terrestrial receptors, the following organic chemicals were assessed to have the potential to pose a higher environmental hazard relative to the other chemicals assessed based on persistence and potential to biomagnify:

- Diethanolamine; and
- Hydrotreated light petroleum distillate.

Diethanolamine has low volatility but it does not persistent in the soil and does not biomagnify. Hydrotreated light petroleum distillate has a high potential to biomagnify but it does not persist in the environment based on its fast half-life and high volatility. Therefore, although these chemicals appear to pose a higher hazard than others, their risk profile to terrestrial receptors is relatively low.

The remaining chemicals were considered likely to degrade quickly or moderately quickly and/or have a high or moderate volatility. Hence, whilst direct toxicity to terrestrial receptors may occur from exposure to these chemicals either after a spill or breach of containment, the effect will likely be reduced over time.

7.1.2 Human Health Assessment

The hazard evaluation for human health undertaken in accordance with the 'low-medium-high' hazard ranking methodology indicated three of the twenty chemicals assessed to have a 'moderate to high' relative ranking:

- Methanol
- Sodium iodide
- Acetic acid.

The hazard evaluation for human health undertaken in accordance with the IMAP Framework hazard ranking methodology indicated twelve of the seventeen chemicals assessed under this methodology to be a Hazard Rank of 4 or 3.

- Ethylene Glycol
- Sodium bisulfite
- Ulexite
- Diethanolamine
- Sodium polyacrylate
- Butyl alcohol
- Tributyl tetradecyl phosphonium chloride
- Guar gum
- Hydrotreated light petroleum distillate
- Glutaraldehyde
- Monoethanolamine borate.

The hazard evaluation for human health suggests that the dominant concerns are related to occupational hazards such as carcinogenicity, silicosis, skin, eye and respiratory irritancy or corrosivity and sensitisation. In some cases, physical hazards of flammability and explosion prevail and are identified in this report. While extensive dilution of the stimulation chemicals is anticipated such that potential exposure concentrations will be much reduced compared to concentrations injected into the well and in flowback fluid, there are a number of hazards that are suggested from this human health evaluation. These include the potential for:

- Residual elevations of organic moieties, e.g. some salts have an organic part that will be present following dissociation that may increase in environmental waters.
- Changes in pH of environmental waters due to alkaline or acidic components.
- Elevations of certain metal concentrations in environmental waters.
- Some additives to exert endocrine disruption effects.
- Certain inorganic substances to generate atmospheric particulates that may impact nearby communities in close proximity; and
- Volatile components to comprise nuisance or irritant effects should atmospheric concentrations be elevated in close proximity to communities.

These environmental hazards may be assessed further, and/or managed as required. Some of the exposure pathways identified (linking source to receptor) may be absent.

7.2 Discussion of Exposure Assessment

Potential exposure pathways were evaluated for on-site (i.e. within the lease) and those relevant for off-site (i.e. anything beyond the well lease boundary). Potentially complete exposure pathways were evaluated for workers, trespassers, native fauna and flora and livestock. The environment immediately surrounding the well lease (i.e. off-site) throughout the study area may vary from lease to lease, but was considered to potentially include homesteads (adult and child residents), water supply bores, creeks or waterholes, livestock and native flora and fauna.

The on-site assessment indicated that the majority of potential exposure pathways were unlikely or incomplete, given the application of operational controls by Santos. These operational controls include:

- OH&S procedures implemented during stimulation operations to prevent workers from direct contact and inhalation exposure to chemicals during spills and when handling flowback water or sediments.
- Implementation of spill containment procedures during operations to prevent migration of and exposure to chemicals.
- Vacuum removal of sediments and fluids contained within panel tanks, to prevent exposure to contaminants in windborne dust.
- Installation of signs to indicate the well lease (including the panel tank) is a work zone to be accessed by authorised personnel; and
- The use of panel tanks of approximately 2 m in height to prevent access by livestock and large native fauna.

One potentially complete exposure pathway was identified, which is direct contact to the flowback water in the panel tank for birds and flying mammals such as bats. All reasonable measures will be implemented to discourage entry of small native fauna into the well lease area during stimulation operations.

Potential off-site exposure pathways were evaluated for homesteads, livestock, native flora and fauna and aquatic ecosystems. Three possible sources were identified: stimulation fluids, sediments from the panel tank and flowback water. The exposure assessment concluded:

- Based on understanding of the Eromanga and Cooper Basin geology and hydrogeology, and Santos' well integrity testing procedures and operational monitoring, exposure to residual stimulation chemicals through subsurface pathways is considered unlikely and incomplete; and
- At the surface, a spill or leak of flowback water from the panel tank was considered possible, however the implementation of operational controls, including use of liners in the tank, removal of fluid and sediment using vacuum techniques and engineering and operational controls (grading of well leases and stormwater controls) is considered sufficient to limit the potential for uncontrolled releases of flowback water to the environment. A further margin of safety is provided by Santos' evaluation of 'environmentally sensitive areas' when establishing well leases, which includes the establishment of buffers between petroleum (and stimulation) activities and features of potential environmental concern. Subsequently, the potential off-site exposure scenarios are considered unlikely and incomplete.

7.3 Qualitative Risk Assessment of Fluids

In 2012 Santos collected seven fluid samples during South Australian stimulation activities for chemical analysis. Two of these fluids ('*DFS-BCG(H) (formally HyborH) Treatments'* and '*High Temperature Acid Spearheads*') are still in use or proposed for use by Haliburton in SWQ stimulation activities. The other two

fluids assessed in this report *('DeltaFrac(H) Treatments' and 'DFS-BCG Treatments'*) were not assessed in the qualitative assessment of fluids.

A preliminary characterisation of stimulation fluids, makeup and site waters, and flowback quality was performed, comprising a broad suite of chemical analyses with the purpose of initial identification of the types of chemicals present, relative concentrations of chemicals detected, and to assess the concentrations against readily available benchmarks[19]. The initial suite may be refined progressively as required.

The initial chemical suite and assessment was to assist in further identification of potential hazards to humans and the environment using reported concentrations of stimulation fluid constituents at a Santos wellsite targeting conventional gas in Cooper Basin, South Australia. While located in a different jurisdiction, the stratigraphy, geology and fracture stimulation methodology was similar to that proposed for SWQ and is therefore considered to be representative. Direct contact with flowback fluid in the panel tanks has been identified as a potentially complete exposure pathway for human and ecological receptors. This preliminary assessment of flowback fluid quality will inform the scope of future investigations, where required.

At the time of reporting, no information on fluid chemical composition for the two new fluids *('DeltaFrac(H) Treatments' and 'DFS-BCG Treatments'*) had been provided to Golder and has therefore not been included in this report.

7.3.1 Methodology for Qualitative Risk Assessment

7.3.1.1 Field Work and Sampling Approach

The objective of the sampling was to provide a preliminary perspective of substances in stimulation flowback fluids. The approach is not a definitive representation of chemical or physical contamination, as this would ideally require a larger number of samples over a longer time frame. It does, however, provide some confidence to the hazard assessment process.

Santos indicated that the following sampling procedure was adopted:

- When collecting a sample from a pond or pit, a surface water sampler with a dedicated sampling container was used to collect a sample from 100 mm below the surface of the water in the pit. Prior to sampling, the sampling container was rinsed out three times with fluid obtained from that Flare Pit or vessel (as relevant).
- The fluid sample was placed in a sample jar prepared by the analytical laboratory. The sample bottle was filled to the top to minimise loss of volatile chemicals, and oxidation of the sample.
- Disposable gloves were used during sampling.
- The fluid sample was placed in a chilled, insulated container and delivered to the laboratory under a chain of custody (COC) procedure within recommended holding times for the specific analytical suite; and
- Subsequent samples were obtained with a new sampling container to minimise cross contamination.

7.3.1.2 Analytical Approach

ALS Environmental (ALS) was engaged to perform chemical analyses. ALS is registered by the National Association of Testing Authorities (NATA) for the analyses performed. Analysis of the flowback fluid sample included a range of parameters consistent with those traditionally examined to assess water quality and to account for information from stimulation mixtures as follows:

[19] Assessment of individual chemicals used in stimulation was not proposed because the number of stimulation chemicals used at sites varies and because some stimulation chemicals cannot be readily analysed by commercial laboratories. For some stimulation chemicals, reliable measurement in environmental media requires the laboratory to develop in-house analytical techniques, which is demanding in time and cost. Furthermore, readily available risk-based screening benchmarks for environmental media do not exist for many of the stimulation chemicals.

- Metals and metalloids (Al, As, Ba, Be, B, Cd, Cr, Co, Cu, Fe, Hg, Li, Mn, Mo, Ni, Pb, Se, Sn, Sr, U, V, Zn).
- pH
- TDS
- Major cations and anions
- Nutrients (ammonia, nitrate, nitrite, total nitrogen, total phosphorous, reactive phosphorous, Total Kjeldahl Nitrogen (TKN)).
- Cyanide
- Total organic carbon
- Volatile organic compounds (VOC)
- Semi-volatile organic compounds (SVOC)
- Phenols
- Surfactants
- Formaldehyde
- Silica
- Chlorine
- Iodide
- Monocyclic aromatic hydrocarbons (MAH)
- Polycyclic aromatic hydrocarbons (PAH)
- Petroleum hydrocarbons (PHC)
- Organochlorine pesticides; and
- Organophosphorus pesticides.

These analyses represent a broad screen of organic and inorganic chemicals that may be present in stimulation or flowback fluids and may be used in a toxicity assessment of the fluid. The analytical suite is broad and is designed to capture the majority of substances of potential concern. There may be some unique proprietary substances that may not have been included and further evaluation of these may be required. The tabulated results of the fluid, waters and flowback analysis are presented in full in APPENDIX F at the end of this report. The laboratory certificates are also presented in APPENDIX F. Chemicals exceeding adopted benchmarks are discussed below in Sections 7.3.2.1 and 7.3.2.2.

7.3.2 Flowback Fluid Risk Assessment

The purpose of the flowback fluid assessment was a preliminary, qualitative assessment of risk to humans and the environment.

The analytical suite for assessment of the flowback fluid was developed after consideration of the following information and guidance documents:

- *Baseline Assessment Guideline*, DERM, May 2011; and
- Santos GLNG CSG *Groundwater Baseline Suite*, *CSG Water Characterisation Suite* and *Hydraulic Stimulation Suite*.

In review of these documents it is noted that the EVs for aquatic ecosystems and for human uses of water (e.g. water for drinking, farm supply, agriculture, industry and recreational use) under the Queensland Environmental Protection (Water) Policy 2009 (EPP Water) have not yet been developed for SWQ. In the

absence of regionally defined water quality objectives for the study area, adoption of national water quality guidelines for screening are considered appropriate, namely:

- **Ecological receptors (aquatic ecosystems, livestock drinking water, crop irrigation)**: *Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand "Australian and New Zealand Guidelines for Fresh and Marine Water Quality".*
- **Human health, potable water**: *National Health and Medical Research Council (NHMRC) and Natural Resource Management Ministerial Council (NRMMC) (2011). Guidelines for Drinking Water Quality in Australia; and*
- **Human health, recreational water**: *NHMRC (2008). Guidelines for Managing Risks in Recreational Water.*

The above water quality guidelines are suitable for qualitative assessment of flowback water with regard to sensitive environmental receptors and humans. In addition, consideration was given to benchmarks for petroleum hydrocarbon fractions prepared by international regulatory and research agencies or ministerial councils, namely the Dutch National Institute for Public Health and the Environment (RIVM), the Canadian Council of Ministers of the Environment (CCME), and the American Petroleum Institute (API). It is noted that comparison of flowback water quality to potable water quality guidelines constitutes a conservative, screening level assessment as the exposure scenario upon which the guidelines were derived (i.e. chronic exposure from direct ingestion of water) is not strictly relevant to the management of flowback fluids.

The screening assessment of risk from the flowback fluid to ecological receptors and people is presented in Sections 7.3.2.1 and 7.3.2.2, respectively.

7.3.2.1 Ecological Assessment

Fluid data reported from the Tindilpie Pad Fluid Pit were evaluated against the following ecological benchmarks:

- ANZECC and ARMCANZ (2000) 95% Species Protection Level and Low Reliability Trigger Values for Freshwater.
- ANZECC and ARMCANZ (2000) Livestock Drinking Water Guidelines.
- ANZECC and ARMCANZ (2000) Crop Irrigation Guidelines.
- CCME (2008) Toxicity Aquatic Life Benchmarks.
- American Petroleum Institute (API) Risk Based Screening Levels (2004) for livestock; and
- RIVM (2004) Serious Risk Concentrations for Ecological Receptors (SRC eco).

Table 49 presents the chemical concentrations that exceeded the adopted benchmarks for the flowback fluid sample.

Table 49: Concentrations of Chemicals above Adopted Ecological Benchmarks

Chemical	Lowest Ecological Benchmark (mg/L)	Benchmark Reference	Concentration (mg/L)
Chemical Parameters			
Total dissolved solids (TDS)	4,000	ANZG (2018)	***10,100***
Anions and Cations			
Chloride	40	ANZG (2018) [3]	***3,710***
Sodium	115	ANZG (2018) [3]	***2,810***
Fluoride	1	ANZG (2018) [3]	***1.8***
Metals and Metalloids			
Arsenic	0.013	ANZG (2018)	***0.182***
Boron	0.37	ANZG (2018)	***57.9***
Copper	0.0014	ANZG (2018)	***0.061***
Lead	0.0034	ANZG (2018)	***0.088***
Manganese	1.9	ANZG (2018)	***2.68***
Nickel	0.011	ANZG (2018)	***0.028***
Zinc	0.008	ANZG (2018)	***0.052***
Aluminium	0.055	ANZG (2018)	***0.09***
BTEX			
Xylene (o-)	0.35	ANZG (2018)	***1.35***
Xylene (m+p)	0.275	ANZG (2018)	***7.21***
PAH			
Naphthalene	0.016	ANZG (2018)	***0.156***
Phenanthrene	0.002	ANZG (2018) LR [1]	***0.032***
Miscellaneous Organics			
Phenol	0.32	ANZG (2018)	***0.418***
Nutrients			
Ammonia (as N)	0.025	ANZG (2018) [2]	***55.4***
Nitrogen (total)	1	ANZG (2018) [2]	***166***
Phosphorous	0.025	ANZG (2018) [2]	***2.22***

Chemical	Lowest Ecological Benchmark (mg/L)	Benchmark Reference	Concentration (mg/L)
Petroleum Hydrocarbons			
Aromatic >EC7-8[5]	1.6	RIVM (2004)	***4.42***
Aromatic >EC8-10	0.14	CCME (2008)	***10.1***
Aromatic >EC10-12	0.096	RIVM (2004)	***4.1***
Aromatic >EC12-16	0.0554	CCME (2008)	***3.66***
Aromatic >EC16-21	0.071	RIVM (2004)	***2.78***
Aromatic >EC21-35	0.0061	RIVM (2004)	***0.64***
Aliphatic >EC5-6	0.33	RIVM (2004)	***3.44***
Aliphatic >EC6-8	0.0465	CCME (2008)	***24.1***
Aliphatic >EC8-10	0.0076	CCME (2008)	***47.4***
Aliphatic >EC10-12	0.00118	CCME (2008)	***5.18***
Aliphatic >EC12-16	0.000074	CCME (2008)	***12.5***

Notes:
[1] Low Reliability Trigger Value
[2] Default Trigger Value for South Central Australia – low rainfall areas, freshwater lakes and reservoirs
[3] Crop irrigation
[4] Livestock Drinking Water
[5] EC represents an equivalent carbon range (EC).

Chemicals reported below the laboratory limit of reporting (LOR), even where the screening benchmarks were below the LOR, were considered unlikely to pose a risk and were not considered further.

7.3.2.2 Human Health Assessment

Flowback fluid data reported from the Tindilpie Pad Frac Pit were screened against the following human health benchmarks:

- NHMRC (2011) Drinking Water Guidelines.
- NHMRC (2008) Recreational (Primary contact recreation).
- WHO (2005) Petroleum Products in Drinking Water.
- USEPA (2012b) Tap Water Guideline; and
- TPHCWG (1997) Total Petroleum Hydrocarbon Criteria Working Group.

Table 50 reports the concentrations in the flowback sample that exceeded adopted human health benchmarks.

Table 50: Concentrations of Chemicals above Adopted Human Health Benchmarks

Chemical	NHMRC 2008 (Primary Contact Recreation) mg/L	NHMRC 2011 (Human Health) mg/L	Concentration (mg/L)
Chemical Parameters			
Total Dissolved Solids @180°C	-	600	***10,100***
Anions and Cations			
Fluoride	1.5	1.5	***1.8***
Sodium	-	180	***2810***
Chloride	-	250	***3710***
Iodide	0.1	0.5	***1.29***
Metals and Metalloids			
Arsenic	0.007	0.01	***0.182***
Barium	0.7	2	***31.6***
Boron	4	4	***57.9***
Copper	2	2	***0.061***
Iron	-	0.3	***15.6***
Lead	0.01	0.01	***0.088***
Manganese	0.5	0.1	***2.68***
Nickel	0.02	0.02	***0.028***
Zinc	-	3	***0.052***
Aluminium	-	0.2	***0.09***
Miscellaneous Organics			
2,4-dimethylphenol	-	0.27 [1]	***0.337***
2-methylnaphthalene	-	0.027 [1]	***0.33***
1,2,4-trimethylbenzene	-	0.015 [1]	***2.55***
1,3,5-trimethylbenzene	-	0.087 [1]	***1.76***
n-propylbenzene	-	0.53 [2]	***0.628***
Formaldehyde	-	0.5	***2.9***
PAH[6]			
Naphthalene	-	0.00014 [1]	***0.156***
BTEX			
Benzene	0.001	0.001	***0.848***
Ethylbenzene	0.3	0.003	***0.533***

Chemical	NHMRC 2008 (Primary Contact Recreation) mg/L	NHMRC 2011 (Human Health) mg/L	Concentration (mg/L)
Toluene	0.8	0.025	***5.32***
Xylene (o)	-	0.5	***1.35***
Xylenes (m & p)	-	0.5	***7.21***
Petroleum Hydrocarbons			
Aromatic >EC5-7[5]	-	0.001 [3]	***0.837***
Aromatic >EC7-8	-	0.025 [3]	***4.42***
Aromatic >EC8-10	-	0.003 [4]	***10.1***
Aromatic >EC10-16	-	0.1 [4]	***7.76***
Aromatic >EC16-35	-	0.09 [4]	***3.42***
Aliphatic >EC5-8	-	15 [4]	***27.54***
Aliphatic >EC8-16	-	0.3 [4]	***65.08***

Notes:
[1] USEPA (2012b) tap water guideline
[2] N propylbenzene USEPA (2012b) tap water guideline
[3] WHO (2005)
[4] Benchmark for Ethylbenzene.
[5] EC represents an equivalent carbon range (EC).
[6] This has not included a Toxic Equivalency Factor (TEF) approach which examines the combined effects of PAHs based on their potency against benzo(a)pyrene.

Chemicals reported below the laboratory LOR, even where the screening benchmarks were below the LOR, were considered unlikely to pose a risk and were not considered further. The exclusions here are benzo(a)pyrene where the laboratory LOR exceeded the NHMRC (2011) guideline value, some chlorinated hydrocarbons and some of the pesticides such as the organochlorines aldrin, dieldrin and heptachlor. This uncertainty is not considered to be significant on this occasion as many other chemicals exceeded the potable and recreation water quality criteria.

In addition, the evaluation of PAHs as a mixture has not been undertaken at this stage as the naphthalene guideline is already exceeded. This would normally involve the calculation of BaP equivalents (BaPE) using potency data for other PAHs against BaP and their summation and comparison against the BaP guideline. This could be addressed in subsequent evaluation.

7.3.2.3 Chemicals for which Guidelines were Unavailable

The following chemicals were reported above the laboratory detection limit but there were no available guidelines or benchmarks for risk assessment:

- 2- methylphenol (0.5 mg/L);
- 3- and 4- methylphenol (0.35 mg/L);
- Fluorene (0.01 mg/L);
- Isopropyltoluene (2.7 mg/L);
- 1-propanol (23 mg/L); and
- 2-propanol (2.8 mg/L).

7.3.2.4 Discussion

Analysis of the flowback fluid sample analytical results identified concentrations of PHC, phenolics, BTEX, some PAH, metals, formaldehyde, nutrients, and cations and anions in excess of a large number of the adopted human health and ecological benchmarks. Based on the chemical information disclosed by the stimulation service provider in relation to the SWQ study area, it is considered likely that the petroleum hydrocarbon constituents reported in the flowback fluid sample are 'geogenic' and originated from the sandstone formation being fractured. The results are summarised as follows:

- The highest reported concentrations relative to guidelines were some PHC fractions, some BTEX compounds, PAHs such as naphthalene and BaP equivalents, and nutrients (ammonia and total nitrogen) were many times greater (orders of magnitude) than the applicable ecological and/or human health benchmarks.
- Greater concentrations of aliphatic petroleum hydrocarbon fractions (equivalent carbon chain length) were reported relative to aromatic fractions. The aliphatic carbon chain lengths which dominated the analyses were >EC6-C8 (24 mg/L[20]), >EC5-C8 (28 mg/L) and >EC8-C10 (47 mg/L[21]). The aromatic carbon chain lengths which dominated the analyses were >EC8-C10 (10 mg/L[22]) and >EC10-C16 (8 mg/L). These are all volatile hydrocarbon fractions and may present additional risks associated with inhalation exposure.
- The BTEX compounds: benzene (0.8 mg/L), toluene (5 mg/L), ethyl benzene (0.5 mg/L), and the PAH: naphthalene (0.15 mg/L) were 100 or more times greater than the applicable human health benchmarks. These substances are also volatile and may in addition present inhalation exposure risk.
- The presence of reported concentrations of solvents (ethanol and propanol) in the flowback fluid. These are volatile alcohols.
- The following metals were reported in the flowback fluid above adopted screening benchmarks: iron, manganese, barium, boron, arsenic, lead, nickel, aluminium, copper and zinc.
- The following cations and anions were reported in flowback fluid above adopted screening benchmarks: sodium, chloride, iodide, fluoride.
- The flowback fluid was of neutral pH (pH 7.5) and reported total dissolved solids (TDS[23]) concentrations that were considered to be moderately saline based on a reported concentration of 10,100 TDS mg/L compared to rainwater (<1 mg/L), surface[24], ground or sea water (35,000 mg/L); and
- The reported concentrations of nutrients (phosphorous, total nitrogen, ammonia) were elevated above the default[25] ecological benchmarks.

The following chemicals were not detected in the flowback fluid sample: OCPs and OPPs. Petroleum-based constituents are included in some stimulation fluid additive products (DEC, 2011). Review of TPHCWG (1998) reports that crude oil includes some of the individual chemicals reported in the flowback fluid, such as BTEX, 1,2,4-trimethylbenzene, 1,3,5-trimethylbenzene, n-propylbenzene, and PAHs. Based on the chemical information indicated or disclosed to Golder by Santos or its contractors in relation to the SWQ study area, no PHC constituents have been identified or proposed for use in the fluid systems assessed in this report. It is considered highly likely that the PHC constituents reported in the flowback fluid sample originated from the sandstone formation being fractured (i.e. a hydrocarbon reservoir).

[20] Several hundred times above the lowest adopted ecological screening benchmark.

[21] Several thousand times above the lowest adopted ecological screening benchmark.

[22] Several thousand times above the lowest adopted human health screening benchmark

[23] TDS is a measure of all inorganic salts dissolved in water.

[24] Surface waters generally have TDS concentrations lower than groundwaters and higher than rainwater.

[25] The default trigger values for physical and chemicals stressors (i.e., different to toxicants) in ANZECC and ARMCANZ (2000) are not risk-based benchmarks. The default trigger values are indicative of unmodified or slightly-modified ecosystems reference or 'background' ranges for Central South Australia – low rainfall areas, freshwater lakes and reservoirs.

Some substances such as PHC, phenolics, BTEX, PAH, metals, nutrients, anions and cations reported in the flowback fluid may originate from the reservoir geology and/or the stimulation fluid constituents used. The reported concentrations of nutrients were considered likely to reflect organic inputs from stimulation chemicals rather than those naturally present in the formation. However, without additional information (namely, characterisation of (i) the produced water before mixture with stimulation fluid additives, (ii) mixed stimulation fluid prior to injection into the well, and (iii) background groundwater quality data) relative contributions from the stimulation fluid compared to naturally occurring concentrations cannot be assessed.

While some substances such as formaldehyde and the alcohols are not expected within the geological formations the presence of BTEX requires further evaluation as these are explicitly excluded from use in stimulation as stipulated by the EA.

As an initial step to examine this issue, stimulation mixtures were formulated with distilled water and subsequently analysed consistent with the previous analytical suites. These are discussed in Section 7.3.3.

7.3.3 Halliburton Stimulation Fluid Evaluations

As a preliminary step in the evaluation of hydrocarbon components in stimulation mixes two mixtures were formulated with distilled water and submitted for broad screen analyses consistent with the previous analytical profiles. Complete results are presented in Figure 2 and the results summarised in Table 52.

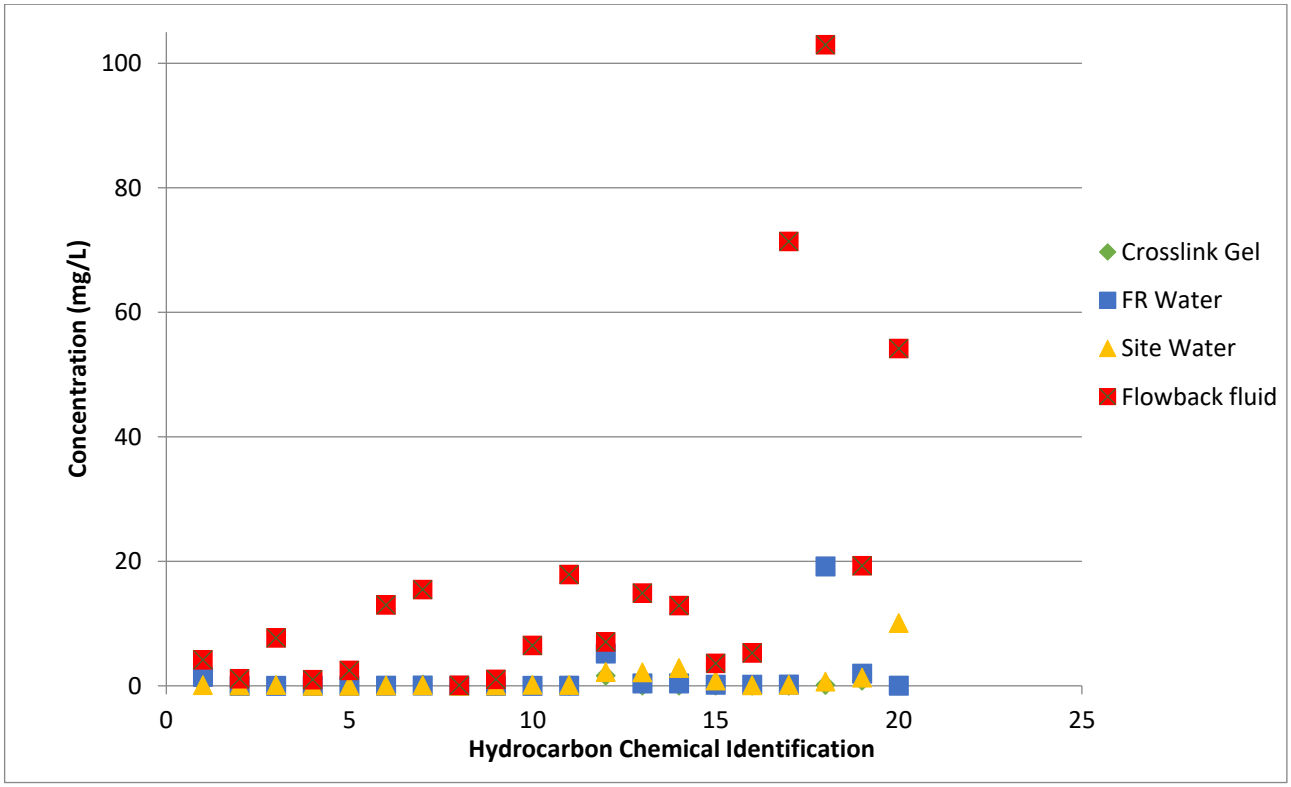

Figure 2: Hydrocarbon Concentrations in Stimulation Fluids (mg/L)

Review of the information suggests that the flowback fluids are substantially higher in residual concentrations of hydrocarbons that are considered to represent geogenically-derived substances, and these exceed conservative, potable water quality guideline concentrations.

Examination of the make up water drawn from formation water sources suggests the hydrocarbon concentrations are substantially lower, although still detectable, and range from concentrations below the limits of reporting to those concentrations approaching or in some cases exceeding certain water quality guidelines. This includes both potable water quality guidelines and ecological guidelines from both the Netherlands (RIVM, 2004) and Canada (CCME, 2008). These exceedances only apply to the TPH fractional ranges and the aesthetics-based health values for ethyl benzene and total xylenes.

The distilled water formulations (Crosslink Gel and FR Water) present a similar PHC concentration profile to the make up water with generally lower concentrations albeit with exceptions in some TPH fractional ranges and for p-isopropyltoluene. The latter are within an order of magnitude of the make up water concentrations. The BTEX results for the distilled water formulations are summarised in Table 51 below. The reported BTEX concentrations were either below the laboratory LOR or, where detected, were below the DEHP regulated criteria for stimulation fluid additives in Queensland.

Table 51: Summary of BTEX Analytical Results for Distilled Water Formulations (mg/L)

Analyte	DEHP Criteria	Crosslink Gel	FR Water
Benzene	0.001	<0.001	<0.01 [1]
Toluene	0.18	0.013	0.026
Ethylbenzene	0.08	<0.002	<0.01 [1]
o-Xylene	0.35	<0.002	<0.01 [1]
m & p-Xylene	0.275 [2]	0.017	0.05

Notes:

1. The laboratory reported that this sample was diluted prior to analysis due to matrix interferences, and the LOR was raised accordingly. While the raised LOR exceeds the benzene criterion of 0.001 mg/L, it does not represent an actual benzene concentration in the sample in exceedance of the criterion.
2. The m & p-Xylene criterion is the sum of the criteria for the individual m- and p-Xylene isomers (0.075 and 0.2 mg/L, respectively). Neither of the reported concentrations exceeds the lower of the individual isomer criteria.

Table 52 presents a comparison of the hydrocarbon results across the distilled water formulations and the (formation) makeup water and the flowback fluid results. It also provides the respective water guidelines based on either the NHMRC/NMMRC potable water quality guidelines and recreational contact guidelines and the ANZECC (2000) ecological guidelines where available. Where Australian guidelines were unavailable, specifically the TPH fractions, human health data were drawn from WHO (2005) and the ecological criteria drawn consistently from RIVM (2004) for this table as a guide.

These results suggest that generally formulations are not contributing substantial amounts of BTEX and TPH into the subsurface regions, however, some qualification of this statement is required as a result of residual uncertainties. These uncertainties require further exploration and reflect:

- Limited sampling frequencies for the respective fluids examined.
- Confidence in the sampling integrity and any potential for introduction of extraneous contamination. This potential is considered possible in view of the immediate environmental surrounds of the stimulation conditions; and
- The sampling process and its consistency with stimulation procedures at the time of sampling including spatial and temporal references, i.e. what was happening at the time of sampling and process locations, etc.

Table 52: Preliminary Stimulation Fluid Makeup Analyses and Fluid Flowback Comparisons (mg/L)

Chemical	NHMRC 2008 Human Health,(Primary Contact Recreation)	NHMRC 2011 (Human Health, Potable)	RIVM (2004); CCME (2008); ANZECC (2000) (Ecological)	Concentration			
				Crosslink Gel	FR Water	Make up water	Flow back fluids
(1) p-isopropyltoluene	NA	NA	NA	0.316	1.45	<0.005-0.11	1.83-4.19
(2) benzene	0.001	0.001	0.95	<0.001	<0.01	0.002-0.065	0.848-1.16
(3) toluene	0.8	0.025	0.18	0.013	0.026	0.004-0.148	5.32-7.7
(4) ethyl benzene	0.3	0.003 (aesthetic) 0.3 (health)	0.08	<0.002	<0.01	<0.002-0.011	0.533-0.995
(5) o-xylene	NA	NA	0.35	<0.002	<0.01	<0.002-0.023	1.35-2.48
(6) m- and p-xylene		NA	0.275	0.017	0.05	<0.002-0.08	7.21-13
(7) xylenes	As for potable	0.02 (aesthetic) 0.6 (health)	NA	<0.19	<0.06	<0.004-0.103	8.56-15.48
(8) iodomethane	NA	NA	NA	0.019	<0.01	<0.005	<0.1
(9) Aromatic EC5-7[a]	(0.001)	(0.001)	2.6	<0.005	<0.01	<0.005-0.07	0.837-1.04
(10) Aromatic >EC7-8[b]	(0.8)	(0.025)	1.8	0.012	0.023	<0.005-0.164	4.42-6.49
(11) Aromatic >EC8-10	NA	0.003[c]	1.3	0.018	0.047	<0.005-0.142	10.1-17.9
(12) Aromatic>EC10-12	NA	0.1	0.94	1.64	5.2	<0.05-2.24	4.1-7.07
(13) Aromatic >EC12-16[e]	NA		0.67	<0.05	0.41	<0.05-2.18	3.66-14.9
(14) Aromatic >EC16-21[e]	NA	0.09	0.6	<0.05	0.41	<0.05-2.86	2.78-12.9
(15) Aromatic >EC21-35	NA		1.2	0.056	0.205	0.099-0.871	0.64-3.61
(16) Aliphatic EC5-6	NA	15.0[d]	0.42	0.038	<0.2	<0.02-0.086	3.44-5.3

Chemical	NHMRC 2008 Human Health,(Primary Contact Recreation)	NHMRC 2011 (Human Health, Potable)	RIVM (2004); CCME (2008); ANZECC (2000) (Ecological)	Concentration			
(17) Aliphatic >EC6-8	NA		0.17	<0.02	0.216	0.02-0.162	22-71.4
(18) Aliphatic >EC8-10	NA	0.3	0.094	0.155	19.2	<0.02-0.688	47.1-103
(19) Aliphatic >EC10-12	NA		0.16	0.85	1.98	<0.05-1.34	5.18-19.3
(20) Aliphatic >EC12-16	NA		1.7	<0.05	<0.05	<0.05-10.1	12.5-54.2

Footnotes:

a. This fractional TPH group is based on benzene.

b. This fractional TPH group is based on toluene.

c. This fractional range includes ethylbenzene for which an aesthetic guideline of 0.003 mg/L has been established but also xylenes and methylethylbenzene that exhibit low taste and odour thresholds.

d. This value exceeds solubility threshold.

e. As PAHs are found within this fractional range these should be evaluated separately.

7.3.4 Assumptions and Limitations

The preliminary assessment of flowback data is subject to the following assumptions and limitations.

- The screening is conservative in that the benchmarks are intended for screening freshwater waters protective of ecological receptors (aquatic plants and animals, livestock drinking water, and plants[26]), and waters for recreation or for potable use by humans. The likelihood of these exposure pathways being realised differs for the receptors identified as discussed in Section 2.0. However, a conservative approach adopts the precautionary principle in risk assessment and provides additional confidence when there are uncertainties.
- The small sample size (six primary samples) for which variance in the flowback fluid cannot be assessed. The exact mix of the flowback fluid may be influenced by the aquifer being fractured and may vary between fracture locations. This may change in space and time so additional sampling strategies would seek to address spatial and temporal variance.
- Limited (one duplicate) quality assurance / quality control (QA/QC) samples were included in this investigation. Consideration of other sources of chemicals/contaminants: the quality and chemical characterisation of the make-up water; contamination status of the tankers used to transport and store water and to mix stimulation fluids: note this to a degree was addressed by making up representative samples of fracture chemicals using distilled water.
- Sampling was performed by non-Golder personnel, although managed by experienced Santos personnel in consultation with Golder. It is uncertain whether the sample represented a homogeneous sample of the distribution of contaminants throughout the water column, although all reasonable efforts were made to address this.
- The screening benchmarks adopted do not account for risk to humans via the vapour inhalation exposure pathway. A number of substances are volatile and present an inhalation hazard from ambient or confined atmospheric sources; and
- Further review of stimulation chemical constituents and mass balance data was not performed.

The combined effects of the stimulation chemical mixture were not assessed as it was considered outside the scope of a preliminary screening level risk assessment. Such an assessment reflects the ability for components to biologically interact and result in enhanced or minimised effects.

7.3.5 Conclusions

Based on this preliminary qualitative risk assessment, some substances (refer to Table 52) reported in the flowback fluid may originate from the reservoir geology and the reported concentrations of these chemicals may pose unacceptable risks to humans and ecological receptors exposed to flowback fluids. Further risk assessment would assist in better defining these risks and preliminary evaluations. It is noted that limited presence of toluene, xylenes and some TPH components were reported albeit at or near target acceptable concentrations. These may require further exploration and clarification to reduce residual uncertainties.

However, these risks may be managed by appropriate occupational and environmental health safety procedures and controls provided there is consistency in materials and methods. Changes in materials would require re-evaluation.

7.4 Overall Evaluation of Risk

Considering the hazard and exposure assessment and operational controls discussed, the overall risk to human health and environment associated with the chemicals involved in stimulation are expected to be low. These operational controls include:

[26] Crop irrigation.

- OH&S procedures implemented during stimulation operations to prevent workers from direct contact and inhalation exposure to chemicals during spills and when handling flowback water or sediments.
- Assigning buffers during establishment of well leases between petroleum operations and potential “environmentally sensitive areas” identified though database review and site-specific ecological assessment where warranted.
- Implementation of spill containment procedures during operations to prevent migration of and exposure to chemicals.
- Removal of sediments and fluids contained within drained panel tanks to prevent exposure to contaminants in windborne dust.
- Installation of signs to indicate well leases (including panel tanks) are a work zones to be accessed by authorised personnel.
- The use of panel tanks of approximately 2m in height to prevent access by livestock and large native fauna.
- Santos operational procedures regarding well integrity verification and fracture design to stay within the target formation.
- Double lining of panel tanks as a minimum standard, to prevent seepage of flowback water into the underlying aquifer; and
- Engineering and operational controls (grading of well leases and stormwater controls to limit the potential for uncontrolled surface releases of flowback water to the environment.

7.5 Other Considerations

7.5.1 Noise and Vibration

The activities associated with stimulation have the potential to generate noise or vibration that could potentially impact nearby receptors. However, given the remote nature of Cooper Basin stimulation activities the presence of nearby receptors is considered unlikely. In addition, whilst the proposed activities will take place on a continuous basis, they will be undertaken sequentially for short periods of time at different sites over a wide area. As a result, individual sensitive receivers are only likely to be exposed to the effects of noise and vibration from these activities for a few weeks at a time. On this basis, risk associated with noise and vibration to offsite receptors has not been considered further in this report.

Potential for onsite noise and vibration exposure to workers exist during stimulation activities. Santos and stimulation service provider’s equipment are subject to noise emission testing by a professional third party. Prevention of exposure to workers is managed through Santos OH&S procedures.

7.5.2 Cumulative Impacts

Cumulative underground impacts from stimulation processes in a well lease are not anticipated based on the controls described in this report. Stimulation will be confined to the target sequences and vertical fracturing into overlying aquifer units is highly unlikely to occur.

Potential cumulative impacts associated with the development activities on a well lease may be associated with extraction of water from the reservoirs (after completion of the stimulation activities) and associated aquifer systems within respective formations. These cumulative impacts have been assessed separately and a groundwater monitoring and management plan developed which includes “make-good” provisions for potentially affected wells which may see reductions in water levels and associated yield.

8.0 CONCLUSIONS

8.1 Environmental Setting

Santos operates conventional gas and oil fields across petroleum tenements within an approximately 30,000 km^2 portion of Southwest Queensland. These tenements and the land surrounding the Santos tenement boundaries comprise the Santos SWQ *study area*.

The terrain in the study area is generally characterised by low undulating topography (hills and ridges) between the drainage channel systems of the Cooper Creek. The area is sparsely developed, and generally comprises rural communities and homesteads that are largely engaged in farming and livestock.

It is within the stratigraphy that comprises the Eromanga Basin and the underlying Cooper Basin that oil and gas reservoirs are located which contain the proposed target formations for stimulation. A detailed description of key geological and hydrogeological features is provided in Volume One, including geological models for the study area, target hydrocarbon-bearing sandstone formations (oil in the Eromanga Basin formations at depths ranging from 700 to 1,200 mbgl, and gas in the Cooper Basin formations at depths of 1,500 to greater than 2,000 mbgl), their hydraulic characteristics, adjacent aquifers and aquitards, structural features including faults and fracture characteristics (and their potential to behave as barriers or conduits), regional and local seismicity characteristics, aquifer environmental values and the location of groundwater users.

In terms of the environmental setting, Volume One of the SWQ HSRA has provided specific information which addresses the requirements anticipated of the EA conditions regarding stimulation that will apply to existing and new areas.

Based on understanding of the environmental setting, this qualitative risk assessment considered the key environmental values as follows:

Groundwater Environmental Values:

- Town water supply
- Stock and domestic water supply
- Sandstone aquifers of the GAB; and
- GDEs.

Surface Water Environmental Values:

- Protection of aquatic ecosystems
- Recreation and aesthetics: primary recreation with direct contact, and visual appreciation with no contact; and
- Cultural and spiritual values.

Terrestrial Environmental Values:

- Protection of flora and fauna, such as small mammals, reptiles and birds.

The report has considered each in terms of the risk to aquatic ecosystems, terrestrial ecosystems and human health.

8.2 Stimulation Process Description Summary

With regard to the process of stimulation, information addressing the EA blueprint conditions (with reference to the model conditions) are located within Volume One of the SWQ HSRA, including:

- Practices and procedures to ensure that the stimulation activity(ies) is designed to be contained within the target gas producing formation.

- Provide details of where, when and how often stimulation is to be undertaken on the tenures covered by this environmental authority.
- A description of the well mechanical integrity testing program.
- Process control and assessment techniques to be applied for determining extent of stimulation activity(ies) (e.g. microseismic measurements, modelling etc); and
- A process description of the stimulation activity to be applied, including equipment and a comparison to best international practice.

8.3 Toxicological Evaluation

The toxicity of the chemicals used in the stimulation process by Halliburton has been assessed for persistence, bioaccumulation and aquatic toxicity (PBT), terrestrial toxicity and human health toxicity including the physical hazards of fire and explosion. The review of toxicity is qualitative and has provided a ranking of chemicals considered to represent a high, moderate or low hazard in respect to the ecological or human health end points with qualification as appropriate.

A preliminary quantitative assessment has also been undertaken, with Santos and Halliburton in 2012 collecting a total of seven fluid samples during South Australian stimulation activities for chemical analysis. These stimulation activities are undertaken by Halliburton and are considered reasonably indicative of the proposed SWQ activities. At the data of reporting no quantitative assessment had been undertaken for DeltaFrac(H) and DFS-BCG(H).

Concentrations of toluene, xylenes and PHC fractions were reported in two samples of distilled water mixed with stimulation fluid additives, prepared by Halliburton. The concentrations were reported below the DEHP (2012) BTEX standard.

Review of the data indicates that the flowback fluids contain substantially higher concentrations of hydrocarbons, which are considered to represent geogenically derived substances and these exceed the respective water quality guideline concentrations (where available).

Examination of the make up water drawn from formation water sources suggests the hydrocarbon concentrations are lower and range from concentrations below the limits of reporting to concentrations approaching or in some cases exceeding the respective water quality guidelines. This includes both potable water quality guidelines and ecological guidelines from both the Netherlands (RIVM, 2004) and Canada (CCME, 2008), which were referenced in the absence of water quality guidelines for hydrocarbon fractions in Australia. These exceedances only apply to the TPH fractional ranges and the aesthetics-based health values for ethyl benzene and total xylenes.

The distilled water fluid formulations present a similar hydrocarbon concentration profile to the make up water, with generally lower concentrations albeit with exceptions in some TPH fractional ranges and for p-isopropyltoluene. The latter are within an order of magnitude of the make up water concentrations. In the case of the BTEX group the distilled water formulations have not identified BTEX concentrations exceeding BTEX water quality criteria specified in the Queensland Environmental Protection Regulation.

These results suggest that stimulation fluid formulations are not contributing substantial amounts of BTEX and TPH into the subsurface regions, and certainly at concentrations that are both below the regulated criteria (where available) and below the concentrations in the hydrocarbon reservoirs being fractured. Some qualification of this statement is required as a result of residual uncertainties.

8.4 Evaluation of Exposure Pathways

Potential exposure pathways were evaluated for on-site (i.e. within the well lease), and those relevant for off-site (i.e. anything beyond the well lease boundary). The on-site assessment indicated that the majority of possible exposures were unlikely or incomplete. One complete exposure pathway was identified, which is direct contact to the flowback water in the panel tanks for small fauna (i.e. birds and flying mammals such as bats). All reasonable measures will be conducted to discourage entry of small native fauna into the well lease area during stimulation operations. Improvement of flowback water containment will further reduce the potential for this exposure scenario to occur.

For the off-site exposure assessment, it was assumed that potential off-site receptors could include homesteads (adult and child residents), water supply bores, creeks and waterholes, livestock and native flora and fauna. Three possible chemical sources were identified: injected stimulation fluids, sediments from panel tanks and flowback water. The exposure assessment concluded:

- Subsurface exposure to stimulation fluids is controlled by Santos' well integrity testing procedures and operational monitoring, and this pathway (whereby stimulation fluids could escape into the formation and contaminate adjacent aquifers that are used for domestic or stock water supply) is considered unlikely or incomplete.
- Based on an understanding of the Eromanga and Cooper Basin geology and hydrogeology, and the nature and extent of groundwater supply development, exposure to residual stimulation chemicals through subsurface pathways is considered unlikely and incomplete; and
- At the surface, a spill or leak of flowback water from the panel tank was considered as a possible exposure scenario, however the implementation of operational controls, including use of liners in panel tanks, removal of fluid and sediment using vacuum techniques and engineering and operational controls (grading of well leases and stormwater controls) is considered sufficient to limit the potential for uncontrolled releases of flowback water to the environment. A further margin of safety is provided by Santos' evaluation of 'environmentally sensitive areas' when establishing well leases, which includes the establishment of buffers between petroleum (and stimulation) activities and features of potential environmental concern. Subsequently, the potential off-site exposure scenarios are considered unlikely and incomplete.

8.5 Overall Risk Evaluation

Considering the hazard, exposure assessment and qualitative assessment of fluids, although unlikely, flowback water at surface presents some inherent risk. However, with Santos operational controls and management, the overall or residual risk to human health and environment associated with the chemicals involved in stimulation are expected to be low. The management measures implemented through operational controls include:

- OH&S procedures implemented during stimulation operations to prevent workers from direct contact with chemicals during spills and when handling flowback water or sediments.
- Santos operational procedures regarding well integrity verification and fracture design to stay within the target formation.
- Assigning buffers during establishment of well leases between petroleum operations and potential "environmentally sensitive areas" identified though database review and site-specific ecological assessment where warranted.
- Implementation of spill containment procedures during operations to prevent migration of and exposure to chemicals.
- Vacuum removal of sediments and fluids contained within panel tanks, to prevent exposure to contaminants in fluids and windborne dust.

- Installation of signs to indicate that well leases (including panel tanks) are work zones to be accessed by authorised personnel.
- The use of panel tanks of approximately 2m in height to prevent access by livestock and large native fauna. Double lining of panel tanks to prevent seepage of flowback water into the underlying aquifer; and
- Engineering and operational controls (grading of well leases and stormwater controls) to limit the potential for uncontrolled surface releases of flowback water to the environment.

The adequacy and appropriateness of these exposure controls will be routinely evaluated by Santos and modifications and revisions made, where necessary, to achieve continuous improvement.

9.0 REFERENCES

American Petroleum Institute (API) (2004). Risk Based Screening Levels for the protection of livestock exposed to petroleum hydrocarbons. Regulatory Analysis and Scientific Affairs, Publication Number 4733, Prepared under contract by: Mala Pattanayek and Bridgette DeShields, Blasland, Bouck, and Lee, Inc., Petaluma, California, July 2004.

Australian and New Zealand Environment Conservation Council (ANZECC) and Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ) (2000). Australian and New Zealand Guidelines for Fresh and Marine Water Quality for protection of aquatic ecosystems and stock watering.

Australian and New Zealand Guidelines (ANZG) (2018). Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Australian and New Zealand Governments and Australian state and territory governments, Canberra ACT, Australia.

Bulloo Shire Council, 2012. Our Community: Sport and Recreational Facilities – Fishing. Accessed at: http://www.bulloo.qld.gov.au.

Bunn, S.E., Thoms, M.C., Stephen, K.H., Capon, S.J., 2006. Flow variability in dryland rivers: boom, bust and the bits in between. River Research and Applications, 22, 179–186.

CCME (2008) Canadian Council of Ministers of the Environment, National Classification System for Contaminated Sites (NCSCS) Guidance Document, Winnipeg.

Cendon, D.I., Larsen, J.R., Jones, B.G., Nanson, G.C., Rickleman, D., Hankin, S.I., Pueyo, J.J., Maroulis, J., 2010. Freshwater recharge into a shallow saline groundwater system, Cooper Creek floodplain, Queensland, Australia. Journal of Hydrology, 392, 150-163.

Christensen, F.M., de Bruijn J.H.M., Hansen, B.G., Munn, S.J., Sokull-Kluttgen, B. and Pedersen, F. (2003). Assessment Tools under the New European Union Chemicals Policy. GMI 41, Springleaf Publishing, 2003.

Clean Production Organisation (2009). The Green Screen for Safer Chemicals Version 1.0. White paper. Available @ http//: http://www.cleanproduction.org/Greenscreen.php (accessed 30 May 2011).

Costelloe, J.F., Shields, A., Grayson, R.B., McMahon, T.A., 2007. Determining loss characteristics of arid zone river waterbodies. River Research and Applications, 23, 715–731.

DEC (2011). Department of Environmental Conservation (DEC), New York State, Revised Draft SGEIS on the Oil, Gas and Solution Mining Regulatory Program (September 2011). Accessed at: http://www.dec.ny.gov/energy/75370.html

Department of Environment and Heritage Protection (DEHP) (2010). Regional Ecosystems, updated April 2010. Accessed at: http://www.ehp.qld.gov.au/ecosystems/

Dunn A.M. (2009) A relative risk ranking of selected substances on Canada's National Pollutant Release Inventory. HERA 15: 579-603.

ECETOC (2005). European Centre for Ecotoxicology and Toxicology of Chemicals Risk Assessment of PBT Chemicals Technical Report No.98, Accessed at: http://www.ecetoc.org/technical-reports

ECHA (2012). European Chemical Agency. Accessed at: http://echa.europa.eu/

Economides, M.J. and Martin, T. (2007). Modern Stimulation, Enhancing Natural Gas Production. Energy Tribune Publishing Inc.

ECOSAR (2012). Ecological Structure Activity Relationships ECOSAR™ software version 1.11 dated July 2012. Accessed at: http://www.epa.gov/oppt/newchems/tools/21ecosar.htm.

Environment Canada (2003) Existing Substances Branch Guidance Manual for the Categorization of Organic and Inorganic Substances on Canada's Domestic Substances List (DSL).

EPHC (2009a). Environment Protection and Heritage Council Environmental Risk Assessment Guidance Manual for Industrial Chemicals, February 2009. Accessed at: http://www.ephc.gov.au/sites/default/files/CMgt_NChEM__ERAGM_for_Industrial_Chemicals_200902.pdf

EPHC (2009b). Environment Protection and Heritage Council Environmental Risk Assessment Guidance Manual for Agricultural and Veterinary Chemicals February 2009. Accessed at: http://www.scew.gov.au/publications/pubs/chemicals/cmgt_nchem__eragm_for_agricultural_and_veterinary_chemicals_200902.pdf

EPISUITE (2011). United States Environmental Protection Agency Exposure Tools and Assessment EPISUITE v4.1. Accessed at: http://www.epa.gov/oppt/exposure/pubs/episuitedl.htm

enHealth (2004). Environmental Health Risk Assessment, Guidelines for Assessing Human Health Risks from Environmental Hazards, Department of Health and Ageing and enHealth Council, June 2004.European Commission (2003). European Chemicals Bureau Technical Guidance Document on Risk Assessment in support of Commission Directive 93/67/EEC on Risk Assessment for New Notified Substances. Accessed at: http://ihcp.jrc.ec.europa.eu/our_activities/public-health/risk_assessment_of_Biocides/doc/tgd/tgdpart2_2ed.pdf

European Commission (2012). Toxicity and Assessment of Chemical Mixtures. Accessed at: http://ec.europa.eu/health/scientific_committees/environmental_risks/docs/scher_o_155.pdf

Franke, C., Studinger, G., Berger,G., Bohling, D., Bruckmann, U., Cohors-Fresenborg, D. and Johncke, U. (1994), The Assessment of Bioaccumulation. Chemosphere 29: 1501-1514.

Gibson, E., Strudwick, D and P. Walker (1997). Draft National Framework for Ecological Risk Assessment of Contaminated Sites, Victorian Environment Protection Authority (VIC EPA).

Hamilton, S.K., Bunn, S.E., Thoms, M.C., Marshall, J.C., 2005. Persistence of aquatic refugia between flow pulses in a dryland river system (Cooper Creek, Australia). Limnology and Oceanography, 50, 743–754.

HSDB (2012). Hazardous Substances Data Bank. Accessed at: http://toxnet.nlm.nih.gov/

Hulzebos, E.M., Ademab, D.M.M., Dirven-van Breemena, E.M., Henzenb, L. and Van Gestela, C.A.M. (1991). QSARs in Phytotoxicity. The Science of the Total Environment. Volumes 109-110, December 1991, Pages 493-497.

INCHEM (2012). OECD Screening Information DataSet (SIDS) High Production Volume Chemicals. Accessed at: http://www.inchem.org/documents/sids/sids/Naco.pdf

IUCLID (2012) European Commission - European Chemicals Bureau IUCLID Dataset. Accessed at: http://esis.jrc.ec.europa.eu

Kortenkamp, A., Backhaus, T., and Faust, M. (2009). State of the Art Report on Mixture Toxicity (Final) prepared for the European Commission Directorate General for Environment, Study Contract Number 070307/2007/485103/ETU/D.1, dated 22 December 2009.

Langley, A (1993) Refining Exposure Assessment. In: Langley, A.J. and Van Alphen, M. (eds). The health risk assessment and management of contaminated sites. Proceedings of the Second National Workshop on the

Health Risk Assessment and Management of Contaminated Sites. South Australian Health Commission, Adelaide, pp. 89-117.

Logue J.M, McKone T.E, Sherman M.H and Singer B.C. (2011) Hazard assessment of chemical air contaminants measured in residences. Indoor Air 21: 92-109.

Nanson, G.C., Price, D.M., Jones, B.G., Maroulis, J.C., Coleman, M., Bowman, H., Cohen, T.J., Pietsch, T.J., Larsen, J.R., 2008. Alluvial evidence for major climate and flow regime changes during the middle and late Quaternary in eastern central Australia. Geomorphology, 101, 109–129.

NEPC (1999). National Environment Protection (Assessment of Site Contamination) Measure. National Environment Protection Council Service Corporation. Adelaide, SA.

NEPC (2013). National Environment Protection (Assessment of Site Contamination) Amendment Measure. National Environment Protection Council Service Corporation. Adelaide, SA, April 2013.

NHMRC (2011). National Health and Medical Research Council (NHMRC). Australian Drinking Water Guidelines

NICNAS (2013) Inventory Multi-tiered Assessment and Prioritisation (IMAP) Framework. National Industrial Chemicals Notification and Assessment Scheme. Department of Health and Aging, Canberra.

OECD (2001) Harmonised integrated classification system for human health and environmental hazards of chemical substances and mixtures. OECD Series on Testing and Assessment, number 33. Organisation for Economic Co-operation and Development, Paris France.

OECD (2010). Online Glossary of Statistical Terms. Accessed at: http://stats.oecd.org/glossary/detail.asp?ID=203

Pennington, DW and Bare JC (2001) Comparison of Chemical Screening and Ranking Approaches: The Waste Minimisation Prioritization Tool versus Toxic Equivalency Potentials. Risk Analysis 21 (5): 897-912.

Pittinger CA, Brennan TH, Badger DA, Hakkinen PJ and Fehrenbacher MC (2003). Aligning Chemical Assessment Tools Across the Hazard-Risk Continuum. Risk Analysis 23 (3): 529-535.

RIVM (2004). Environmental Risk Limits for Mineral Oil (Total Petroleum Hydrocarbons). RIVM report 605201021/2004

Safe Work Australia (2020) Hazardous Chemical Information System (HCIS). http://hcis.safeworkaustralia.gov.au/HazardousChemical. Accessed February 2020. Last updated 09/05/2018

Swann, R.l., Laskowski, D.A. and McCall, P.J. (1983) A rapid method for the estimation of the environmental parameters octanol/water partition coefficient, soil sorption constant, water to air ratio, and water solubility. Residue Reviews 85: 17-28.

TPH CWG (1997). Total Petroleum Hydrocarbon Criteria Working Group A risk-based approach for the management of total petroleum hydrocarbons in soil.

TPH CWG (1998). Total Petroleum Hydrocarbon Criteria Working Group Series Composition of Petroleum Mixtures Volume 2.

UNECE (2005) Globally Harmonised System (GHS) of Classification and Labelling of Chemicals. Accessed at: http://www.unece.org/trans/danger/publi/adr/adr2005/05contentse.html

UNECE (2009) Globally Harmonised System (GHS) of Classification and Labelling of Chemicals. Accessed at: http://www.unece.org/trans/danger/publi/adr/adr2009/09contentse.html

UNECE (2011) Globally Harmonized System of Classification and Labelling of Chemicals (GHS). Fourth revised edition. United Nations Economic Cooperation for Europe (UNECE), New York and Geneva.

USEPA (2020) ECOTOXicology Database Version 4.0. Accessed at: http://cfpub.epa.gov/ecotox/

USEPA (2012b). United States Environmental Protection Agency Regional Screening Level (RSL) Summary Table, April 2012. Accessed at: http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/Generic_Tables/pdf/master_sl_table_run_MAY2012.pdf

Van Gestel, C.A.M (1992). The influence of soil characteristics on the toxicity of chemicals for earthworms: a review in H. Becker (ed.) Ecotoxicology of Earthworms, Intercept, Andover, UK, pp 44-54.

Warne M.St.J., G.E. Batley, R.A. van Dam, J.V. Chapman, D.R. Fox, C.W. Hickey and J.L. Stauber. 2018. Revised Method for Deriving Australian and New Zealand Water Quality Guideline Values for Toxicants – update of 2015 version. Prepared for the revision of the Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Australian and New Zealand Government and Australian state and territory government, Canberra.

WHO (2005). World Health Organisation (WHO). Petroleum Products in Drinking Water. Background Document for Development of WHO Guidelines for Drinking Water Quality

Signature Page

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APPENDIX A

Limitations

The document ("Report") to which this page is attached and which this page forms a part of, has been issued by Golder Associates Pty Ltd ("Golder") subject to the important limitations and other qualifications set out below.

This Report constitutes or is part of services ("Services") provided by Golder to its client ("Client") under and subject to a contract between Golder and its Client ("Contract"). The contents of this page are not intended to and do not alter Golder's obligations (including any limits on those obligations) to its Client under the Contract.

This Report is provided for use solely by Golder's Client and persons acting on the Client's behalf, such as its professional advisers. Golder is responsible only to its Client for this Report. Golder has no responsibility to any other person who relies or makes decisions based upon this Report or who makes any other use of this Report. Golder accepts no responsibility for any loss or damage suffered by any person other than its Client as a result of any reliance upon any part of this Report, decisions made based upon this Report or any other use of it.

This Report has been prepared in the context of the circumstances and purposes referred to in, or derived from, the Contract and Golder accepts no responsibility for use of the Report, in whole or in part, in any other context or circumstance or for any other purpose.

The scope of Golder's Services and the period of time they relate to are determined by the Contract and are subject to restrictions and limitations set out in the Contract. If a service or other work is not expressly referred to in this Report, do not assume that it has been provided or performed. If a matter is not addressed in this Report, do not assume that any determination has been made by Golder in regards to it.

At any location relevant to the Services conditions may exist which were not detected by Golder, in particular due to the specific scope of the investigation Golder has been engaged to undertake. Conditions can only be verified at the exact location of any tests undertaken. Variations in conditions may occur between tested locations and there may be conditions which have not been revealed by the investigation and which have not therefore been taken into account in this Report.

Golder accepts no responsibility for and makes no representation as to the accuracy or completeness of the information provided to it by or on behalf of the Client or sourced from any third party. Golder has assumed that such information is correct unless otherwise stated and no responsibility is accepted by Golder for incomplete or inaccurate data supplied by its Client or any other person for whom Golder is not responsible. Golder has not taken account of matters that may have existed when the Report was prepared but which were only later disclosed to Golder.

Having regard to the matters referred to in the previous paragraphs on this page in particular, carrying out the Services has allowed Golder to form no more than an opinion as to the actual conditions at any relevant location. That opinion is necessarily constrained by the extent of the information collected by Golder or otherwise made available to Golder. Further, the passage of time may affect the accuracy, applicability or usefulness of the opinions, assessments or other information in this Report. This Report is based upon the information and other circumstances that existed and were known to Golder when the Services were performed and this Report was prepared. Golder has not considered the effect of any possible future developments including physical changes to any relevant location or changes to any laws or regulations relevant to such location.

Where permitted by the Contract, Golder may have retained subconsultants affiliated with Golder to provide some or all of the Services. However, it is Golder which remains solely responsible for the Services and there is no legal recourse against any of Golder's affiliated companies or the employees, officers or directors of any of them.

By date, or revision, the Report supersedes any prior report or other document issued by Golder dealing with any matter that is addressed in the Report.

Any uncertainty as to the extent to which this Report can be used or relied upon in any respect should be referred to Golder for clarification

APPENDIX B

Safety Data Sheets

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A HALLIBURTON SERVICE

SAFETY DATA SHEET

ACETIC ACID 55%-90%

Revision Date: 20-Aug-2018 **Revision Number:** 3

1. Product Identifier & Identity for the Chemical

Statement of Hazardous Nature Hazardous according to the criteria of the 3rd Revised Edition of the Globally Harmonised System of Classification and Labelling of Chemicals (GHS), Dangerous Goods according to the criteria of ADG.

1.1. Product Identifier

Product Name ACETIC ACID 55%-90%

Other means of Identification

Synonyms None

Hazardous Material Number: MC600186

Recommended use of the chemical and restrictions on use

Recommended Use Scale Control

Uses advised against Consumer use

Supplier's name, address and phone number

Manufacturer/Supplier

Multi-Chem Mintech
1 Ward Road
East Rockingham
WA 6168
Australia

Telephone Number: 61 (08) 9419 5300
Fax Number: 61 (08) 9439 1055
Emergency Telephone Number: + 61 1 800 686 951

E-mail Address fdunexchem@halliburton.com

Emergency phone number

+ 61 1 800 686 951
Global Incident Response Access Code: 334305
Contract Number: 14012

Australian Poisons Information Centre

24 Hour Service: - 13 11 26
Police or Fire Brigade: - 000 (exchange): - 1100

2. Hazard Identification

Statement of Hazardous Nature Hazardous according to the criteria of the 3rd Revised Edition of the Globally Harmonised System of Classification and Labelling of Chemicals (GHS), Dangerous Goods according to the criteria of ADG.

Classification of the hazardous chemical

Skin Corrosion/Irritation	Category 1 - H314
Serious Eye Damage/Irritation	Category 1 - H318
Specific Target Organ Toxicity - (Single Exposure)	Category 3 - H335
Flammable liquids.	Category 3 - H226

Label elements, including precautionary statements

Hazard Pictograms

Signal Word DANGER

Hazard Statements:
H226 - Flammable liquid and vapor
H314 - Causes severe skin burns and eye damage
H318 - Causes serious eye damage
H335 - May cause respiratory irritation

Precautionary Statements

Prevention
P210 - Keep away from heat, hot surfaces, sparks, open flames and other ignition sources. No smoking.
P233 - Keep container tightly closed
P240 - Ground and bond container and receiving equipment.
P241 - Use explosion-proof electrical/ventilating/lighting/equipment
P242 - Use only non-sparking tools
P243 - Take action to prevent static discharges.
P260 - Do not breathe dust/fume/gas/mist/vapors/spray
P261 - Avoid breathing dust/fume/gas/mist/vapors/spray
P271 - Use only outdoors or in a well-ventilated area
P280 - Wear protective gloves/protective clothing/eye protection/face protection

Response
P301 + P330 + P331 - IF SWALLOWED: rinse mouth. Do NOT induce vomiting
P303 + P361 + P353 - IF ON SKIN (or hair): Take off immediately all contaminated clothing. Rinse skin with water [or shower].
P363 - Wash contaminated clothing before reuse
P304 + P340 - IF INHALED: Remove victim to fresh air and keep at rest in a position comfortable for breathing
P305 + P351 + P338 - IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing
P310 - Immediately call a POISON CENTER or doctor/physician
P370 + P378 - In case of fire: Use water spray for extinction

Storage
P403 + P233 - Store in a well-ventilated place. Keep container tightly closed
P403 + P235 - Store in a well-ventilated place. Keep cool
P405 - Store locked up

Disposal
P501 - Dispose of contents/container in accordance with local/regional/national/international regulations

Contains Substances	**CAS Number**
Acetic acid	64-19-7

Other hazards which do not result in classification
This mixture contains no substance considered to be persistent, bioaccumulating nor toxic (PBT).
This mixture contains no substance considered to be very persistent nor very bioaccumulating (vPvB).

For the full text of the H-phrases mentioned in this Section, see Section 16

3. Composition/information on Ingredients

Substances	CAS Number	PERCENT (w/w)	GHS Classification - Australia
Acetic acid	64-19-7	60 - 100%	Skin Corr. 1A (H314) Eye Corr. 1 (H318) STOT SE 3 (H335) Flam. Liq. 3 (H226)

4. First aid measures

Description of necessary first aid measures

Inhalation If inhaled, remove from area to fresh air. Get medical attention if respiratory irritation develops or if breathing becomes difficult.

Eyes In case of contact, immediately flush eyes with plenty of water for at least 30 minutes. Remove contact lenses after the first 5 minutes and continue washing. Seek immediate medical attention/advice. Suitable emergency eye wash facility should be immediately available

Skin In case of contact, immediately flush skin with plenty of soap and water for at least 30 minutes and remove contaminated clothing, shoes and leather goods immediately. Get medical attention immediately.

Ingestion Rinse mouth with water many times. Get medical attention, if symptoms occur

Symptoms caused by exposure

Causes severe skin irritation with tissue destruction. Causes severe eye irritation which may damage tissue. May cause respiratory irritation.

Medical Attention and Special Treatment

Notes to Physician Treat symptomatically

5. Fire Fighting Measures

Suitable extinguishing equipment

Suitable Extinguishing Media

Water fog, carbon dioxide, foam, dry chemical.

Extinguishing media which must not be used for safety reasons

Do NOT spray pool fires directly with water. A solid stream of water directed into hot burning liquid can cause splattering.

Specific hazards arising from the chemical

Special exposure hazards in a fire

Decomposition in fire may produce harmful gases.

Special protective equipment and precautions for fire fighters

Special protective equipment for firefighters

Full protective clothing and approved self-contained breathing apparatus required for fire fighting personnel.

6. Accidental release measures

6.1. Personal precautions, protective equipment and emergency procedures

Ensure adequate ventilation. Use appropriate protective equipment. Do not breathe dust/fume/gas/mist/vapors/spray. Remove sources of ignition. Take precautionary measures against static discharges All equipment used when handling the product must be grounded Avoid contact with skin, eyes and clothing.

6.2. Environmental precautions

Prevent from entering sewers, waterways, or low areas.

6.3. Methods and material for containment and cleaning up

Dike far ahead of liquid spill for later disposal. Soak up with inert absorbent material. Pick up and transfer to properly labeled containers. Remove ignition sources and work with non-sparking tools.

7. Handling and storage

7.1. Precautions for safe handling

Handling Precautions

Do not breathe dust/fume/gas/mist/vapors/spray. Ensure adequate ventilation. Use appropriate protective equipment. Remove sources of ignition. Ground and bond containers when transferring from one container to another. Avoid contact with eyes, skin, or clothing.

Hygiene Measures

Handle in accordance with good industrial hygiene and safety practice.

7.2. Conditions for safe storage, including any incompatibilities

Storage Information

Store in a cool well ventilated area. Keep from heat, sparks, and open flames.

Other Guidelines

No information available

8. Exposure Controls/Personal Protection

Control parameters - exposure standards, biological monitoring

Exposure Limits

Substances	CAS Number	Australia NOHSC	ACGIH TLV-TWA
Acetic acid	64-19-7	TWA: 10 ppm TWA: 25 mg/m^3 STEL: 15 ppm STEL: 37 mg/m^3	TWA: 10 ppm STEL: 15 ppm

Appropriate engineering controls

Engineering Controls Ensure adequate ventilation, especially in confined areas

Personal protective equipment (PPE)

Personal Protective Equipment If engineering controls and work practices cannot prevent excessive exposures, the selection and proper use of personal protective equipment should be determined by an industrial hygienist or other qualified professional based on the specific application of this product.

Respiratory Protection If engineering controls and work practices cannot keep exposure below occupational exposure limits or if exposure is unknown, wear a NIOSH certified, European Standard EN 149, AS/NZS 1715:2009, or equivalent respirator when using this product. Selection of and instruction on using all personal protective equipment, including respirators, should be performed by an Industrial Hygienist or other qualified professional.

Hand Protection Use gloves which are suitable for the chemicals present in this product as well as other environmental factors in the workplace.

Skin Protection Wear impervious protective clothing, including boots, gloves, lab coat, apron, rain jacket, pants or coverall, as appropriate, to prevent skin contact.

Eye Protection None known.

Other Precautions None known.

Environmental Exposure Controls No information available

9. Physical and Chemical Properties

9.1. Information on basic physical and chemical properties

Physical State: Liquid

Color Light Amber to Dark Amber , Clear to Slightly Hazy

Odor: Pungent

Odor Threshold: No information available

Property Remarks/ - Method	Values
pH:	2.5-3.8 (10% in 1:1 IPA:H2O)
Freezing Point / Range	No data available
Melting Point / Range	No data available
Boiling Point / Range	No data available
Flash Point	> 40 °C / > 104 °F (SFCC)
Evaporation rate	No data available
Vapor Pressure	No data available
Vapor Density	No data available
Specific Gravity	1.0653-1.0903 (20 °C/68 °F)
Water Solubility	Soluble in water
Solubility in other solvents	No data available
Partition coefficient: n-octanol/water	No data available
Autoignition Temperature	No data available
Decomposition Temperature	No data available
Viscosity	No data available
Explosive Properties	No information available
Oxidizing Properties	No information available

9.2. Other information

VOC Content (%)	No data available
Liquid Density	8.88-9.09 lbs/gal
Bulk Density	1065-1090 kg/m^3

10. Stability and Reactivity

10.1. Reactivity
Not expected to be reactive.
10.2. Chemical stability
Stable
10.3. Possibility of hazardous reactions
Will Not Occur
10.4. Conditions to avoid
Keep away from heat, sparks and flame.
10.5. Incompatible materials
Strong oxidizers.
10.6. Hazardous decomposition products
Carbon oxides.

11. Toxicological Information

Information on routes of exposure
Principle Route of Exposure Skin contact. Eye contact. Inhalation.

Symptoms related to exposure
Most Important Symptoms/Effects
Causes severe skin irritation with tissue destruction. Causes severe eye irritation which may damage tissue. May cause respiratory irritation.

Toxicology data for the components

Substances	CAS Number	LD50 Oral	LD50 Dermal	LC50 Inhalation
Acetic acid	64-19-7	No data available	1060 mg/kg-bw (rabbit)	11.4 mg/L (rat, 4 h, vapor)

Immediate, delayed and chronic health effects from exposure

Inhalation	May cause respiratory irritation.
Eye Contact	Causes serious eye damage.
Skin Contact	Causes severe burns.

Ingestion Causes burns of the mouth, throat and stomach.

Exposure Levels
No data available

Interactive effects
No data available

Data limitations
No data available

Substances	CAS Number	Skin corrosion/irritation
Acetic acid	64-19-7	Extremely corrosive and destructive to tissue Skin, rabbit:

Substances	CAS Number	Serious eye damage/irritation
Acetic acid	64-19-7	Eye, rabbit: Causes serious eye damage

Substances	CAS Number	Skin Sensitization
Acetic acid	64-19-7	Not regarded as a sensitizer.

Substances	CAS Number	Respiratory Sensitization
Acetic acid	64-19-7	No information available

Substances	CAS Number	Mutagenic Effects
Acetic acid	64-19-7	In vivo tests did not show mutagenic effects. In vitro tests did not show mutagenic effects.

Substances	CAS Number	Carcinogenic Effects
Acetic acid	64-19-7	Did not show carcinogenic effects in animal experiments

Substances	CAS Number	Reproductive toxicity
Acetic acid	64-19-7	Did not show teratogenic effects in animal experiments. Animal testing did not show any effects on fertility.

Substances	CAS Number	STOT - single exposure
Acetic acid	64-19-7	May cause respiratory irritation. No information available

Substances	CAS Number	STOT - repeated exposure
Acetic acid	64-19-7	No significant toxicity observed in animal studies at concentration requiring classification.

Substances	CAS Number	Aspiration hazard
Acetic acid	64-19-7	Not applicable

12. Ecological Information

Ecotoxicity
Product Ecotoxicity Data
Product is not classified as hazardous to the environment.

Substance Ecotoxicity Data

Substances	CAS Number	Toxicity to Algae	Toxicity to Fish	Toxicity to Microorganisms	Toxicity to Invertebrates
Acetic acid	64-19-7	EC50(72 h)=55.22 mg/L (Anabaena flos-aquae)	LC50(96 h)=251 mg/L (Gambusia affinis) LC50(96 h)=75 mg/L (Lepomis macrochirus)	NOAEC (16 h) =1150 mg/L (Pseudomonas putida)	EC50(48 h)=65 mg/L (Daphnia magna)

12.2. Persistence and degradability

Substances	CAS Number	Persistence and Degradability
Acetic acid	64-19-7	Readily biodegradable (99% @ 7d)

12.3. Bioaccumulative potential

Substances	CAS Number	Bioaccumulation
Acetic acid	64-19-7	LogPow-0.17

12.4. Mobility in soil

Substances	CAS Number	Mobility
Acetic acid	64-19-7	No information available

12.6. Other adverse effects

Endocrine Disruptor Information
This product does not contain any known or suspected endocrine disruptors

13. Disposal Considerations

Safe handling and disposal methods
Disposal should be made in accordance with federal, state, and local regulations.

Disposal of any contaminated packaging
Follow all applicable national or local regulations.

Environmental regulations
Not applicable

14. Transport Information

Transportation Information

Australia ADG

UN Number UN2789
UN proper shipping name: Acetic Acid Solution
Transport Hazard Class(es): 8 (3)
Packing Group: III
Environmental Hazards: Not applicable

IMDG/IMO

UN Number UN2789
UN proper shipping name: Acetic Acid Solution
Transport Hazard Class(es): 8 (3)
Packing Group: III
Environmental Hazards: Not applicable
EMS: EmS F-E, S-C

IATA/ICAO

UN Number UN2789
UN proper shipping name: Acetic Acid Solution
Transport Hazard Class(es): 8 (3)
Packing Group: III
Environmental Hazards: Not applicable

Special precautions during transport
None

HazChem Code
•2P

15. Regulatory Information

Safety, health and environmental regulations specific for the product

International Inventories

Australian AICS Inventory	All components are listed on the AICS or are subject to a relevant exemption, permit, or assessment certificate.
New Zealand Inventory of Chemicals	All components are listed on the NZIoC or are subject to a relevant exemption, permit, or assessment certificate.
EINECS (European Inventory of Existing Chemical Substances)	This product, and all its components, complies with EINECS
US TSCA Inventory	All components listed on inventory or are exempt.
Canadian Domestic Substances List (DSL)	All components listed on inventory or are exempt.

Poisons Schedule number
S6

International Agreements

Montreal Protocol - Ozone Depleting Substances:	Does not apply.
Stockholm Convention - Persistent Organic Pollutants:	Does not apply
Rotterdam Convention - Prior Informed Consent:	Does not apply.
Basel Convention - Hazardous Waste:	Does not apply.

16. Other information

Date of preparation or review

Revision Date: 20-Aug-2018

Revision Note
Update to Format

Full text of H-Statements referred to under sections 2 and 3
H226 - Flammable liquid and vapor
H314 - Causes severe skin burns and eye damage
H318 - Causes serious eye damage
H335 - May cause respiratory irritation

Additional information For additional information on the use of this product, contact your local Halliburton representative.

For questions about the Safety Data Sheet for this or other Halliburton products, contact Chemical Stewardship at 1-580-251-4335.

Key abreviations or acronyms used
bw – body weight
CAS – Chemical Abstracts Service
EC50 – Effective Concentration 50%
LC50 – Lethal Concentration 50%
LD50 – Lethal Dose 50%
LL50 – Lethal Loading 50%
mg/kg – milligram/kilogram
mg/L – milligram/liter
NOEC – No Observed Effect Concentration
OEL – Occupational Exposure Limit
PBT – Persistent Bioaccumulative and Toxic
ppm – parts per million
STEL – Short Term Exposure Limit
TWA – Time-Weighted Average
vPvB – very Persistent and very Bioaccumulative
h - hour
mg/m^3 - milligram/cubic meter
mm - millimeter
mmHg - millimeter mercury

w/w - weight/weight
d - day

Key literature references and sources for data
www.ChemADVISOR.com/

Disclaimer Statement
This information is furnished without warranty, expressed or implied, as to accuracy or completeness. The information is obtained from various sources including the manufacturer and other third party sources. The information may not be valid under all conditions nor if this material is used in combination with other materials or in any process. Final determination of suitability of any material is the sole responsibility of the user.

End of Safety Data Sheet

HALLIBURTON

SAFETY DATA SHEET

ACETIC ACID 60%

Revision Date: 26-Jun-2019 **Revision Number:** 11

1. Product Identifier & Identity for the Chemical

Statement of Hazardous Nature Hazardous according to the criteria of the 3rd Revised Edition of the Globally Harmonised System of Classification and Labelling of Chemicals (GHS), Dangerous Goods according to the criteria of ADG.

1.1. Product Identifier

Product Name ACETIC ACID 60%

Other means of Identification

Synonyms None

Hazardous Material Number: HM004481

Recommended use of the chemical and restrictions on use

Recommended Use Solvent

Uses advised against No information available

Supplier's name, address and phone number

Manufacturer/Supplier Halliburton Australia Pty. Ltd.
15 Marriott Road, Jandakot, WA 6164
Australia
ACN Number: 009 000 775
Telephone Number: + 61 1 800 686 951
Fax Number: 61 (08) 9455 5300

E-mail Address fdunexchem@halliburton.com

Emergency phone number

+ 61 1 800 686 951
Global Incident Response Access Code: 334305
Contract Number: 14012

Australian Poisons Information Centre
24 Hour Service: - 13 11 26
Police or Fire Brigade: - 000 (exchange): - 1100

2. Hazard Identification

Statement of Hazardous Nature Hazardous according to the criteria of the 3rd Revised Edition of the Globally Harmonised System of Classification and Labelling of Chemicals (GHS), Dangerous Goods according to the criteria of ADG.

Classification of the hazardous chemical

Skin Corrosion/Irritation	Category 1 - H314
Serious Eye Damage/Irritation	Category 1 - H318
Specific Target Organ Toxicity - (Single Exposure)	Category 3 - H335
Flammable liquids.	Category 3 - H226

Label elements, including precautionary statements

Hazard Pictograms

Signal Word DANGER

Hazard Statements:
H314 - Causes severe skin burns and eye damage
H318 - Causes serious eye damage
H335 - May cause respiratory irritation
H226 - Flammable liquid and vapor

Precautionary Statements

Prevention
P210 - Keep away from heat, hot surfaces, sparks, open flames and other ignition sources. No smoking.
P233 - Keep container tightly closed
P240 - Ground and bond container and receiving equipment.
P241 - Use explosion-proof electrical/ventilating/lighting/equipment
P242 - Use only non-sparking tools
P243 - Take action to prevent static discharges.
P260 - Do not breathe dust/fume/gas/mist/vapors/spray
P264 - Wash face, hands and any exposed skin thoroughly after handling
P271 - Use only outdoors or in a well-ventilated area
P280 - Wear protective gloves/protective clothing/eye protection/face protection

Response
P301+ P330 + P331 - IF SWALLOWED: Rinse mouth. Do NOT induce vomiting
P303 + P361 + P353 - IF ON SKIN (or hair): Take off immediately all contaminated clothing. Rinse skin with water [or shower].
P363 - Wash contaminated clothing before reuse
P312 - Call a POISON CENTER or doctor/physician if you feel unwell
P305 + P351 + P338 - IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing
P310 - Immediately call a POISON CENTER or doctor/physician
P370 + P378 - In case of fire: Use water spray for extinction
P304 + P340 - IF INHALED: Remove victim to fresh air and keep at rest in a position comfortable for breathing

Storage
P403 + P233 - Store in a well-ventilated place. Keep container tightly closed
P403 + P235 - Store in a well-ventilated place. Keep cool
P405 - Store locked up

Disposal
P501 - Dispose of contents/container in accordance with local/regional/national/international regulations

Contains Substances	**CAS Number**
Acetic acid	64-19-7

Other hazards which do not result in classification
None known

For the full text of the H-phrases mentioned in this Section, see Section 16

3. Composition/information on Ingredients

Substances	CAS Number	PERCENT (w/w)	GHS Classification - Australia
Acetic acid	64-19-7	60 - 100%	Skin Corr. 1A (H314) Eye Corr. 1 (H318) STOT SE 3 (H335)

			Flam. Liq. 3 (H226)

4. First aid measures

Description of necessary first aid measures

Inhalation If inhaled, move victim to fresh air and seek medical attention.

Eyes Immediately flush eyes with large amounts of water for at least 30 minutes. Seek prompt medical attention.

Skin In case of contact, immediately flush skin with plenty of soap and water for at least 30 minutes and remove contaminated clothing, shoes and leather goods immediately. Get medical attention immediately.

Ingestion Do NOT induce vomiting. Give nothing by mouth. Obtain immediate medical attention.

Symptoms caused by exposure

Causes severe eye irritation which may damage tissue. Causes severe skin irritation with tissue destruction. May cause respiratory irritation.

Medical Attention and Special Treatment

Notes to Physician Treat symptomatically

5. Fire Fighting Measures

Suitable extinguishing equipment

Suitable Extinguishing Media

Water fog, carbon dioxide, foam, dry chemical.

Extinguishing media which must not be used for safety reasons

None known.

Specific hazards arising from the chemical

Special exposure hazards in a fire

Use water spray to cool fire exposed surfaces. Decomposition in fire may produce harmful gases. Do not allow runoff to enter waterways.

Special protective equipment and precautions for fire fighters

Special protective equipment for firefighters

Full protective clothing and approved self-contained breathing apparatus required for fire fighting personnel.

6. Accidental release measures

6.1. Personal precautions, protective equipment and emergency procedures

Use appropriate protective equipment.

6.2. Environmental precautions

Prevent from entering sewers, waterways, or low areas.

6.3. Methods and material for containment and cleaning up

Isolate spill and stop leak where safe. Contain spill with sand or other inert materials. Neutralize to pH of 6-8. Scoop up and remove.

7. Handling and storage

7.1. Precautions for safe handling

Handling Precautions

Avoid contact with eyes, skin, or clothing. Avoid breathing vapors. Wash hands after use. Launder contaminated clothing before reuse.

Hygiene Measures

Handle in accordance with good industrial hygiene and safety practice.

7.2. Conditions for safe storage, including any incompatibilities

Storage Information

Store in a cool well ventilated area. Keep container closed when not in use. Product has a shelf life of 24 months. Store locked up.

Other Guidelines

No information available

8. Exposure Controls/Personal Protection

Control parameters - exposure standards, biological monitoring

Exposure Limits

Substances	CAS Number	Australia NOHSC	ACGIH TLV-TWA
Acetic acid	64-19-7	TWA: 10 ppm TWA: 25 mg/m^3 STEL: 15 ppm STEL: 37 mg/m^3	TWA: 10 ppm STEL: 15 ppm

Appropriate engineering controls

Engineering Controls Use in a well ventilated area. Local exhaust ventilation should be used in areas without good cross ventilation.

Personal protective equipment (PPE)

Personal Protective Equipment If engineering controls and work practices cannot prevent excessive exposures, the selection and proper use of personal protective equipment should be determined by an industrial hygienist or other qualified professional based on the specific application of this product.

Respiratory Protection Organic vapor/acid gas respirator.

Hand Protection Impervious rubber gloves.

Skin Protection Full protective chemical resistant clothing.

Eye Protection Chemical goggles; also wear a face shield if splashing hazard exists.

Other Precautions Eyewash fountains and safety showers must be easily accessible.

Environmental Exposure Controls No information available

9. Physical and Chemical Properties

9.1. Information on basic physical and chemical properties

Physical State: Liquid **Color** Clear

Odor: Acrid **Odor Threshold:** No information available

Property Remarks/ - Method	Values
pH:	1.38
Freezing Point / Range	16 °C
Melting Point / Range	No data available
Pour Point / Range	No data available
Boiling Point / Range	117 °C / 244 °F
Flash Point	55 °C / 131 °F (PMCC)
Upper flammability limit	16%
Lower flammability limit	5.4%
Evaporation rate	No data available
Vapor Pressure	11.7 mmHg @ 20 C
Vapor Density	No data available
Specific Gravity	1.05
Water Solubility	Soluble in water
Solubility in other solvents	No data available
Partition coefficient: n-octanol/water	No data available
Autoignition Temperature	No data available
Decomposition Temperature	No data available
Viscosity	No data available
Explosive Properties	No information available
Oxidizing Properties	No information available

9.2. Other information

Molecular Weight	60.6 (g/mole)
VOC Content (%)	No data available

10. Stability and Reactivity

10.1. Reactivity
Not expected to be reactive.
10.2. Chemical stability
Stable
10.3. Possibility of hazardous reactions
Will Not Occur
10.4. Conditions to avoid
Keep away from heat, sparks and flame.
10.5. Incompatible materials
Strong alkalis.
10.6. Hazardous decomposition products
Carbon monoxide and carbon dioxide.

11. Toxicological Information

Information on routes of exposure
Principle Route of Exposure Eye or skin contact, inhalation.

Symptoms related to exposure
Most Important Symptoms/Effects
Causes severe eye irritation which may damage tissue. Causes severe skin irritation with tissue destruction. May cause respiratory irritation.

Toxicology data for the components

Substances	CAS Number	LD50 Oral	LD50 Dermal	LC50 Inhalation
Acetic acid	64-19-7	No data available	1060 mg/kg-bw (rabbit)	11.4 mg/L (rat, 4 h, vapor)

Immediate, delayed and chronic health effects from exposure

Inhalation	Causes severe respiratory irritation.
Eye Contact	Causes eye burns
Skin Contact	Causes skin burns which may not be immediately painful or visible.
Ingestion	Causes burns of the mouth, throat and stomach.

Chronic Effects/Carcinogenicity Prolonged, excessive exposure may cause erosion of the teeth.

Exposure Levels
No data available

Interactive effects
Skin disorders.

Data limitations
No data available

Substances	CAS Number	Skin corrosion/irritation
Acetic acid	64-19-7	Extremely corrosive and destructive to tissue Skin, rabbit:

Substances	CAS Number	Serious eye damage/irritation
Acetic acid	64-19-7	Eye, rabbit: Causes serious eye damage

Substances	CAS Number	Skin Sensitization
Acetic acid	64-19-7	Not regarded as a sensitizer.

Substances	CAS Number	Respiratory Sensitization
Acetic acid	64-19-7	No information available

Substances	CAS Number	Mutagenic Effects
Acetic acid	64-19-7	In vivo tests did not show mutagenic effects. In vitro tests did not show mutagenic effects.

Substances	CAS Number	Carcinogenic Effects
Acetic acid	64-19-7	Did not show carcinogenic effects in animal experiments

Substances	CAS Number	Reproductive toxicity
Acetic acid	64-19-7	Did not show teratogenic effects in animal experiments. Animal testing did not show any effects on fertility.

Substances	CAS Number	STOT - single exposure
Acetic acid	64-19-7	May cause respiratory irritation. No information available

Substances	CAS Number	STOT - repeated exposure
Acetic acid	64-19-7	No significant toxicity observed in animal studies at concentration requiring classification.

Substances	CAS Number	Aspiration hazard
Acetic acid	64-19-7	Not applicable

12. Ecological Information

Ecotoxicity

Substance Ecotoxicity Data

Substances	CAS Number	Toxicity to Algae	Toxicity to Fish	Toxicity to Microorganisms	Toxicity to Invertebrates
Acetic acid	64-19-7	EC50(72 h)=55.22 mg/L (Anabaena flos-aquae)	LC50(96 h)=251 mg/L (Gambusia affinis) LC50(96 h)=75 mg/L (Lepomis macrochirus)	NOAEC (16 h) =1150 mg/L (Pseudomonas putida)	EC50(48 h)=65 mg/L (Daphnia magna)

12.2. Persistence and degradability

Substances	CAS Number	Persistence and Degradability
Acetic acid	64-19-7	Readily biodegradable (99% @ 7d)

12.3. Bioaccumulative potential

Substances	CAS Number	Bioaccumulation
Acetic acid	64-19-7	LogPow-0.17

12.4. Mobility in soil

Substances	CAS Number	Mobility
Acetic acid	64-19-7	No information available

12.6. Other adverse effects

Endocrine Disruptor Information

This product does not contain any known or suspected endocrine disruptors

13. Disposal Considerations

Safe handling and disposal methods

Disposal should be made in accordance with federal, state, and local regulations.

Disposal of any contaminated packaging

Follow all applicable national or local regulations.

Environmental regulations
Not applicable

14. Transport Information

Transportation Information

Australia ADG

UN Number	UN2790
UN proper shipping name:	Acetic Acid Solution
Transport Hazard Class(es):	8
Packing Group:	II
Environmental Hazards:	Not applicable

IMDG/IMO

UN Number	UN2790
UN proper shipping name:	Acetic Acid Solution
Transport Hazard Class(es):	8
Packing Group:	II
Environmental Hazards:	Not applicable
EMS:	EmS F-A, S-B

IATA/ICAO

UN Number	UN2790
UN proper shipping name:	Acetic Acid Solution
Transport Hazard Class(es):	8
Packing Group:	II
Environmental Hazards:	Not applicable

Special precautions during transport
None

HazChem Code
2R

15. Regulatory Information

Safety, health and environmental regulations specific for the product

International Inventories

Australian AICS Inventory	All components are listed on the AICS or are subject to a relevant exemption, permit, or assessment certificate.
New Zealand Inventory of Chemicals	All components are listed on the NZIoC or are subject to a relevant exemption, permit, or assessment certificate.
US TSCA Inventory	All components listed on inventory or are exempt.
Canadian Domestic Substances List (DSL)	All components listed on inventory or are exempt.

Poisons Schedule number
S6

International Agreements

Montreal Protocol - Ozone Depleting Substances:	Does not apply.
Stockholm Convention - Persistent Organic Pollutants:	Does not apply
Rotterdam Convention - Prior Informed Consent:	Does not apply.
Basel Convention - Hazardous Waste:	Does not apply.

16. Other information

Date of preparation or review

Revision Date: 26-Jun-2019

Revision Note
SDS sections updated:
2

Full text of H-Statements referred to under sections 2 and 3
H226 - Flammable liquid and vapor
H314 - Causes severe skin burns and eye damage
H318 - Causes serious eye damage
H335 - May cause respiratory irritation

Additional information

For additional information on the use of this product, contact your local Halliburton representative.

For questions about the Safety Data Sheet for this or other Halliburton products, contact Chemical Stewardship at 1-580-251-4335.

Key abreviations or acronyms used
bw – body weight
CAS – Chemical Abstracts Service
EC50 – Effective Concentration 50%
LC50 – Lethal Concentration 50%
LD50 – Lethal Dose 50%
LL50 – Lethal Loading 50%
mg/kg – milligram/kilogram
mg/L – milligram/liter
NOEC – No Observed Effect Concentration
OEL – Occupational Exposure Limit
PBT – Persistent Bioaccumulative and Toxic
ppm – parts per million
STEL – Short Term Exposure Limit
TWA – Time-Weighted Average
vPvB – very Persistent and very Bioaccumulative
h - hour
mg/m^3 - milligram/cubic meter
mm - millimeter
mmHg - millimeter mercury
w/w - weight/weight
d - day

Key literature references and sources for data
www.ChemADVISOR.com/
NZ CCID

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End of Safety Data Sheet

HALLIBURTON

SAFETY DATA SHEET

BC-140C

Revision Date: 01-Oct-2015 **Revision Number:** 18

1. Product Identifier & Identity for the Chemical

Statement of Hazardous Nature Non-Hazardous according to the criteria of the 3rd Revised Edition of the Globally Harmonised System of Classification and Labelling of Chemicals (GHS), Non-Dangerous Goods according to the criteria of ADG.

1.1. Product Identifier

Product Name BC-140C

Other means of Identification

Synonyms: None

Product Code: HM000110

Recommended use of the chemical and restrictions on use

Recommended Use Crosslinker

Uses Advised Against No information available

Supplier's name, address and phone number

Manufacturer/Supplier Halliburton Australia Pty. Ltd.
15 Marriott Road
Jandakot
WA 6164
Australia

ACN Number: 009 000 775
Telephone Number: + 61 1 800 686 951
Fax Number: 61 (08) 9455 5300

E-Mail address: fdunexchem@halliburton.com

Emergency phone number

+ 61 1 800 686 951

Australian Poisons Information Centre

24 Hour Service: - 13 11 26

Police or Fire Brigade: - 000 (exchange): - 1100

2. Hazard Identification

Statement of Hazardous Nature Non-Hazardous according to the criteria of the 3rd Revised Edition of the Globally Harmonised System of Classification and Labelling of Chemicals (GHS), Non-Dangerous Goods according to the criteria of ADG.

Classification of the hazardous chemical

Not classified

Label elements, including precautionary statements

Hazard Pictograms

Signal Word Not Hazardous

Hazard Statements Not Classified

Precautionary Statements

Prevention None

Response None

Storage None

Disposal None

Contains

Substances	**CAS Number**
Contains no hazardous substances in concentrations above cut-off values according to the competent authority	NA

Other hazards which do not result in classification

This mixture contains no substance considered to be persistent, bioaccumulating nor toxic (PBT).
This mixture contains no substance considered to be very persistent nor very bioaccumulating (vPvB).

Australia Classification

For the full text of the H-phrases mentioned in this Section, see Section 16

Classification Not Classified
Risk Phrases None

3. Composition/information on Ingredients

Substances	CAS Number	PERCENT (w/w)	GHS Classification - Australia
Contains no hazardous substances in concentrations above cut-off values according to the competent authority	NA	60 - 100%	Not Applicable

4. First aid measures

Description of necessary first aid measures

Inhalation If inhaled, move victim to fresh air and seek medical attention.

Eyes In case of contact, or suspected contact, immediately flush eyes with plenty of water for at least 15 minutes and get medical attention immediately after flushing.

Skin In case of contact, immediately flush skin with plenty of soap and water for at least 15 minutes. Get medical attention. Remove contaminated clothing and launder before reuse.

Ingestion Do NOT induce vomiting. Give nothing by mouth. Obtain immediate medical attention.

Symptoms caused by exposure

No significant hazards expected.

Medical Attention and Special Treatment

Notes to Physician Treat symptomatically

5. Fire Fighting Measures

Suitable extinguishing equipment

Suitable Extinguishing Media

Water fog, carbon dioxide, foam, dry chemical.

Extinguishing media which must not be used for safety reasons
None known.

Specific hazards arising from the chemical
Special Exposure Hazards
Decomposition in fire may produce harmful gases.

Special protective equipment and precautions for fire fighters
Special Protective Equipment for Fire-Fighters
Full protective clothing and approved self-contained breathing apparatus required for fire fighting personnel.

6. Accidental release measures

6.1. Personal precautions, protective equipment and emergency procedures
Use appropriate protective equipment. Avoid contact with skin, eyes and clothing. Avoid breathing vapors. Ensure adequate ventilation.

6.2. Environmental precautions
Prevent from entering sewers, waterways, or low areas.

6.3. Methods and material for containment and cleaning up
Isolate spill and stop leak where safe. Contain spill with sand or other inert materials. Scoop up and remove.

7. Handling and storage

7.1. Precautions for Safe Handling
Handling Precautions
Avoid contact with eyes, skin, or clothing. Avoid breathing vapors. Ensure adequate ventilation. Wash hands after use. Launder contaminated clothing before reuse. Use appropriate protective equipment.
Hygiene Measures
Handle in accordance with good industrial hygiene and safety practice.

7.2. Conditions for safe storage, including any incompatibilities
Storage Information
Store away from oxidizers. Store in a cool well ventilated area. Keep container closed when not in use. Product has a shelf life of 36 months.
Other Guidelines
No information available

8. Exposure Controls/Personal Protection

Control parameters - exposure standards, biological monitoring
Exposure Limits

Substances	CAS Number	Australia NOHSC	ACGIH TLV-TWA
Contains no hazardous substances in concentrations above cut-off values according to the competent authority	NA	Not applicable	Not applicable

Appropriate engineering controls
Engineering Controls Use in a well ventilated area. Local exhaust ventilation should be used in areas without good cross ventilation.

Personal protective equipment (PPE)
Respiratory Protection Not normally needed. But if significant exposures are possible then the following respirator is recommended:
Organic vapor respirator.

Hand Protection Impervious rubber gloves.
Skin Protection Rubber apron.
Eye Protection Safety glasses.

Other Precautions None known.
Environmental Exposure Controls Do not allow material to contaminate ground water system

9. Physical and Chemical Properties

9.1. Information on basic physical and chemical properties

Physical State: Liquid
Color: Blue
Odor: Amine
Odor Threshold: No information available

Property Remarks/ - Method	Values
pH:	7.9
Freezing Point/Range	No data available
Melting Point/Range	No data available
Boiling Point/Range	No data available
Flash Point	No data available
Evaporation rate	No data available
Vapor Pressure	No data available
Vapor Density	No data available
Specific Gravity	1.16
Water Solubility	Soluble in water
Solubility in other solvents	No data available
Partition coefficient: n-octanol/water	No data available
Autoignition Temperature	No data available
Decomposition Temperature	No data available
Viscosity	No data available
Explosive Properties	No information available
Oxidizing Properties	No information available

9.2. Other information

VOC Content (%)	No data available
Liquid Density	9.66 lbs/gal @ 20 C

10. Stability and Reactivity

10.1. Reactivity
Not expected to be reactive.
10.2. Chemical Stability
Stable
10.3. Possibility of Hazardous Reactions
Will Not Occur
10.4. Conditions to Avoid
None anticipated
10.5. Incompatible Materials
Strong oxidizers. Dehydrating agents.
10.6. Hazardous Decomposition Products
Toxic fumes. Carbon monoxide and carbon dioxide.

11. Toxicological Information

Information on routes of exposure
Principle Route of Exposure Eye or skin contact, inhalation.

Sympotoms related to exposure
Most Important Symptoms/Effects
No significant hazards expected.

Numerical measures of toxicity

Toxicology data for the components

Substances	CAS Number	LD50 Oral	LD50 Dermal	LC50 Inhalation
Contains no hazardous substances in concentrations above cut-off values according to the competent authority	NA	No data available	No data available	No data available

Immediate, delayed and chronic health effects from exposure

Inhalation May cause mild respiratory irritation.
Eye Contact May cause mild eye irritation.
Skin Contact May cause mild skin irritation.
Ingestion None known.

Chronic Effects/Carcinogenicity No data available to indicate product or components present at greater than 0.1% are chronic health hazards.

Exposure Levels
No data available

Interactive effects
Skin disorders. Eye ailments.

Data limitations
No data available

12. Ecological Information

Ecotoxicity
Product Ecotoxicity Data
No data available

Substance Ecotoxicity Data

Substances	CAS Number	Toxicity to Algae	Toxicity to Fish	Toxicity to Microorganisms	Toxicity to Invertebrates
Contains no hazardous substances in concentrations above cut-off values according to the competent authority	NA	No information available	No information available	No information available	No information available

12.2. Persistence and degradability

Substances	CAS Number	Persistence and Degradability
Contains no hazardous substances in concentrations above cut-off values according to the competent authority	NA	No information available

12.3. Bioaccumulative potential

Substances	CAS Number	Log Pow
Contains no hazardous substances in concentrations above cut-off values according to the competent authority	NA	No information available

12.4. Mobility in soil

Substances	CAS Number	Mobility
Contains no hazardous substances in concentrations above cut-off values according to the competent authority	NA	No information available

12.6. Other adverse effects

Endocrine Disruptor Information

This product does not contain any known or suspected endocrine disruptors

13. Disposal Considerations

Safe handling and disposal methods

Disposal should be made in accordance with federal, state, and local regulations.

Disposal of any contaminated packaging

Follow all applicable national or local regulations.

Environmental regulations

Not applicable

14. Transport Information

Transportation Information

UN Number:	Not restricted
UN Proper Shipping Name:	Not restricted
Transport Hazard Class(es):	Not applicable
Packing Group:	Not applicable
Environmental Hazards:	Not applicable

Special precautions during transport

None

HazChem Code

None Allocated

15. Regulatory Information

Safety, health and environmental regulations specific for the product

International Inventories

Australian AICS Inventory	All components listed on inventory or are exempt.
New Zealand Inventory of Chemicals	All components listed on inventory or are exempt.
EINECS Inventory	This product, and all its components, complies with EINECS
US TSCA Inventory	All components listed on inventory or are exempt.
Canadian DSL Inventory	All components listed on inventory or are exempt.

Poisons Schedule number

None Allocated

16. Other information

Date of preparation or review

Revision Date: 01-Oct-2015

Revision Note
SDS sections updated: 2

Full text of R-phrases referred to under Sections 2 and 3
None

Full text of H-Statements referred to under sections 2 and 3
None

Additional information

For additional information on the use of this product, contact your local Halliburton representative.

For questions about the Safety Data Sheet for this or other Halliburton products, contact Chemical Stewardship at 1-580-251-4335.

Key abreviations or acronyms used
bw – body weight
CAS – Chemical Abstracts Service
EC50 – Effective Concentration 50%
LC50 – Lethal Concentration 50%
LD50 – Lethal Dose 50%
LL50 – Lethal Loading 50%
mg/kg – milligram/kilogram
mg/L – milligram/liter
NOEC – No Observed Effect Concentration
OEL – Occupational Exposure Limit
PBT – Persistent Bioaccumulative and Toxic
ppm – parts per million
STEL – Short Term Exposure Limit
TWA – Time-Weighted Average
vPvB – very Persistent and very Bioaccumulative
h - hour
mg/m^3 - milligram/cubic meter
mm - millimeter
mmHg - millimeter mercury
w/w - weight/weight
d - day

Key literature references and sources for data
www.ChemADVISOR.com/

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End of Safety Data Sheet

HALLIBURTON

SAFETY DATA SHEET

BE-9

Revision Date: 13-Oct-2017 **Revision Number:** 20

1. Product Identifier & Identity for the Chemical

Statement of Hazardous Nature Hazardous according to the criteria of the 3rd Revised Edition of the Globally Harmonised System of Classification and Labelling of Chemicals (GHS), Dangerous Goods according to the criteria of ADG.

1.1. Product Identifier

Product Name BE-9

Other means of Identification

Synonyms None

Hazardous Material Number: HB006583

Recommended use of the chemical and restrictions on use

Recommended Use Biocide

Uses advised against No information available

Supplier's name, address and phone number

Manufacturer/Supplier Halliburton Australia Pty. Ltd.
15 Marriott Road, Jandakot, WA 6164
Australia
ACN Number: 009 000 775
Telephone Number: + 61 1 800 686 951
Fax Number: 61 (08) 9455 5300

E-mail Address fdunexchem@halliburton.com

Emergency phone number

+ 61 1 800 686 951
Global Incident Response Access Code: 334305
Contract Number: 14012

Australian Poisons Information Centre
24 Hour Service: - 13 11 26
Police or Fire Brigade: - 000 (exchange): - 1100

2. Hazard Identification

Statement of Hazardous Nature Hazardous according to the criteria of the 3rd Revised Edition of the Globally Harmonised System of Classification and Labelling of Chemicals (GHS), Dangerous Goods according to the criteria of ADG.

Classification of the hazardous chemical

Skin Corrosion/Irritation	Category 1 - H314
Serious Eye Damage/Irritation	Category 1 - H318
Acute Aquatic Toxicity	Category 1 - H400
Chronic Aquatic Toxicity	Category 2 - H411

Label elements, including precautionary statements

Hazard Pictograms

Signal Word DANGER

Hazard Statements:
H314 - Causes severe skin burns and eye damage
H318 - Causes serious eye damage
H400 - Very toxic to aquatic life
H411 - Toxic to aquatic life with long lasting effects

Precautionary Statements

Prevention
P260 - Do not breathe dust/fume/gas/mist/vapors/spray
P273 - Avoid release to the environment
P280 - Wear protective gloves/protective clothing/eye protection/face protection

Response
P301 + P330 + P331 - IF SWALLOWED: rinse mouth. Do NOT induce vomiting
P303 + P361 + P353 - IF ON SKIN (or hair): Take off immediately all contaminated clothing. Rinse skin with water [or shower].
P363 - Wash contaminated clothing before reuse
P304 + P340 - IF INHALED: Remove victim to fresh air and keep at rest in a position comfortable for breathing
P310 - Immediately call a POISON CENTER or doctor/physician
P305 + P351 + P338 - IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing
P391 - Collect spillage

Storage
P405 - Store locked up

Disposal
P501 - Dispose of contents/container in accordance with local/regional/national/international regulations

Contains

Substances	**CAS Number**
Tributyl tetradecyl phosphonium chloride	81741-28-8

Other hazards which do not result in classification
None known

For the full text of the H-phrases mentioned in this Section, see Section 16

3. Composition/information on Ingredients

Substances	CAS Number	PERCENT (w/w)	GHS Classification - Australia
Tributyl tetradecyl phosphonium chloride	81741-28-8	5 - 10%	Acute Tox. 4 (H302) Acute Tox. 2 (H330) Skin Corr. 1B (H314) Eye Corr. 1 (H318) Aquatic Acute 1 (H400) Aquatic Chronic 1 (H410)

4. First aid measures

Description of necessary first aid measures

Inhalation If inhaled, move victim to fresh air and seek medical attention.

Eyes Immediately flush eyes with large amounts of water for at least 30 minutes. Seek prompt medical attention.

Skin In case of contact, immediately flush skin with plenty of soap and water for at least 30 minutes and remove contaminated clothing, shoes and leather goods immediately. Get medical attention immediately.

Ingestion Do NOT induce vomiting. Give nothing by mouth. Obtain immediate medical attention.

Symptoms caused by exposure

Causes severe eye irritation which may damage tissue. Causes severe skin irritation with tissue destruction.

Medical Attention and Special Treatment

Notes to Physician Treat symptomatically

5. Fire Fighting Measures

Suitable extinguishing equipment

Suitable Extinguishing Media

Water fog, carbon dioxide, foam, dry chemical.

Extinguishing media which must not be used for safety reasons

None known.

Specific hazards arising from the chemical

Special exposure hazards in a fire

Decomposition in fire may produce harmful gases. Do not allow runoff to enter waterways. Use water spray to cool fire exposed surfaces.

Special protective equipment and precautions for fire fighters

Special protective equipment for firefighters

Full protective clothing and approved self-contained breathing apparatus required for fire fighting personnel.

6. Accidental release measures

6.1. Personal precautions, protective equipment and emergency procedures

Use appropriate protective equipment.

6.2. Environmental precautions

Prevent from entering sewers, waterways, or low areas.

6.3. Methods and material for containment and cleaning up

Isolate spill and stop leak where safe. Contain spill with sand or other inert materials. Scoop up and remove.

7. Handling and storage

7.1. Precautions for safe handling

Handling Precautions

Avoid contact with eyes, skin, or clothing. Wash hands after use. Launder contaminated clothing before reuse. Do NOT consume food, drink, or tobacco in contaminated areas.

Hygiene Measures

Handle in accordance with good industrial hygiene and safety practice.

7.2. Conditions for safe storage, including any incompatibilities

Storage Information

Store in a cool well ventilated area. Keep container closed when not in use. Store away from direct sunlight. Store in a dry location. Store in a manner to prevent commingling with incompatible materials. Store away from alkalis. Store away from reducing agents. Store locked up.

Other Guidelines

No information available

8. Exposure Controls/Personal Protection

Control parameters - exposure standards, biological monitoring

Exposure Limits

Substances	CAS Number	Australia NOHSC	ACGIH TLV-TWA
Tributyl tetradecyl phosphonium chloride	81741-28-8	Not applicable	Not applicable

Appropriate engineering controls

Engineering Controls Use in a well ventilated area. Local exhaust ventilation should be used in areas without good cross ventilation.

Personal protective equipment (PPE)

Personal Protective Equipment If engineering controls and work practices cannot prevent excessive exposures, the selection and proper use of personal protective equipment should be determined by an industrial hygienist or other qualified professional based on the specific application of this product.

Respiratory Protection If engineering controls and work practices cannot keep exposure below occupational exposure limits or if exposure is unknown, wear a NIOSH certified, European Standard EN 149, AS/NZS 1715:2009, or equivalent respirator when using this product. Selection of and instruction on using all personal protective equipment, including respirators, should be performed by an Industrial Hygienist or other qualified professional.
Dust/mist respirator. (N95, P2/P3)

Hand Protection Chemical-resistant protective gloves (EN 374) Suitable materials for longer, direct contact (recommended: protection index 6, corresponding to > 480 minutes permeation time as per EN 374): Neoprene gloves. (>= 0.75 mm thickness)
This information is based on literature references and on information provided by glove manufacturers, or is derived by analogy with similar substances. Please note that in practice the working life of chemical-resistant protective gloves may be considerably shorter than the permeation time determined in accordance with EN 374 as a result of the many influencing factors (e.g. temperature). If signs of wear and tear are noticed then the gloves should be replaced. Manufacturer's directions for use should be observed because of great diversity of types.

Skin Protection Wear impervious protective clothing, including boots, gloves, lab coat, apron, rain jacket, pants or coverall, as appropriate, to prevent skin contact.

Eye Protection Chemical goggles; also wear a face shield if splashing hazard exists.

Other Precautions Eyewash fountains and safety showers must be easily accessible.

Environmental Exposure Controls No information available

9. Physical and Chemical Properties

9.1. Information on basic physical and chemical properties

Physical State: Liquid
Color Clear colorless
Odor: Slight
Odor Threshold: No information available

Property Remarks/ - Method	Values
pH:	6-8
Freezing Point / Range	-8 - -10 °C
Melting Point / Range	No data available
Boiling Point / Range	100 °C / 212 °F
Flash Point	No data available
Evaporation rate	No data available
Vapor Pressure	No data available
Vapor Density	No data available
Specific Gravity	0.95 - 1.0
Water Solubility	Miscible with water
Solubility in other solvents	No data available
Partition coefficient: n-octanol/water	No data available
Autoignition Temperature	No data available
Decomposition Temperature	No data available
Viscosity	No data available
Explosive Properties	No information available
Oxidizing Properties	No information available

9.2. Other information

VOC Content (%) No data available

10. Stability and Reactivity

10.1. Reactivity

Not expected to be reactive.

10.2. Chemical stability

Stable

10.3. Possibility of hazardous reactions

Will Not Occur

10.4. Conditions to avoid

None anticipated

10.5. Incompatible materials

Reducing agents. Strong alkalis.

10.6. Hazardous decomposition products

Chlorine. Phosphorus acids. Carbon monoxide and carbon dioxide.

11. Toxicological Information

Information on routes of exposure

Principle Route of Exposure Eye or skin contact, inhalation.

Symptoms related to exposure

Most Important Symptoms/Effects

Causes severe eye irritation which may damage tissue. Causes severe skin irritation with tissue destruction.

Toxicology data for the components

Substances	CAS Number	LD50 Oral	LD50 Dermal	LC50 Inhalation
Tributyl tetradecyl phosphonium chloride	81741-28-8	= 611 mg/kg (rat)	No data of sufficient quality are available	> 0.908 mg/L (rat, 4hr, mist)

Immediate, delayed and chronic health effects from exposure

Inhalation May cause respiratory irritation.

Eye Contact Causes severe eye irritation which may damage tissue. May cause eye burns.

Skin Contact Causes severe skin irritation with tissue destruction.

Ingestion Irritation of the mouth, throat, and stomach. May cause abdominal pain, vomiting, nausea, and diarrhea.

Chronic Effects/Carcinogenicity No data available to indicate product or components present at greater than 0.1% are chronic health hazards.

Exposure Levels

No data available

Interactive effects

Lung disorders. Skin disorders.

Data limitations

No data available

Substances	CAS Number	Skin corrosion/irritation
Tributyl tetradecyl phosphonium chloride	81741-28-8	Causes burns (Rabbit)

Substances	CAS Number	Serious eye damage/irritation
Tributyl tetradecyl phosphonium chloride	81741-28-8	Causes severe eye irritation which may damage tissue. (Rabbit)

Substances	CAS Number	Skin Sensitization
Tributyl tetradecyl phosphonium chloride	81741-28-8	No information available

Substances	CAS Number	Respiratory Sensitization
Tributyl tetradecyl phosphonium chloride	81741-28-8	No information available

Substances	CAS Number	Mutagenic Effects
Tributyl tetradecyl phosphonium chloride	81741-28-8	No data of sufficient quality are available.

Substances	CAS Number	Carcinogenic Effects
Tributyl tetradecyl phosphonium chloride	81741-28-8	No information available

Substances	CAS Number	Reproductive toxicity
Tributyl tetradecyl phosphonium chloride	81741-28-8	No information available

Substances	CAS Number	STOT - single exposure
Tributyl tetradecyl phosphonium chloride	81741-28-8	No information available

Substances	CAS Number	STOT - repeated exposure
Tributyl tetradecyl phosphonium chloride	81741-28-8	No data of sufficient quality are available.

Substances	CAS Number	Aspiration hazard
Tributyl tetradecyl phosphonium chloride	81741-28-8	No information available

12. Ecological Information

Ecotoxicity

Substance Ecotoxicity Data

Substances	CAS Number	Toxicity to Algae	Toxicity to Fish	Toxicity to Microorganisms	Toxicity to Invertebrates
Tributyl tetradecyl phosphonium chloride	81741-28-8	No information available	LC50 (96 h) 0.46 mg/L (Oncorhynchus mykiss) LC50 (96 h) 0.06 mg/L (Lepomis macrochirus)	No information available	EC50 (48 h) 0.025 mg/L (Daphnia sp.)

12.2. Persistence and degradability

Substances	CAS Number	Persistence and Degradability
Tributyl tetradecyl phosphonium chloride	81741-28-8	(0% @ 28d)

12.3. Bioaccumulative potential

Substances	CAS Number	Log Pow
Tributyl tetradecyl phosphonium chloride	81741-28-8	< 3

12.4. Mobility in soil

Substances	CAS Number	Mobility
Tributyl tetradecyl phosphonium chloride	81741-28-8	No information available

12.6. Other adverse effects

Endocrine Disruptor Information

This product does not contain any known or suspected endocrine disruptors

13. Disposal Considerations

Safe handling and disposal methods
Disposal should be made in accordance with federal, state, and local regulations. Incineration recommended in approved incinerator according to federal, state, and local regulations. Substance should NOT be deposited into a sewage facility.

Disposal of any contaminated packaging
Follow all applicable national or local regulations.

Environmental regulations
Not applicable

14. Transport Information

Transportation Information

Australia ADG

UN Number	UN2922
UN proper shipping name:	Corrosive Liquid, Toxic, N.O.S. (contains Tributyl Tetradecyl Phosphonium Chloride)
Transport Hazard Class(es):	8, (6.1)
Packing Group:	II
Environmental Hazards:	Marine Pollutant

IMDG/IMO

UN Number	UN2922
UN proper shipping name:	Corrosive Liquid, Toxic, N.O.S. (contains Tributyl Tetradecyl Phosphonium Chloride)
Transport Hazard Class(es):	8, (6.1)
Packing Group:	II
Environmental Hazards:	Marine Pollutant
EMS:	EmS F-A, S-B

IATA/ICAO

UN Number	UN2922
UN proper shipping name:	Corrosive Liquid, Toxic, N.O.S. (contains Tributyl Tetradecyl Phosphonium Chloride)
Transport Hazard Class(es):	8, (6.1)
Packing Group:	II
Environmental Hazards:	Marine Pollutant

Special precautions during transport
None

HazChem Code
2X

15. Regulatory Information

Safety, health and environmental regulations specific for the product

International Inventories

Australian AICS Inventory	All components are listed on the AICS or are subject to a relevant exemption, permit, or assessment certificate.
New Zealand Inventory of Chemicals	All components are listed on the NZIoC or are subject to a relevant exemption, permit, or assessment certificate.
EINECS (European Inventory of Existing Chemical Substances)	This product, and all its components, complies with EINECS
US TSCA Inventory	All components listed on inventory or are exempt.
Canadian Domestic Substances List (DSL)	All components listed on inventory or are exempt.

Poisons Schedule number

None Allocated

International Agreements

Montreal Protocol - Ozone Depleting Substances:	Does not apply
Stockholm Convention - Persistent Organic Pollutants:	Does not apply
Rotterdam Convention - Prior Informed Consent:	Does not apply
Basel Convention - Hazardous Waste:	Does not apply

16. Other information

Date of preparation or review

Revision Date: 13-Oct-2017

Revision Note
SDS sections updated:
2

Full text of H-Statements referred to under sections 2 and 3
H302 - Harmful if swallowed
H314 - Causes severe skin burns and eye damage
H318 - Causes serious eye damage
H330 - Fatal if inhaled
H400 - Very toxic to aquatic life
H401 - Toxic to aquatic life
H410 - Very toxic to aquatic life with long lasting effects
H411 - Toxic to aquatic life with long lasting effects

Additional information

For additional information on the use of this product, contact your local Halliburton representative.

For questions about the Safety Data Sheet for this or other Halliburton products, contact Chemical Stewardship at 1-580-251-4335.

Key abreviations or acronyms used
bw – body weight
CAS – Chemical Abstracts Service
EC50 – Effective Concentration 50%
LC50 – Lethal Concentration 50%
LD50 – Lethal Dose 50%
LL50 – Lethal Loading 50%
mg/kg – milligram/kilogram
mg/L – milligram/liter
NOEC – No Observed Effect Concentration
OEL – Occupational Exposure Limit
PBT – Persistent Bioaccumulative and Toxic
ppm – parts per million
STEL – Short Term Exposure Limit
TWA – Time-Weighted Average
vPvB – very Persistent and very Bioaccumulative
h - hour
mg/m^3 - milligram/cubic meter
mm - millimeter
mmHg - millimeter mercury
w/w - weight/weight
d - day

Key literature references and sources for data
www.ChemADVISOR.com/
NZ CCID

Disclaimer Statement

This information is furnished without warranty, expressed or implied, as to accuracy or completeness. The information is obtained from various sources including the manufacturer and other third party sources. The information may not be valid under all conditions nor if this material is used in combination with other materials or in any process. Final determination of suitability of any material is the sole responsibility of the user.

End of Safety Data Sheet

HALLIBURTON

SAFETY DATA SHEET

CAUSTIC SODA LIQUID

Revision Date: 16-Apr-2015 **Revision Number:** 8

1. Product Identifier & Identity for the Chemical

Statement of Hazardous Nature Hazardous according to the criteria of the 3rd Revised Edition of the Globally Harmonised System of Classification and Labelling of Chemicals (GHS), Dangerous Goods according to the criteria of ADG.

1.1. Product Identifier

Product Name CAUSTIC SODA LIQUID

Other means of Identification

Synonyms None

Hazardous Material Number: HM005652

Recommended use of the chemical and restrictions on use

Recommended Use pH Control

Uses advised against No information available

Supplier's name, address and phone number

Manufacturer/Supplier Halliburton Australia Pty. Ltd.
15 Marriott Road, Jandakot, WA 6164
Australia
ACN Number: 009 000 775
Telephone Number: + 61 1 800 686 951
Fax Number: 61 (08) 9455 5300

E-mail Address fdunexchem@halliburton.com

Emergency phone number

+ 61 1 800 686 951
Global Incident Response Access Code: 334305
Contract Number: 14012

Australian Poisons Information Centre
24 Hour Service: - 13 11 26
Police or Fire Brigade: - 000 (exchange): - 1100

2. Hazard Identification

Statement of Hazardous Nature Hazardous according to the criteria of the 3rd Revised Edition of the Globally Harmonised System of Classification and Labelling of Chemicals (GHS), Dangerous Goods according to the criteria of ADG.

Classification of the hazardous chemical

Skin Corrosion/Irritation	Category 1 - H314
Serious Eye Damage/Irritation	Category 1 - H318
Specific Target Organ Toxicity - (Single Exposure)	Category 3 - H335
Substances/mixtures corrosive to metal.	Category 1 - H290

Label elements, including precautionary statements

Hazard Pictograms

Signal Word DANGER

Hazard Statements:
H290 - May be corrosive to metals
H314 - Causes severe skin burns and eye damage
H318 - Causes serious eye damage
H335 - May cause respiratory irritation

Precautionary Statements

Prevention
P234 - Keep only in original packaging.
P260 - Do not breathe dust/fume/gas/mist/vapors/spray
P261 - Avoid breathing dust/fume/gas/mist/vapors/spray
P264 - Wash face, hands and any exposed skin thoroughly after handling
P271 - Use only outdoors or in a well-ventilated area
P280 - Wear protective gloves/eye protection/face protection

Response
P301 + P330 + P331 - IF SWALLOWED: rinse mouth. Do NOT induce vomiting
P303 + P361 + P353 - IF ON SKIN (or hair): Take off immediately all contaminated clothing. Rinse skin with water [or shower].
P363 - Wash contaminated clothing before reuse
P310 - Immediately call a POISON CENTER or doctor/physician
P305 + P351 + P338 - IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing
P390 - Absorb spillage to prevent material damage
P304 + P340 - IF INHALED: Remove victim to fresh air and keep at rest in a position comfortable for breathing

Storage
P403 + P233 - Store in a well-ventilated place. Keep container tightly closed
P405 - Store locked up

Disposal
P501 - Dispose of contents/container in accordance with local/regional/national/international regulations

Contains Substances	**CAS Number**
Sodium hydroxide	1310-73-2

Other hazards which do not result in classification
None known

For the full text of the H-phrases mentioned in this Section, see Section 16

3. Composition/information on Ingredients

Substances	CAS Number	PERCENT (w/w)	GHS Classification - Australia
Sodium hydroxide	1310-73-2	30 - 60%	Skin Corr. 1A (H314) Eye Corr. 1 (H318) STOT SE 3 (H335) Met. Corr. 1 (H290)

4. First aid measures

Description of necessary first aid measures

Inhalation If inhaled, move victim to fresh air and seek medical attention.

Eyes	Immediately flush eyes with large amounts of water for at least 30 minutes. Seek prompt medical attention.
Skin	Remove contaminated clothing and launder before reuse. Destroy or properly dispose of contaminated shoes. In case of contact, immediately flush skin with plenty of soap and water for at least 30 minutes and remove contaminated clothing, shoes and leather goods immediately. Get medical attention immediately.
Ingestion	Do NOT induce vomiting. Give nothing by mouth. Obtain immediate medical attention.

Symptoms caused by exposure

May cause eye and skin burns. May cause respiratory irritation. Causes severe skin irritation with tissue destruction. Causes severe eye irritation which may damage tissue.

Medical Attention and Special Treatment

Notes to Physician Treat symptomatically

5. Fire Fighting Measures

Suitable extinguishing equipment

Suitable Extinguishing Media

All standard fire fighting media

Extinguishing media which must not be used for safety reasons

None known.

Specific hazards arising from the chemical

Special exposure hazards in a fire

May form explosive mixtures with strong acids. Reaction with steel and certain other metals generates flammable hydrogen gas.

Special protective equipment and precautions for fire fighters

Special protective equipment for firefighters

Full protective clothing and approved self-contained breathing apparatus required for fire fighting personnel.

6. Accidental release measures

6.1. Personal precautions, protective equipment and emergency procedures

Use appropriate protective equipment.

6.2. Environmental precautions

Prevent from entering sewers, waterways, or low areas.

6.3. Methods and material for containment and cleaning up

Contain spill with sand or other inert materials. Neutralize to pH of 6-8. Scoop up and remove. Isolate spill and stop leak where safe.

7. Handling and storage

7.1. Precautions for safe handling

Handling Precautions

Avoid contact with eyes, skin, or clothing. Avoid breathing vapors. Wash hands after use. Launder contaminated clothing before reuse.

Hygiene Measures

Handle in accordance with good industrial hygiene and safety practice.

7.2. Conditions for safe storage, including any incompatibilities

Storage Information

Store away from acids. Store in a cool well ventilated area. Keep container closed when not in use. Product has a shelf life of 12 months.

Other Guidelines

No information available

8. Exposure Controls/Personal Protection

Control parameters - exposure standards, biological monitoring

Exposure Limits

Substances	CAS Number	Australia NOHSC	ACGIH TLV-TWA
Sodium hydroxide	1310-73-2	2 mg/m³	Not applicable

Appropriate engineering controls

Engineering Controls Use in a well ventilated area. Local exhaust ventilation should be used in areas without good cross ventilation.

Personal protective equipment (PPE)

Personal Protective Equipment If engineering controls and work practices cannot prevent excessive exposures, the selection and proper use of personal protective equipment should be determined by an industrial hygienist or other qualified professional based on the specific application of this product.

Respiratory Protection If engineering controls and work practices cannot keep exposure below occupational exposure limits or if exposure is unknown, wear a NIOSH certified, European Standard EN 149, AS/NZS 1715:2009, or equivalent respirator when using this product. Selection of and instruction on using all personal protective equipment, including respirators, should be performed by an Industrial Hygienist or other qualified professional.
Dust/mist respirator. (N95, P2/P3)

Hand Protection Chemical-resistant protective gloves (EN 374) Suitable materials for longer, direct contact (recommended: protection index 6, corresponding to > 480 minutes permeation time as per EN 374): Butyl rubber gloves. (>= 0.7 mm thickness)
This information is based on literature references and on information provided by glove manufacturers, or is derived by analogy with similar substances. Please note that in practice the working life of chemical-resistant protective gloves may be considerably shorter than the permeation time determined in accordance with EN 374 as a result of the many influencing factors (e.g. temperature). If signs of wear and tear are noticed then the gloves should be replaced. Manufacturer's directions for use should be observed because of great diversity of types.

Skin Protection Full protective chemical resistant clothing.

Eye Protection Chemical goggles; also wear a face shield if splashing hazard exists.

Other Precautions Eyewash fountains and safety showers must be easily accessible.

Environmental Exposure Controls No information available

9. Physical and Chemical Properties

9.1. Information on basic physical and chemical properties

Physical State: Liquid
Color Clear colorless
Odor: Odorless
Odor Threshold: No information available

Property Remarks/ - Method	Values
pH:	14
Freezing Point / Range	12 °C
Melting Point / Range	No data available
Boiling Point / Range	144 °C / 291 °F
Flash Point	No data available
Evaporation rate	No data available
Vapor Pressure	13 mmHg
Vapor Density	No data available
Specific Gravity	1.52
Water Solubility	Miscible with water
Solubility in other solvents	No data available
Partition coefficient: n-octanol/water	No data available
Autoignition Temperature	No data available
Decomposition Temperature	No data available
Viscosity	No data available

Explosive Properties	No information available
Oxidizing Properties	No information available

9.2. Other information

Molecular Weight	40
VOC Content (%)	No data available

10. Stability and Reactivity

10.1. Reactivity
Not expected to be reactive.
10.2. Chemical stability
Stable
10.3. Possibility of hazardous reactions
Will Not Occur
10.4. Conditions to avoid
None anticipated
10.5. Incompatible materials
Strong acids. Peroxides. Halogenated compounds. Amphoteric metals such as aluminum, magnesium, lead, tin, or zinc.
10.6. Hazardous decomposition products
None known.

11. Toxicological Information

Information on routes of exposure
Principle Route of Exposure Eye or skin contact, inhalation.

Symptoms related to exposure
Most Important Symptoms/Effects
May cause eye and skin burns. May cause respiratory irritation. Causes severe skin irritation with tissue destruction. Causes severe eye irritation which may damage tissue.

Toxicology data for the components

Substances	CAS Number	LD50 Oral	LD50 Dermal	LC50 Inhalation
Sodium hydroxide	1310-73-2	Not applicable due to corrosivity of the substance.	Not applicable due to corrosivity of the substance.	Not applicable due to corrosivity of the substance.

Immediate, delayed and chronic health effects from exposure

Inhalation	Causes severe respiratory burns.
Eye Contact	Causes severe eye burns.
Skin Contact	Causes severe burns.
Ingestion	Causes burns of the mouth, throat and stomach.

Chronic Effects/Carcinogenicity Prolonged, excessive exposure may cause erosion of the teeth.

Exposure Levels
No data available

Interactive effects
Skin disorders.

Data limitations
No data available

Substances	CAS Number	Skin corrosion/irritation
Sodium hydroxide	1310-73-2	Causes severe burns

Substances	CAS Number	Serious eye damage/irritation
Sodium hydroxide	1310-73-2	Causes severe eye burns (Rabbit)

Substances	CAS Number	Skin Sensitization
Sodium hydroxide	1310-73-2	Did not cause sensitization on laboratory animals (guinea pig)

Substances	CAS Number	Respiratory Sensitization
Sodium hydroxide	1310-73-2	No information available

Substances	CAS Number	Mutagenic Effects
Sodium hydroxide	1310-73-2	Did not show mutagenic effects in animal experiments In vitro tests did not show mutagenic effects.

Substances	CAS Number	Carcinogenic Effects
Sodium hydroxide	1310-73-2	No data of sufficient quality are available.

Substances	CAS Number	Reproductive toxicity
Sodium hydroxide	1310-73-2	No information available

Substances	CAS Number	STOT - single exposure
Sodium hydroxide	1310-73-2	May cause respiratory irritation.

Substances	CAS Number	STOT - repeated exposure
Sodium hydroxide	1310-73-2	No significant toxicity observed in animal studies at concentration requiring classification. Not applicable due to corrosivity of the substance.

Substances	CAS Number	Aspiration hazard
Sodium hydroxide	1310-73-2	Not applicable

12. Ecological Information

Ecotoxicity

Substance Ecotoxicity Data

Substances	CAS Number	Toxicity to Algae	Toxicity to Fish	Toxicity to Microorganisms	Toxicity to Invertebrates
Sodium hydroxide	1310-73-2	No information available	LC50(48h) 189 mg/L (Leuciscus idus melanotus) LLC50(48h) 189 mg/L (Leuciscus melanotus) LC50(24h) 145 mg/L (Poecilia reticulate) LC50(96h) 125 mg/L (Gambusia affinis) LOEL(150 d) = 25 mg/L (Lebistes reticulatus)	No information available	EC50 (48h) 40.4 mg/L (Ceriodaphnia sp.)

12.2. Persistence and degradability

Substances	CAS Number	Persistence and Degradability
Sodium hydroxide	1310-73-2	The methods for determining biodegradability are not applicable to inorganic substances.

12.3. Bioaccumulative potential

Substances	CAS Number	Log Pow
Sodium hydroxide	1310-73-2	No information available

12.4. Mobility in soil

Substances	CAS Number	Mobility
Sodium hydroxide	1310-73-2	No information available

12.6. Other adverse effects

Endocrine Disruptor Information

This product does not contain any known or suspected endocrine disruptors

13. Disposal Considerations

Safe handling and disposal methods
Disposal should be made in accordance with federal, state, and local regulations.

Disposal of any contaminated packaging
Follow all applicable national or local regulations.

Environmental regulations
Not applicable

14. Transport Information

Transportation Information
Australia ADG

UN Number	UN1824
UN proper shipping name:	Sodium Hydroxide Solution
Transport Hazard Class(es):	8
Packing Group:	II
Environmental Hazards:	Not applicable

IMDG/IMO

UN Number	UN1824
UN proper shipping name:	Sodium Hydroxide Solution
Transport Hazard Class(es):	8
Packing Group:	II
Environmental Hazards:	Not applicable
EMS:	EmS F-A, S-B

IATA/ICAO

UN Number	UN1824
UN proper shipping name:	Sodium Hydroxide Solution
Transport Hazard Class(es):	8
Packing Group:	II
Environmental Hazards:	Not applicable

Special precautions during transport
None

HazChem Code
2R

15. Regulatory Information

Safety, health and environmental regulations specific for the product

International Inventories

Australian AICS Inventory	All components are listed on the AICS or are subject to a relevant exemption, permit, or assessment certificate.
New Zealand Inventory of Chemicals	All components are listed on the NZIoC or are subject to a relevant exemption, permit, or assessment certificate.
EINECS (European Inventory of Existing Chemical Substances)	This product, and all its components, complies with EINECS
US TSCA Inventory	All components listed on inventory or are exempt.
Canadian Domestic Substances List (DSL)	All components listed on inventory or are exempt.

Poisons Schedule number

None Allocated

International Agreements

Montreal Protocol - Ozone Depleting Substances:	Does not apply
Stockholm Convention - Persistent Organic Pollutants:	Does not apply
Rotterdam Convention - Prior Informed Consent:	Does not apply
Basel Convention - Hazardous Waste:	Does not apply

16. Other information

Date of preparation or review

Revision Date: 16-Apr-2015

Revision Note

Full text of H-Statements referred to under sections 2 and 3
H290 - May be corrosive to metals
H314 - Causes severe skin burns and eye damage
H318 - Causes serious eye damage
H335 - May cause respiratory irritation

Additional information For additional information on the use of this product, contact your local Halliburton representative.

For questions about the Safety Data Sheet for this or other Halliburton products, contact Chemical Stewardship at 1-580-251-4335.

Key abreviations or acronyms used
bw – body weight
CAS – Chemical Abstracts Service
EC50 – Effective Concentration 50%
LC50 – Lethal Concentration 50%
LD50 – Lethal Dose 50%
LL50 – Lethal Loading 50%
mg/kg – milligram/kilogram
mg/L – milligram/liter
NOEC – No Observed Effect Concentration
OEL – Occupational Exposure Limit
PBT – Persistent Bioaccumulative and Toxic
ppm – parts per million
STEL – Short Term Exposure Limit
TWA – Time-Weighted Average
vPvB – very Persistent and very Bioaccumulative
h - hour
mg/m^3 - milligram/cubic meter
mm - millimeter
mmHg - millimeter mercury
w/w - weight/weight
d - day

Key literature references and sources for data
www.ChemADVISOR.com/

Disclaimer Statement
This information is furnished without warranty, expressed or implied, as to accuracy or completeness. The information is obtained from various sources including the manufacturer and other third party sources. The information may not be valid under all conditions nor if this material is used in combination with other materials or in any process. Final determination of suitability of any material is the sole responsibility of the user.

End of Safety Data Sheet

HALLIBURTON

SAFETY DATA SHEET

CERAMIC PROP PLUS

Revision Date: 28-Sep-2018 **Revision Number:** 18

1. Product Identifier & Identity for the Chemical

Statement of Hazardous Nature Hazardous according to the criteria of the 3rd Revised Edition of the Globally Harmonised System of Classification and Labelling of Chemicals (GHS), Non-Dangerous Goods according to the criteria of ADG.

1.1. Product Identifier

Product Name CERAMIC PROP PLUS

Other means of Identification

Synonyms None

Hazardous Material Number: HM004807

Recommended use of the chemical and restrictions on use

Recommended Use Proppant

Uses advised against No information available

Supplier's name, address and phone number

Manufacturer/Supplier Halliburton Australia Pty. Ltd.
15 Marriott Road, Jandakot, WA 6164
Australia
ACN Number: 009 000 775
Telephone Number: + 61 1 800 686 951
Fax Number: 61 (08) 9455 5300

E-mail Address fdunexchem@halliburton.com

Emergency phone number

+ 61 1 800 686 951
Global Incident Response Access Code: 334305
Contract Number: 14012

Australian Poisons Information Centre
24 Hour Service: - 13 11 26
Police or Fire Brigade: - 000 (exchange): - 1100

2. Hazard Identification

Statement of Hazardous Nature Hazardous according to the criteria of the 3rd Revised Edition of the Globally Harmonised System of Classification and Labelling of Chemicals (GHS), Non-Dangerous Goods according to the criteria of ADG.

Classification of the hazardous chemical

Carcinogenicity	Category 1A - H350
Specific Target Organ Toxicity - (Repeated Exposure)	Category 1 - H372

Label elements, including precautionary statements

Hazard Pictograms

Signal Word DANGER

Hazard Statements:
H350 - May cause cancer by inhalation
H372 - Causes damage to organs through prolonged or repeated exposure if inhaled

Precautionary Statements

Prevention
P201 - Obtain special instructions before use
P202 - Do not handle until all safety precautions have been read and understood
P260 - Do not breathe dust/fume/gas/mist/vapors/spray
P264 - Wash face, hands and any exposed skin thoroughly after handling
P270 - Do not eat, drink or smoke when using this product
P281 - Use personal protective equipment as required

Response
P308 + P313 - IF exposed or concerned: Get medical advice/attention
P314 - Get medical attention/advice if you feel unwell

Storage
P405 - Store locked up

Disposal
P501 - Dispose of contents/container in accordance with local/regional/national/international regulations

Contains Substances	**CAS Number**
Crystalline silica, cristobalite	14464-46-1

Other hazards which do not result in classification
This substance is not considered to be persistent, bioaccumulating nor toxic (PBT).
This substance is not considered to be very persistent nor very bioaccumulating (vPvB).

For the full text of the H-phrases mentioned in this Section, see Section 16

3. Composition/information on Ingredients

Substances	CAS Number	PERCENT (w/w)	GHS Classification - Australia
Crystalline silica, cristobalite	14464-46-1	10 - 30%	Carc. 1A (H350) STOT RE 1 (H372)

4. First aid measures

Description of necessary first aid measures

Inhalation If inhaled, remove from area to fresh air. Get medical attention if respiratory irritation develops or if breathing becomes difficult.

Eyes In case of contact, immediately flush eyes with plenty of water for at least 15 minutes and get medical attention if irritation persists.

Skin Remove contaminated clothing. wash skin with water, using soap if available. Get medical attention if irritation persists.

Ingestion Rinse mouth with water many times.

Symptoms caused by exposure
Breathing crystalline silica can cause lung disease, including silicosis and lung cancer. Crystalline silica has also been associated with scleroderma and kidney disease.

Medical Attention and Special Treatment
Notes to Physician Treat symptomatically

5. Fire Fighting Measures

Suitable extinguishing equipment
Suitable Extinguishing Media
All standard fire fighting media
Extinguishing media which must not be used for safety reasons
None known.

Specific hazards arising from the chemical
Special exposure hazards in a fire
Not applicable

Special protective equipment and precautions for fire fighters
Special protective equipment for firefighters
Full protective clothing and approved self-contained breathing apparatus required for fire fighting personnel.

6. Accidental release measures

6.1. Personal precautions, protective equipment and emergency procedures
Use appropriate protective equipment. Avoid creating and breathing dust. Ensure adequate ventilation. Avoid contact with skin, eyes and clothing.

6.2. Environmental precautions
None known.

6.3. Methods and material for containment and cleaning up
Collect using dustless method and hold for appropriate disposal. Consider possible toxic or fire hazards associated with contaminating substances and use appropriate methods for collection, storage and disposal.

7. Handling and storage

7.1. Precautions for safe handling
Handling Precautions
This product contains quartz, cristobalite, and/or tridymite which may become airborne without a visible cloud. Avoid breathing dust. Avoid creating dusty conditions. Use only with adequate ventilation to keep exposure below recommended exposure limits. Wear a NIOSH certified, European Standard En 149, or equivalent respirator when using this product. Material is slippery when wet.
Hygiene Measures
Handle in accordance with good industrial hygiene and safety practice.

7.2. Conditions for safe storage, including any incompatibilities
Storage Information
Store in a cool well ventilated area. Use good housekeeping in storage and work areas to prevent accumulation of dust. Close container when not in use.
Other Guidelines
No information available

8. Exposure Controls/Personal Protection

Control parameters - exposure standards, biological monitoring
Exposure Limits

Substances	CAS Number	Australia NOHSC	ACGIH TLV-TWA
Crystalline silica, cristobalite	14464-46-1	TWA: 0.1 mg/m^3	TWA: 0.025 mg/m^3

Appropriate engineering controls

Engineering Controls	Use approved industrial ventilation and local exhaust as required to maintain exposures below applicable exposure limits.

Personal protective equipment (PPE)

Personal Protective Equipment	If engineering controls and work practices cannot prevent excessive exposures, the selection and proper use of personal protective equipment should be determined by an industrial hygienist or other qualified professional based on the specific application of this product.
Respiratory Protection	Wear a NIOSH certified, European Standard EN 149 (FFP2/FFP3), AS/NZS 1715, or equivalent respirator when using this product.
Hand Protection	Normal work gloves.
Skin Protection	Wear clothing appropriate for the work environment. Dusty clothing should be laundered before reuse. Use precautionary measures to avoid creating dust when removing or laundering clothing.
Eye Protection	Wear safety glasses or goggles to protect against exposure.
Other Precautions	None known.
Environmental Exposure Controls	No information available

9. Physical and Chemical Properties

9.1. Information on basic physical and chemical properties

Physical State:	Granules	**Color**	Gray to tan
Odor:	Odorless	**Odor Threshold:**	No information available

Property Remarks/ - Method	Values
pH:	No data available
Freezing Point / Range	No data available
Melting Point / Range	No data available
Pour Point / Range	No data available
Boiling Point / Range	No data available
Flash Point	No data available
Evaporation rate	No data available
Vapor Pressure	No data available
Vapor Density	No data available
Specific Gravity	2.7
Water Solubility	Insoluble in water
Solubility in other solvents	No data available
Partition coefficient: n-octanol/water	No data available
Autoignition Temperature	No data available
Decomposition Temperature	No data available
Viscosity	No data available
Explosive Properties	No information available
Oxidizing Properties	No information available

9.2. Other information

VOC Content (%)	No data available

10. Stability and Reactivity

10.1. Reactivity
Not expected to be reactive.
10.2. Chemical stability
Stable
10.3. Possibility of hazardous reactions
Will Not Occur
10.4. Conditions to avoid
None anticipated
10.5. Incompatible materials
Hydrofluoric acid.

10.6. Hazardous decomposition products
Amorphous silica may transform at elevated temperatures to tridymite (870 C) or cristobalite (1470 C).

11. Toxicological Information

Information on routes of exposure
Principle Route of Exposure Eye or skin contact, inhalation.

Symptoms related to exposure
Most Important Symptoms/Effects
Breathing crystalline silica can cause lung disease, including silicosis and lung cancer. Crystalline silica has also been associated with scleroderma and kidney disease.

Toxicology data for the components

Substances	CAS Number	LD50 Oral	LD50 Dermal	LC50 Inhalation
Crystalline silica, cristobalite	14464-46-1	> 15000 mg/kg (human) (similar substance)	No information available	No data available

Immediate, delayed and chronic health effects from exposure

Inhalation Inhaled crystalline silica in the form of quartz or cristobalite from occupational sources is carcinogenic to humans (IARC, Group 1). There is sufficient evidence in experimental animals for the carcinogenicity of tridymite (IARC, Group 2A).

Breathing silica dust may cause irritation of the nose, throat, and respiratory passages. Breathing silica dust may not cause noticeable injury or illness even though permanent lung damage may be occurring. Inhalation of dust may also have serious chronic health effects (See "Chronic Effects/Carcinogenicity" subsection below).

Eye Contact May cause mechanical irritation to eye.
Skin Contact None known.
Ingestion None known.

Chronic Effects/Carcinogenicity Silicosis: Excessive inhalation of respirable crystalline silica dust may cause a progressive, disabling, and sometimes-fatal lung disease called silicosis. Symptoms include cough, shortness of breath, wheezing, non-specific chest illness, and reduced pulmonary function. This disease is exacerbated by smoking. Individuals with silicosis are predisposed to develop tuberculosis.

Cancer Status: The International Agency for Research on Cancer (IARC) has determined that crystalline silica inhaled in the form of quartz or cristobalite from occupational sources can cause lung cancer in humans (Group 1 - carcinogenic to humans) and has determined that there is sufficient evidence in experimental animals for the carcinogenicity of tridymite (Group 2A - possible carcinogen to humans). Refer to IARC Monograph 68, Silica, Some Silicates and Organic Fibres (June 1997) in conjunction with the use of these minerals. The National Toxicology Program classifies respirable crystalline silica as "Known to be a human carcinogen". Refer to the 9th Report on Carcinogens (2000). The American Conference of Governmental Industrial Hygienists (ACGIH) classifies crystalline silica, quartz, as a suspected human carcinogen (A2). There is some evidence that breathing respirable crystalline silica or the disease silicosis is associated with an increased incidence of significant disease endpoints such as scleroderma (an immune system disorder manifested by scarring of the lungs, skin, and other internal organs) and kidney disease.

Exposure Levels
No data available

Interactive effects
Individuals with respiratory disease, including but not limited to asthma and bronchitis, or subject to eye irritation, should not be exposed to quartz dust.

Data limitations
No data available

Substances	CAS Number	Skin corrosion/irritation
Crystalline silica, cristobalite	14464-46-1	Non-irritating to the skin

Substances	CAS Number	Serious eye damage/irritation
Crystalline silica, cristobalite	14464-46-1	Mechanical irritation of the eyes is possible.

Substances	CAS Number	Skin Sensitization
Crystalline silica, cristobalite	14464-46-1	No information available

Substances	CAS Number	Respiratory Sensitization
Crystalline silica, cristobalite	14464-46-1	No information available

Substances	CAS Number	Mutagenic Effects
Crystalline silica, cristobalite	14464-46-1	Not regarded as mutagenic.

Substances	CAS Number	Carcinogenic Effects
Crystalline silica, cristobalite	14464-46-1	Contains crystalline silica which may cause silicosis, a delayed and progressive lung disease. The IARC and NTP have determined there is sufficient evidence in humans of the carcinogenicity of crystalline silica with repeated respiratory exposure. Based on available scientific evidence, this substance is a threshold carcinogen with a mode of action involving indirect genotoxicity secondary to lung injury.

Substances	CAS Number	Reproductive toxicity
Crystalline silica, cristobalite	14464-46-1	No information available

Substances	CAS Number	STOT - single exposure
Crystalline silica, cristobalite	14464-46-1	No significant toxicity observed in animal studies at concentration requiring classification.

Substances	CAS Number	STOT - repeated exposure
Crystalline silica, cristobalite	14464-46-1	Causes damage to organs through prolonged or repeated exposure if inhaled: (Lungs)

Substances	CAS Number	Aspiration hazard
Crystalline silica, cristobalite	14464-46-1	Not applicable

12. Ecological Information

Ecotoxicity

Substance Ecotoxicity Data

Substances	CAS Number	Toxicity to Algae	Toxicity to Fish	Toxicity to Microorganisms	Toxicity to Invertebrates
Crystalline silica, cristobalite	14464-46-1	No information available	LL0(96 h)=10000 mg/L (Danio rerio)	No information available	LL50(24 h)>10000 mg/L (Daphnia magna)

12.2. Persistence and degradability

Substances	CAS Number	Persistence and Degradability
Crystalline silica, cristobalite	14464-46-1	The methods for determining biodegradability are not applicable to inorganic substances.

12.3. Bioaccumulative potential

Substances	CAS Number	Bioaccumulation

Crystalline silica, cristobalite	14464-46-1	Not bioaccumulative

12.4. Mobility in soil

Substances	CAS Number	Mobility
Crystalline silica, cristobalite	14464-46-1	No information available

12.6. Other adverse effects

Endocrine Disruptor Information

This product does not contain any known or suspected endocrine disruptors

13. Disposal Considerations

Safe handling and disposal methods

Bury in a licensed landfill according to federal, state, and local regulations.

Disposal of any contaminated packaging

Follow all applicable national or local regulations.

Environmental regulations

Not applicable

14. Transport Information

Transportation Information

Australia ADG

UN Number	Not restricted
UN proper shipping name:	Not restricted
Transport Hazard Class(es):	Not applicable
Packing Group:	Not applicable
Environmental Hazards:	Not applicable

IMDG/IMO

UN Number	Not restricted
UN proper shipping name:	Not restricted
Transport Hazard Class(es):	Not applicable
Packing Group:	Not applicable
Environmental Hazards:	Not applicable

IATA/ICAO

UN Number	Not restricted
UN proper shipping name:	Not restricted
Transport Hazard Class(es):	Not applicable
Packing Group:	Not applicable
Environmental Hazards:	Not applicable

Special precautions during transport

None

HazChem Code

None Allocated

15. Regulatory Information

Safety, health and environmental regulations specific for the product

International Inventories

Australian AICS Inventory	All components are listed on the AICS or are subject to a relevant exemption, permit, or assessment certificate.
New Zealand Inventory of	All components are listed on the NZIoC or are subject to a relevant exemption, permit, or

Chemicals	assessment certificate.
US TSCA Inventory	All components listed on inventory or are exempt.
Canadian Domestic Substances List (DSL)	All components listed on inventory or are exempt.

Poisons Schedule number
None Allocated

International Agreements

Montreal Protocol - Ozone Depleting Substances:	Does not apply.
Stockholm Convention - Persistent Organic Pollutants:	Does not apply
Rotterdam Convention - Prior Informed Consent:	Does not apply.
Basel Convention - Hazardous Waste:	Does not apply.

16. Other information

Date of preparation or review

Revision Date: 28-Sep-2018

Revision Note
SDS sections updated:
2

Full text of H-Statements referred to under sections 2 and 3
H350 - May cause cancer by inhalation
H372 - Causes damage to organs through prolonged or repeated exposure if inhaled

Additional information

For additional information on the use of this product, contact your local Halliburton representative.

For questions about the Safety Data Sheet for this or other Halliburton products, contact Chemical Stewardship at 1-580-251-4335.

Key abreviations or acronyms used
bw – body weight
CAS – Chemical Abstracts Service
EC50 – Effective Concentration 50%
LC50 – Lethal Concentration 50%
LD50 – Lethal Dose 50%
LL50 – Lethal Loading 50%
mg/kg – milligram/kilogram
mg/L – milligram/liter
NOEC – No Observed Effect Concentration
OEL – Occupational Exposure Limit
PBT – Persistent Bioaccumulative and Toxic
ppm – parts per million
STEL – Short Term Exposure Limit
TWA – Time-Weighted Average
vPvB – very Persistent and very Bioaccumulative
h - hour
mg/m^3 - milligram/cubic meter
mm - millimeter
mmHg - millimeter mercury
w/w - weight/weight
d - day

Key literature references and sources for data
www.ChemADVISOR.com/

Disclaimer Statement

This information is furnished without warranty, expressed or implied, as to accuracy or completeness. The information is obtained from various sources including the manufacturer and other third party sources. The information may not be valid under all conditions nor if this material is used in combination with other materials or in any process. Final determination of suitability of any material is the sole responsibility of the user.

End of Safety Data Sheet

HALLIBURTON

SAFETY DATA SHEET

PREMIUM PROP

Revision Date: 18-Sep-2018 **Revision Number:** 13

1. Product Identifier & Identity for the Chemical

Statement of Hazardous Nature Hazardous according to the criteria of the 3rd Revised Edition of the Globally Harmonised System of Classification and Labelling of Chemicals (GHS), Non-Dangerous Goods according to the criteria of ADG.

1.1. Product Identifier

Product Name PREMIUM PROP

Other means of Identification

Synonyms None

Hazardous Material Number: HM004809

Recommended use of the chemical and restrictions on use

Recommended Use Proppant

Uses advised against No information available

Supplier's name, address and phone number

Manufacturer/Supplier Halliburton Australia Pty. Ltd.
15 Marriott Road, Jandakot, WA 6164
Australia
ACN Number: 009 000 775
Telephone Number: + 61 1 800 686 951
Fax Number: 61 (08) 9455 5300

E-mail Address fdunexchem@halliburton.com

Emergency phone number

+ 61 1 800 686 951
Global Incident Response Access Code: 334305
Contract Number: 14012

Australian Poisons Information Centre
24 Hour Service: - 13 11 26
Police or Fire Brigade: - 000 (exchange): - 1100

2. Hazard Identification

Statement of Hazardous Nature Hazardous according to the criteria of the 3rd Revised Edition of the Globally Harmonised System of Classification and Labelling of Chemicals (GHS), Non-Dangerous Goods according to the criteria of ADG.

Classification of the hazardous chemical

Carcinogenicity	Category 1A - H350
Specific Target Organ Toxicity - (Repeated Exposure)	Category 1 - H372

Label elements, including precautionary statements

Hazard Pictograms

Signal Word DANGER

Hazard Statements:
H350 - May cause cancer by inhalation
H372 - Causes damage to organs through prolonged or repeated exposure if inhaled

Precautionary Statements

Prevention
P201 - Obtain special instructions before use
P202 - Do not handle until all safety precautions have been read and understood
P260 - Do not breathe dust/fume/gas/mist/vapors/spray
P264 - Wash face, hands and any exposed skin thoroughly after handling
P270 - Do not eat, drink or smoke when using this product
P281 - Use personal protective equipment as required

Response
P308 + P313 - IF exposed or concerned: Get medical advice/attention
P314 - Get medical attention/advice if you feel unwell

Storage
P405 - Store locked up

Disposal
P501 - Dispose of contents/container in accordance with local/regional/national/international regulations

Contains Substances	**CAS Number**
Crystalline silica, cristobalite	14464-46-1

Other hazards which do not result in classification
This substance is not considered to be persistent, bioaccumulating nor toxic (PBT).
This substance is not considered to be very persistent nor very bioaccumulating (vPvB).

For the full text of the H-phrases mentioned in this Section, see Section 16

3. Composition/information on Ingredients

Substances	CAS Number	PERCENT (w/w)	GHS Classification - Australia
Crystalline silica, cristobalite	14464-46-1	1 - 5%	Carc. 1A (H350) STOT RE 1 (H372)

4. First aid measures

Description of necessary first aid measures

Inhalation If inhaled, remove from area to fresh air. Get medical attention if respiratory irritation develops or if breathing becomes difficult.

Eyes In case of contact, immediately flush eyes with plenty of water for at least 15 minutes and get medical attention if irritation persists.

Skin Get medical attention if irritation persists.

Ingestion Under normal conditions, first aid procedures are not required.

Symptoms caused by exposure
Breathing crystalline silica can cause lung disease, including silicosis and lung cancer. Crystalline silica has also been associated with scleroderma and kidney disease.

Medical Attention and Special Treatment

Notes to Physician Treat symptomatically

5. Fire Fighting Measures

Suitable extinguishing equipment
Suitable Extinguishing Media
All standard fire fighting media
Extinguishing media which must not be used for safety reasons
None known.

Specific hazards arising from the chemical
Special exposure hazards in a fire
Not applicable

Special protective equipment and precautions for fire fighters
Special protective equipment for firefighters
Not applicable

6. Accidental release measures

6.1. Personal precautions, protective equipment and emergency procedures
Use appropriate protective equipment. Avoid creating and breathing dust.

6.2. Environmental precautions
None known.

6.3. Methods and material for containment and cleaning up
Collect using dustless method and hold for appropriate disposal. Consider possible toxic or fire hazards associated with contaminating substances and use appropriate methods for collection, storage and disposal.

7. Handling and storage

7.1. Precautions for safe handling
Handling Precautions
This product contains quartz, cristobalite, and/or tridymite which may become airborne without a visible cloud. Avoid breathing dust. Avoid creating dusty conditions. Use only with adequate ventilation to keep exposure below recommended exposure limits. Wear a NIOSH certified, European Standard En 149, or equivalent respirator when using this product. Material is slippery when wet.
Hygiene Measures
Handle in accordance with good industrial hygiene and safety practice.

7.2. Conditions for safe storage, including any incompatibilities
Storage Information
Use good housekeeping in storage and work areas to prevent accumulation of dust. Close container when not in use.
Other Guidelines
No information available

8. Exposure Controls/Personal Protection

Control parameters - exposure standards, biological monitoring
Exposure Limits

Substances	CAS Number	Australia NOHSC	ACGIH TLV-TWA
Crystalline silica, cristobalite	14464-46-1	TWA: 0.1 mg/m^3	TWA: 0.025 mg/m^3

Appropriate engineering controls
Engineering Controls Use approved industrial ventilation and local exhaust as required to maintain exposures below applicable exposure limits.

Personal protective equipment (PPE)

Personal Protective Equipment	If engineering controls and work practices cannot prevent excessive exposures, the selection and proper use of personal protective equipment should be determined by an industrial hygienist or other qualified professional based on the specific application of this product.
Respiratory Protection	Wear a NIOSH certified, European Standard EN 149 (FFP2/FFP3), AS/NZS 1715, or equivalent respirator when using this product.
Hand Protection	Normal work gloves.
Skin Protection	Wear clothing appropriate for the work environment. Dusty clothing should be laundered before reuse. Use precautionary measures to avoid creating dust when removing or laundering clothing.
Eye Protection	Wear safety glasses or goggles to protect against exposure.
Other Precautions	None known.
Environmental Exposure Controls	No information available

9. Physical and Chemical Properties

9.1. Information on basic physical and chemical properties

Physical State:	Solid	**Color**	Dark brown
Odor:	Odorless	**Odor Threshold:**	No information available

Property Remarks/ - Method	Values
pH:	No data available
Freezing Point / Range	No data available
Melting Point / Range	No data available
Pour Point / Range	No data available
Boiling Point / Range	No data available
Flash Point	No data available
Evaporation rate	No data available
Vapor Pressure	No data available
Vapor Density	No data available
Specific Gravity	3.17
Water Solubility	Insoluble in water
Solubility in other solvents	No data available
Partition coefficient: n-octanol/water	No data available
Autoignition Temperature	No data available
Decomposition Temperature	No data available
Viscosity	No data available
Explosive Properties	No information available
Oxidizing Properties	No information available

9.2. Other information

Molecular Weight	228.1
VOC Content (%)	No data available

10. Stability and Reactivity

10.1. Reactivity
Not expected to be reactive.
10.2. Chemical stability
Stable
10.3. Possibility of hazardous reactions
Will Not Occur
10.4. Conditions to avoid
None anticipated
10.5. Incompatible materials
Hydrofluoric acid.

10.6. Hazardous decomposition products

Amorphous silica may transform at elevated temperatures to tridymite (870 C) or cristobalite (1470 C).

11. Toxicological Information

Information on routes of exposure

Principle Route of Exposure Eye or skin contact, inhalation.

Symptoms related to exposure

Most Important Symptoms/Effects

Breathing crystalline silica can cause lung disease, including silicosis and lung cancer. Crystalline silica has also been associated with scleroderma and kidney disease.

Toxicology data for the components

Substances	CAS Number	LD50 Oral	LD50 Dermal	LC50 Inhalation
Crystalline silica, cristobalite	14464-46-1	> 15000 mg/kg (human) (similar substance)	No information available	No data available

Immediate, delayed and chronic health effects from exposure

Inhalation Inhaled crystalline silica in the form of quartz or cristobalite from occupational sources is carcinogenic to humans (IARC, Group 1). There is sufficient evidence in experimental animals for the carcinogenicity of tridymite (IARC, Group 2A).

Breathing silica dust may cause irritation of the nose, throat, and respiratory passages. Breathing silica dust may not cause noticeable injury or illness even though permanent lung damage may be occurring. Inhalation of dust may also have serious chronic health effects (See "Chronic Effects/Carcinogenicity" subsection below).

Eye Contact May cause mechanical irritation to eye.

Skin Contact None known.

Ingestion None known.

Chronic Effects/Carcinogenicity Silicosis: Excessive inhalation of respirable crystalline silica dust may cause a progressive, disabling, and sometimes-fatal lung disease called silicosis. Symptoms include cough, shortness of breath, wheezing, non-specific chest illness, and reduced pulmonary function. This disease is exacerbated by smoking. Individuals with silicosis are predisposed to develop tuberculosis.

Cancer Status: The International Agency for Research on Cancer (IARC) has determined that crystalline silica inhaled in the form of quartz or cristobalite from occupational sources can cause lung cancer in humans (Group 1 - carcinogenic to humans) and has determined that there is sufficient evidence in experimental animals for the carcinogenicity of tridymite (Group 2A - possible carcinogen to humans). Refer to IARC Monograph 68, Silica, Some Silicates and Organic Fibres (June 1997) in conjunction with the use of these minerals. The National Toxicology Program classifies respirable crystalline silica as "Known to be a human carcinogen". Refer to the 9th Report on Carcinogens (2000). The American Conference of Governmental Industrial Hygienists (ACGIH) classifies crystalline silica, quartz, as a suspected human carcinogen (A2). There is some evidence that breathing respirable crystalline silica or the disease silicosis is associated with an increased incidence of significant disease endpoints such as scleroderma (an immune system disorder manifested by scarring of the lungs, skin, and other internal organs) and kidney disease.

Exposure Levels

No data available

Interactive effects

Individuals with respiratory disease, including but not limited to asthma and bronchitis, or subject to eye irritation, should not be exposed to quartz dust.

Data limitations
No data available

Substances	CAS Number	Skin corrosion/irritation
Crystalline silica, cristobalite	14464-46-1	Non-irritating to the skin

Substances	CAS Number	Serious eye damage/irritation
Crystalline silica, cristobalite	14464-46-1	Mechanical irritation of the eyes is possible.

Substances	CAS Number	Skin Sensitization
Crystalline silica, cristobalite	14464-46-1	No information available

Substances	CAS Number	Respiratory Sensitization
Crystalline silica, cristobalite	14464-46-1	No information available

Substances	CAS Number	Mutagenic Effects
Crystalline silica, cristobalite	14464-46-1	Not regarded as mutagenic.

Substances	CAS Number	Carcinogenic Effects
Crystalline silica, cristobalite	14464-46-1	Contains crystalline silica which may cause silicosis, a delayed and progressive lung disease. The IARC and NTP have determined there is sufficient evidence in humans of the carcinogenicity of crystalline silica with repeated respiratory exposure. Based on available scientific evidence, this substance is a threshold carcinogen with a mode of action involving indirect genotoxicity secondary to lung injury.

Substances	CAS Number	Reproductive toxicity
Crystalline silica, cristobalite	14464-46-1	No information available

Substances	CAS Number	STOT - single exposure
Crystalline silica, cristobalite	14464-46-1	No significant toxicity observed in animal studies at concentration requiring classification.

Substances	CAS Number	STOT - repeated exposure
Crystalline silica, cristobalite	14464-46-1	Causes damage to organs through prolonged or repeated exposure if inhaled: (Lungs)

Substances	CAS Number	Aspiration hazard
Crystalline silica, cristobalite	14464-46-1	Not applicable

12. Ecological Information

Ecotoxicity

Substance Ecotoxicity Data

Substances	CAS Number	Toxicity to Algae	Toxicity to Fish	Toxicity to Microorganisms	Toxicity to Invertebrates
Crystalline silica, cristobalite	14464-46-1	No information available	LL0(96 h)=10000 mg/L (Danio rerio)	No information available	LL50(24 h)>10000 mg/L (Daphnia magna)

12.2. Persistence and degradability

Substances	CAS Number	Persistence and Degradability
Crystalline silica, cristobalite	14464-46-1	The methods for determining biodegradability are not applicable to inorganic substances.

12.3. Bioaccumulative potential

Substances	CAS Number	Bioaccumulation
Crystalline silica, cristobalite	14464-46-1	Not bioaccumulative

12.4. Mobility in soil

Substances	CAS Number	Mobility
Crystalline silica, cristobalite	14464-46-1	No information available

12.6. Other adverse effects

Endocrine Disruptor Information
This product does not contain any known or suspected endocrine disruptors

13. Disposal Considerations

Safe handling and disposal methods
Bury in a licensed landfill according to federal, state, and local regulations.

Disposal of any contaminated packaging
Follow all applicable national or local regulations.

Environmental regulations
Not applicable

14. Transport Information

Transportation Information

Australia ADG

UN Number	Not restricted
UN proper shipping name:	Not restricted
Transport Hazard Class(es):	Not applicable
Packing Group:	Not applicable
Environmental Hazards:	Not applicable

IMDG/IMO

UN Number	Not restricted
UN proper shipping name:	Not restricted
Transport Hazard Class(es):	Not applicable
Packing Group:	Not applicable
Environmental Hazards:	Not applicable

IATA/ICAO

UN Number	Not restricted
UN proper shipping name:	Not restricted
Transport Hazard Class(es):	Not applicable
Packing Group:	Not applicable
Environmental Hazards:	Not applicable

Special precautions during transport
None

HazChem Code
None Allocated

15. Regulatory Information

Safety, health and environmental regulations specific for the product

International Inventories

Australian AICS Inventory	All components are listed on the AICS or are subject to a relevant exemption, permit, or assessment certificate.
New Zealand Inventory of Chemicals	All components are listed on the NZIoC or are subject to a relevant exemption, permit, or assessment certificate.
US TSCA Inventory	All components listed on inventory or are exempt.

Canadian Domestic Substances List (DSL) All components listed on inventory or are exempt.

Poisons Schedule number
None Allocated

International Agreements

Montreal Protocol - Ozone Depleting Substances:	Does not apply.
Stockholm Convention - Persistent Organic Pollutants:	Does not apply
Rotterdam Convention - Prior Informed Consent:	Does not apply.
Basel Convention - Hazardous Waste:	Does not apply.

16. Other information

Date of preparation or review

Revision Date: 18-Sep-2018

Revision Note
SDS sections updated:
2

Full text of H-Statements referred to under sections 2 and 3
H350 - May cause cancer by inhalation
H372 - Causes damage to organs through prolonged or repeated exposure if inhaled

Additional information For additional information on the use of this product, contact your local Halliburton representative.

For questions about the Safety Data Sheet for this or other Halliburton products, contact Chemical Stewardship at 1-580-251-4335.

Key abreviations or acronyms used
bw – body weight
CAS – Chemical Abstracts Service
EC50 – Effective Concentration 50%
LC50 – Lethal Concentration 50%
LD50 – Lethal Dose 50%
LL50 – Lethal Loading 50%
mg/kg – milligram/kilogram
mg/L – milligram/liter
NOEC – No Observed Effect Concentration
OEL – Occupational Exposure Limit
PBT – Persistent Bioaccumulative and Toxic
ppm – parts per million
STEL – Short Term Exposure Limit
TWA – Time-Weighted Average
vPvB – very Persistent and very Bioaccumulative
h - hour
mg/m^3 - milligram/cubic meter
mm - millimeter
mmHg - millimeter mercury
w/w - weight/weight
d - day

Key literature references and sources for data
www.ChemADVISOR.com/

Disclaimer Statement
This information is furnished without warranty, expressed or implied, as to accuracy or completeness. The information is obtained from various sources including the manufacturer and other third party sources. The information may not be valid under all

conditions nor if this material is used in combination with other materials or in any process. Final determination of suitability of any material is the sole responsibility of the user.

End of Safety Data Sheet

HALLIBURTON

SAFETY DATA SHEET

CERAMIC PROP

Revision Date: 07-Jun-2018 **Revision Number:** 12

1. Product Identifier & Identity for the Chemical

Statement of Hazardous Nature Hazardous according to the criteria of the 3rd Revised Edition of the Globally Harmonised System of Classification and Labelling of Chemicals (GHS), Non-Dangerous Goods according to the criteria of ADG.

1.1. Product Identifier

Product Name CERAMIC PROP

Other means of Identification

Synonyms None

Hazardous Material Number: HM004805

Recommended use of the chemical and restrictions on use

Recommended Use Proppant

Uses advised against No information available

Supplier's name, address and phone number

Manufacturer/Supplier Halliburton Australia Pty. Ltd.
15 Marriott Road, Jandakot, WA 6164
Australia
ACN Number: 009 000 775
Telephone Number: + 61 1 800 686 951
Fax Number: 61 (08) 9455 5300

E-mail Address fdunexchem@halliburton.com

Emergency phone number

+ 61 1 800 686 951
Global Incident Response Access Code: 334305
Contract Number: 14012

Australian Poisons Information Centre
24 Hour Service: - 13 11 26
Police or Fire Brigade: - 000 (exchange): - 1100

2. Hazard Identification

Statement of Hazardous Nature Hazardous according to the criteria of the 3rd Revised Edition of the Globally Harmonised System of Classification and Labelling of Chemicals (GHS), Non-Dangerous Goods according to the criteria of ADG.

Classification of the hazardous chemical

Carcinogenicity	Category 1A - H350
Specific Target Organ Toxicity - (Repeated Exposure)	Category 1 - H372

Label elements, including precautionary statements

Hazard Pictograms

Signal Word DANGER

Hazard Statements:
H350 - May cause cancer by inhalation
H372 - Causes damage to organs through prolonged or repeated exposure if inhaled

Precautionary Statements

Prevention
P201 - Obtain special instructions before use
P202 - Do not handle until all safety precautions have been read and understood
P260 - Do not breathe dust/fume/gas/mist/vapors/spray
P264 - Wash face, hands and any exposed skin thoroughly after handling
P270 - Do not eat, drink or smoke when using this product
P281 - Use personal protective equipment as required

Response
P308 + P313 - IF exposed or concerned: Get medical advice/attention
P314 - Get medical attention/advice if you feel unwell

Storage
P405 - Store locked up

Disposal
P501 - Dispose of contents/container in accordance with local/regional/national/international regulations

Contains

Substances	**CAS Number**
Crystalline silica, cristobalite	14464-46-1

Other hazards which do not result in classification
This substance is not considered to be persistent, bioaccumulating nor toxic (PBT).
This substance is not considered to be very persistent nor very bioaccumulating (vPvB).

For the full text of the H-phrases mentioned in this Section, see Section 16

3. Composition/information on Ingredients

Substances	CAS Number	PERCENT (w/w)	GHS Classification - Australia
Crystalline silica, cristobalite	14464-46-1	10 - 30%	Carc. 1A (H350) STOT RE 1 (H372)

4. First aid measures

Description of necessary first aid measures

Inhalation If inhaled, remove from area to fresh air. Get medical attention if respiratory irritation develops or if breathing becomes difficult.

Eyes In case of contact, immediately flush eyes with plenty of water for at least 15 minutes and get medical attention if irritation persists.

Skin Wash with soap and water. Get medical attention if irritation persists.

Ingestion Under normal conditions, first aid procedures are not required.

Symptoms caused by exposure
Breathing crystalline silica can cause lung disease, including silicosis and lung cancer. Crystalline silica has also been associated with scleroderma and kidney disease.

Medical Attention and Special Treatment

Notes to Physician Treat symptomatically

5. Fire Fighting Measures

Suitable extinguishing equipment

Suitable Extinguishing Media

None - does not burn.

Extinguishing media which must not be used for safety reasons

None known.

Specific hazards arising from the chemical

Special exposure hazards in a fire

Not applicable

Special protective equipment and precautions for fire fighters

Special protective equipment for firefighters

Full protective clothing and approved self-contained breathing apparatus required for fire fighting personnel.

6. Accidental release measures

6.1. Personal precautions, protective equipment and emergency procedures

Use appropriate protective equipment. Avoid creating and breathing dust. Avoid contact with skin, eyes and clothing.

6.2. Environmental precautions

None known.

6.3. Methods and material for containment and cleaning up

Collect using dustless method and hold for appropriate disposal. Consider possible toxic or fire hazards associated with contaminating substances and use appropriate methods for collection, storage and disposal.

7. Handling and storage

7.1. Precautions for safe handling

Handling Precautions

This product contains quartz, cristobalite, and/or tridymite which may become airborne without a visible cloud. Avoid breathing dust. Avoid creating dusty conditions. Use only with adequate ventilation to keep exposure below recommended exposure limits. Wear a NIOSH certified, European Standard En 149, or equivalent respirator when using this product. Material is slippery when wet.

Hygiene Measures

Handle in accordance with good industrial hygiene and safety practice.

7.2. Conditions for safe storage, including any incompatibilities

Storage Information

Store in a cool well ventilated area. Store locked up. Store in a cool, dry location. Use good housekeeping in storage and work areas to prevent accumulation of dust. Close container when not in use.

Other Guidelines

No information available

8. Exposure Controls/Personal Protection

Control parameters - exposure standards, biological monitoring

Exposure Limits

Substances	CAS Number	Australia NOHSC	ACGIH TLV-TWA
Crystalline silica, cristobalite	14464-46-1	TWA: 0.1 mg/m^3	TWA: 0.025 mg/m^3

Appropriate engineering controls

Engineering Controls Use approved industrial ventilation and local exhaust as required to maintain exposures below applicable exposure limits.

Personal protective equipment (PPE)

Personal Protective Equipment	If engineering controls and work practices cannot prevent excessive exposures, the selection and proper use of personal protective equipment should be determined by an industrial hygienist or other qualified professional based on the specific application of this product.
Respiratory Protection	Wear a NIOSH certified, European Standard EN 149 (FFP2/FFP3), AS/NZS 1715, or equivalent respirator when using this product.
Hand Protection	Normal work gloves.
Skin Protection	Wear clothing appropriate for the work environment. Dusty clothing should be laundered before reuse. Use precautionary measures to avoid creating dust when removing or laundering clothing.
Eye Protection	Wear safety glasses or goggles to protect against exposure.
Other Precautions	None known.
Environmental Exposure Controls	No information available

9. Physical and Chemical Properties

9.1. Information on basic physical and chemical properties

Physical State:	Solid	**Color**	Gray to tan
Odor:	Odorless	**Odor Threshold:**	No information available

Property Remarks/ - Method	Values
pH:	No data available
Freezing Point / Range	No data available
Melting Point / Range	No data available
Pour Point / Range	No data available
Boiling Point / Range	No data available
Flash Point	No data available
Evaporation rate	No data available
Vapor Pressure	No data available
Vapor Density	No data available
Specific Gravity	3.1
Water Solubility	Insoluble in water
Solubility in other solvents	No data available
Partition coefficient: n-octanol/water	No data available
Autoignition Temperature	No data available
Decomposition Temperature	No data available
Viscosity	No data available
Explosive Properties	No information available
Oxidizing Properties	No information available

9.2. Other information

VOC Content (%)	No data available

10. Stability and Reactivity

10.1. Reactivity
Not expected to be reactive.
10.2. Chemical stability
Stable
10.3. Possibility of hazardous reactions
Will Not Occur
10.4. Conditions to avoid
None anticipated
10.5. Incompatible materials
Hydrofluoric acid.

10.6. Hazardous decomposition products

Amorphous silica may transform at elevated temperatures to tridymite (870 C) or cristobalite (1470 C).

11. Toxicological Information

Information on routes of exposure

Principle Route of Exposure Eye or skin contact, inhalation.

Symptoms related to exposure

Most Important Symptoms/Effects

Breathing crystalline silica can cause lung disease, including silicosis and lung cancer. Crystalline silica has also been associated with scleroderma and kidney disease.

Toxicology data for the components

Substances	CAS Number	LD50 Oral	LD50 Dermal	LC50 Inhalation
Crystalline silica, cristobalite	14464-46-1	> 15000 mg/kg (human) (similar substance)	No information available	No data available

Immediate, delayed and chronic health effects from exposure

Inhalation Inhaled crystalline silica in the form of quartz or cristobalite from occupational sources is carcinogenic to humans (IARC, Group 1). There is sufficient evidence in experimental animals for the carcinogenicity of tridymite (IARC, Group 2A).

Breathing silica dust may cause irritation of the nose, throat, and respiratory passages. Breathing silica dust may not cause noticeable injury or illness even though permanent lung damage may be occurring. Inhalation of dust may also have serious chronic health effects (See "Chronic Effects/Carcinogenicity" subsection below).

Eye Contact May cause mechanical irritation to eye.

Skin Contact None known.

Ingestion None known.

Chronic Effects/Carcinogenicity Silicosis: Excessive inhalation of respirable crystalline silica dust may cause a progressive, disabling, and sometimes-fatal lung disease called silicosis. Symptoms include cough, shortness of breath, wheezing, non-specific chest illness, and reduced pulmonary function. This disease is exacerbated by smoking. Individuals with silicosis are predisposed to develop tuberculosis.

Cancer Status: The International Agency for Research on Cancer (IARC) has determined that crystalline silica inhaled in the form of quartz or cristobalite from occupational sources can cause lung cancer in humans (Group 1 - carcinogenic to humans) and has determined that there is sufficient evidence in experimental animals for the carcinogenicity of tridymite (Group 2A - possible carcinogen to humans). Refer to IARC Monograph 68, Silica, Some Silicates and Organic Fibres (June 1997) in conjunction with the use of these minerals. The National Toxicology Program classifies respirable crystalline silica as "Known to be a human carcinogen". Refer to the 9th Report on Carcinogens (2000). The American Conference of Governmental Industrial Hygienists (ACGIH) classifies crystalline silica, quartz, as a suspected human carcinogen (A2). There is some evidence that breathing respirable crystalline silica or the disease silicosis is associated with an increased incidence of significant disease endpoints such as scleroderma (an immune system disorder manifested by scarring of the lungs, skin, and other internal organs) and kidney disease.

Exposure Levels

No data available

Interactive effects

Individuals with respiratory disease, including but not limited to asthma and bronchitis, or subject to eye irritation, should not be exposed to quartz dust.

Data limitations
No data available

Substances	CAS Number	Skin corrosion/irritation
Crystalline silica, cristobalite	14464-46-1	Non-irritating to the skin

Substances	CAS Number	Serious eye damage/irritation
Crystalline silica, cristobalite	14464-46-1	Mechanical irritation of the eyes is possible.

Substances	CAS Number	Skin Sensitization
Crystalline silica, cristobalite	14464-46-1	No information available

Substances	CAS Number	Respiratory Sensitization
Crystalline silica, cristobalite	14464-46-1	No information available

Substances	CAS Number	Mutagenic Effects
Crystalline silica, cristobalite	14464-46-1	Not regarded as mutagenic.

Substances	CAS Number	Carcinogenic Effects
Crystalline silica, cristobalite	14464-46-1	Contains crystalline silica which may cause silicosis, a delayed and progressive lung disease. The IARC and NTP have determined there is sufficient evidence in humans of the carcinogenicity of crystalline silica with repeated respiratory exposure. Based on available scientific evidence, this substance is a threshold carcinogen with a mode of action involving indirect genotoxicity secondary to lung injury.

Substances	CAS Number	Reproductive toxicity
Crystalline silica, cristobalite	14464-46-1	No information available

Substances	CAS Number	STOT - single exposure
Crystalline silica, cristobalite	14464-46-1	No significant toxicity observed in animal studies at concentration requiring classification.

Substances	CAS Number	STOT - repeated exposure
Crystalline silica, cristobalite	14464-46-1	Causes damage to organs through prolonged or repeated exposure if inhaled: (Lungs)

Substances	CAS Number	Aspiration hazard
Crystalline silica, cristobalite	14464-46-1	Not applicable

12. Ecological Information

Ecotoxicity
Product Ecotoxicity Data
Product is not classified as hazardous to the environment.

Substance Ecotoxicity Data

Substances	CAS Number	Toxicity to Algae	Toxicity to Fish	Toxicity to Microorganisms	Toxicity to Invertebrates
Crystalline silica, cristobalite	14464-46-1	No information available	LL0(96 h)=10000 mg/L (Danio rerio)	No information available	LL50(24 h)>10000 mg/L (Daphnia magna)

12.2. Persistence and degradability

Substances	CAS Number	Persistence and Degradability
Crystalline silica, cristobalite	14464-46-1	The methods for determining biodegradability are not applicable to inorganic substances.

12.3. Bioaccumulative potential

Substances	CAS Number	Bioaccumulation

Crystalline silica, cristobalite	14464-46-1	Not bioaccumulative

12.4. Mobility in soil

Substances	CAS Number	Mobility
Crystalline silica, cristobalite	14464-46-1	No information available

12.6. Other adverse effects

Endocrine Disruptor Information

This product does not contain any known or suspected endocrine disruptors

13. Disposal Considerations

Safe handling and disposal methods

Bury in a licensed landfill according to federal, state, and local regulations.

Disposal of any contaminated packaging

Follow all applicable national or local regulations.

Environmental regulations

Not applicable

14. Transport Information

Transportation Information

Australia ADG

UN Number	Not restricted
UN proper shipping name:	Not restricted
Transport Hazard Class(es):	Not applicable
Packing Group:	Not applicable
Environmental Hazards:	Not applicable

IMDG/IMO

UN Number	Not restricted
UN proper shipping name:	Not restricted
Transport Hazard Class(es):	Not applicable
Packing Group:	Not applicable
Environmental Hazards:	Not applicable

IATA/ICAO

UN Number	Not restricted
UN proper shipping name:	Not restricted
Transport Hazard Class(es):	Not applicable
Packing Group:	Not applicable
Environmental Hazards:	Not applicable

Special precautions during transport

None

HazChem Code

None Allocated

15. Regulatory Information

Safety, health and environmental regulations specific for the product

International Inventories

Australian AICS Inventory	All components are listed on the AICS or are subject to a relevant exemption, permit, or assessment certificate.
New Zealand Inventory of	All components are listed on the NZIoC or are subject to a relevant exemption, permit, or

Chemicals	assessment certificate.
US TSCA Inventory	All components listed on inventory or are exempt.
Canadian Domestic Substances List (DSL)	All components listed on inventory or are exempt.

Poisons Schedule number
None Allocated

International Agreements

Montreal Protocol - Ozone Depleting Substances:	Does not apply.
Stockholm Convention - Persistent Organic Pollutants:	Does not apply
Rotterdam Convention - Prior Informed Consent:	Does not apply.
Basel Convention - Hazardous Waste:	Does not apply.

16. Other information

Date of preparation or review

Revision Date: 07-Jun-2018

Revision Note
SDS sections updated:
2

Full text of H-Statements referred to under sections 2 and 3
H350 - May cause cancer by inhalation
H372 - Causes damage to organs through prolonged or repeated exposure if inhaled

Additional information For additional information on the use of this product, contact your local Halliburton representative.

For questions about the Safety Data Sheet for this or other Halliburton products, contact Chemical Stewardship at 1-580-251-4335.

Key abreviations or acronyms used
bw – body weight
CAS – Chemical Abstracts Service
EC50 – Effective Concentration 50%
LC50 – Lethal Concentration 50%
LD50 – Lethal Dose 50%
LL50 – Lethal Loading 50%
mg/kg – milligram/kilogram
mg/L – milligram/liter
NOEC – No Observed Effect Concentration
OEL – Occupational Exposure Limit
PBT – Persistent Bioaccumulative and Toxic
ppm – parts per million
STEL – Short Term Exposure Limit
TWA – Time-Weighted Average
vPvB – very Persistent and very Bioaccumulative
h - hour
mg/m^3 - milligram/cubic meter
mm - millimeter
mmHg - millimeter mercury
w/w - weight/weight
d - day

Key literature references and sources for data
www.ChemADVISOR.com/

Disclaimer Statement

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End of Safety Data Sheet

HALLIBURTON

SAFETY DATA SHEET

CL-28M CROSSLINKER

Revision Date: 03-Apr-2015 **Revision Number:** 19

1. Product Identifier & Identity for the Chemical

Statement of Hazardous Nature Hazardous according to the criteria of the 3rd Revised Edition of the Globally Harmonised System of Classification and Labelling of Chemicals (GHS), Non-Dangerous Goods according to the criteria of ADG.

1.1. Product Identifier

Product Name CL-28M CROSSLINKER

Other means of Identification

Synonyms: None

Product Code: HM000346

Recommended use of the chemical and restrictions on use

Recommended Use Crosslinker

Uses Advised Against No information available

Supplier's name, address and phone number

Manufacturer/Supplier Halliburton Australia Pty. Ltd.
15 Marriott Road
Jandakot
WA 6164
Australia

ACN Number: 009 000 775
Telephone Number: + 61 1 800 686 951
Fax Number: 61 (08) 9455 5300

E-Mail address: fdunexchem@halliburton.com

Emergency phone number

+ 61 1 800 686 951

Australian Poisons Information Centre

24 Hour Service: - 13 11 26

Police or Fire Brigade: - 000 (exchange): - 1100

2. Hazard Identification

Statement of Hazardous Nature Hazardous according to the criteria of the 3rd Revised Edition of the Globally Harmonised System of Classification and Labelling of Chemicals (GHS), Non-Dangerous Goods according to the criteria of ADG.

Classification of the hazardous chemical

Serious Eye Damage / Eye Irritation	Category 2 - H319
Carcinogenicity	Category 1A - H350
Reproductive Toxicity	Category 1B - H360
Specific Target Organ Toxicity - (Repeated Exposure)	Category 2 - H373

Label elements, including precautionary statements

Hazard Pictograms

Signal Word Danger

Hazard Statements
H319 - Causes serious eye irritation
H350i - May cause cancer by inhalation
H360 - May damage fertility or the unborn child
H373 - May cause damage to organs through prolonged or repeated exposure if inhaled

Precautionary Statements

Prevention
P201 - Obtain special instructions before use
P202 - Do not handle until all safety precautions have been read and understood
P260 - Do not breathe dust/fume/gas/mist/vapors/spray
P264 - Wash face, hands and any exposed skin thoroughly after handling
P280 - Wear eye protection/face protection
P281 - Use personal protective equipment as required

Response
P305 + P351 + P338 - IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing
P337 + P313 - If eye irritation persists: Get medical advice/attention
P308 + P313 - IF exposed or concerned: Get medical advice/attention
P314 - Get medical attention/advice if you feel unwell

Storage P405 - Store locked up

Disposal P501 - Dispose of contents/container in accordance with local/regional/national/international regulations

Contains Substances	**CAS Number**
Borate Salts	Proprietary
Crystalline silica, quartz	14808-60-7

Other hazards which do not result in classification
None known

Australia Classification
For the full text of the H-phrases mentioned in this Section, see Section 16

Classification T - Toxic.

Risk Phrases
R36 Irritating to eyes.
R49 May cause cancer by inhalation.
R62 Possible risk of impaired fertility.
R48/20 Harmful: danger of serious damage to health by prolonged exposure through inhalation.

3. Composition/information on Ingredients

Substances	CAS Number	PERCENT (w/w)	GHS Classification - Australia

Borate Salts	Proprietary	30 - 60%	Eye Irrit. 2A (H319) Repr. 1 (H360)
Crystalline silica, quartz	14808-60-7	1 - 5%	Carc. 1 (H350) STOT RE 1 (H372)

4. First aid measures

Description of necessary first aid measures

Inhalation If inhaled, remove from area to fresh air. Get medical attention if respiratory irritation develops or if breathing becomes difficult.

Eyes In case of contact, immediately flush eyes with plenty of water for at least 15 minutes and get medical attention if irritation persists.

Skin Wash with soap and water. Get medical attention if irritation persists.

Ingestion Do NOT induce vomiting. Give nothing by mouth. Obtain immediate medical attention.

Symptoms caused by exposure

Causes eye irritation Breathing crystalline silica can cause lung disease, including silicosis and lung cancer. Crystalline silica has also been associated with scleroderma and kidney disease. Potential reproductive hazard. May cause birth defects. Prolonged or repeated exposure may cause damage to organs.

Medical Attention and Special Treatment

Notes to Physician Treat symptomatically

5. Fire Fighting Measures

Suitable extinguishing equipment

Suitable Extinguishing Media

All standard fire fighting media

Extinguishing media which must not be used for safety reasons

None known.

Specific hazards arising from the chemical

Special Exposure Hazards

Decomposition in fire may produce harmful gases.

Special protective equipment and precautions for fire fighters

Special Protective Equipment for Fire-Fighters

Full protective clothing and approved self-contained breathing apparatus required for fire fighting personnel.

6. Accidental release measures

6.1. Personal precautions, protective equipment and emergency procedures

Use appropriate protective equipment.

6.2. Environmental precautions

Prevent from entering sewers, waterways, or low areas.

6.3. Methods and material for containment and cleaning up

Isolate spill and stop leak where safe. Contain spill with sand or other inert materials. Scoop up and remove.

7. Handling and storage

7.1. Precautions for Safe Handling

Handling Precautions

This product contains quartz, cristobalite, and/or tridymite which may become airborne without a visible cloud. Avoid breathing dust. Avoid creating dusty conditions. Use only with adequate ventilation to keep exposure below recommended exposure limits. Wear a NIOSH certified, European Standard En 149, or equivalent respirator when using this product. Material is slippery when

wet.

Hygiene Measures

Handle in accordance with good industrial hygiene and safety practice.

7.2. Conditions for safe storage, including any incompatibilities

Storage Information

Keep container closed when not in use. Product has a shelf life of 24 months.

Other Guidelines

No information available

8. Exposure Controls/Personal Protection

Control parameters - exposure standards, biological monitoring

Exposure Limits

Substances	CAS Number	Australia NOHSC	ACGIH TLV-TWA
Borate Salts	Proprietary	Not applicable	Not applicable
Crystalline silica, quartz	14808-60-7	TWA: 0.1 mg/m^3	TWA: 0.025 mg/m^3

Appropriate engineering controls

Engineering Controls Use approved industrial ventilation and local exhaust as required to maintain exposures below applicable exposure limits.

Personal protective equipment (PPE)

Respiratory Protection Wear a NIOSH certified, European Standard EN 149 (FFP2/FFP3), AS/NZS 1715, or equivalent respirator when using this product.

Hand Protection Normal work gloves.

Skin Protection Wear clothing appropriate for the work environment. Dusty clothing should be laundered before reuse. Use precautionary measures to avoid creating dust when removing or laundering clothing.

Eye Protection Wear safety glasses or goggles to protect against exposure.

Other Precautions None known.

Environmental Exposure Controls No information available

9. Physical and Chemical Properties

9.1. Information on basic physical and chemical properties

Physical State: Liquid
Color: Gray to tan
Odor: Odorless
Odor Threshold: No information available

Property / Remarks/ - Method	Values
pH:	No data available
Freezing Point/Range	0 °C
Melting Point/Range	No data available
Boiling Point/Range	100 °C / 212 °F
Flash Point	No data available
Evaporation rate	No data available
Vapor Pressure	No data available
Vapor Density	No data available
Specific Gravity	1.27
Water Solubility	Insoluble in water
Solubility in other solvents	No data available
Partition coefficient: n-octanol/water	No data available
Autoignition Temperature	No data available
Decomposition Temperature	No data available
Viscosity	No data available
Explosive Properties	No information available
Oxidizing Properties	No information available

9.2. Other information

VOC Content (%) No data available

10. Stability and Reactivity

10.1. Reactivity
Not expected to be reactive.
10.2. Chemical Stability
Stable
10.3. Possibility of Hazardous Reactions
Will Not Occur
10.4. Conditions to Avoid
None anticipated
10.5. Incompatible Materials
Hydrofluoric acid.

10.6. Hazardous Decomposition Products
Amorphous silica may transform at elevated temperatures to tridymite (870 C) or cristobalite (1470 C).

11. Toxicological Information

Information on routes of exposure
Principle Route of Exposure Eye or skin contact, inhalation.

Sympotoms related to exposure
Most Important Symptoms/Effects
Causes eye irritation Breathing crystalline silica can cause lung disease, including silicosis and lung cancer. Crystalline silica has also been associated with scleroderma and kidney disease. Potential reproductive hazard. May cause birth defects. Prolonged or repeated exposure may cause damage to organs.

Numerical measures of toxicity

Toxicology data for the components

Substances	CAS Number	LD50 Oral	LD50 Dermal	LC50 Inhalation
Borate Salts	Proprietary	3493-6080 mg/kg (Rat) (similar substance) 3450 mg/kg (Male Rat) (similar substance)	> 2000 mg/kg (Rabbit) (similar substance)	> 2 mg/L (Rat) 4h (similar substance) > 2.12 mg/L (Rat) 4h (similar substance) > 2.04 mg/L (Rat) 4h (similar substance)
Crystalline silica, quartz	14808-60-7	>15,000 mg/kg (Human)	No data available	No data available

Immediate, delayed and chronic health effects from exposure
Inhalation Inhaled crystalline silica in the form of quartz or cristobalite from occupational sources is carcinogenic to humans (IARC, Group 1). There is sufficient evidence in experimental animals for the carcinogenicity of tridymite (IARC, Group 2A).

Breathing silica dust may cause irritation of the nose, throat, and respiratory passages. Breathing silica dust may not cause noticeable injury or illness even though permanent lung damage may be occurring. Inhalation of dust may also have serious chronic health effects (See "Chronic Effects/Carcinogenicity" subsection below).
May cause respiratory irritation.
Eye Contact Causes eye irritation.
Skin Contact May cause mild skin irritation.
Ingestion May cause abdominal pain, vomiting, nausea, and diarrhea.

Chronic Effects/Carcinogenicity Silicosis: Excessive inhalation of respirable crystalline silica dust may cause a progressive, disabling, and sometimes-fatal lung disease called silicosis. Symptoms include cough, shortness of breath, wheezing, non-specific chest illness, and reduced pulmonary function. This disease is exacerbated by smoking. Individuals with silicosis are predisposed to develop tuberculosis.

Cancer Status: The International Agency for Research on Cancer (IARC) has determined that crystalline silica inhaled in the form of quartz or cristobalite from occupational sources can cause lung cancer in humans (Group 1 - carcinogenic to humans) and has determined that there is sufficient evidence in experimental animals for the carcinogenicity of tridymite (Group 2A - possible carcinogen to humans). Refer to IARC Monograph 68, Silica, Some Silicates and Organic Fibres (June 1997) in conjunction with the use of these minerals. The National Toxicology Program classifies respirable crystalline silica as "Known to be a human carcinogen". Refer to the 9th Report on Carcinogens (2000). The American Conference of Governmental Industrial Hygienists (ACGIH) classifies crystalline silica, quartz, as a suspected human carcinogen (A2).

There is some evidence that breathing respirable crystalline silica or the disease silicosis is associated with an increased incidence of significant disease endpoints such as scleroderma (an immune system disorder manifested by scarring of the lungs, skin, and other internal organs) and kidney disease.

Prolonged or repeated exposure may cause reproductive system damage.

Exposure Levels
No data available

Interactive effects
Individuals with respiratory disease, including but not limited to asthma and bronchitis, or subject to eye irritation, should not be exposed to quartz dust.

Data limitations
No data available

Substances	CAS Number	Skin corrosion/irritation
Borate Salts		Non-irritating to the skin (Rabbit) (similar substances)
Crystalline silica, quartz	14808-60-7	Non-irritating to the skin

Substances	CAS Number	Eye damage/irritation
Borate Salts		Causes moderate eye irritation. (Rabbit) (similar substances)
Crystalline silica, quartz	14808-60-7	Mechanical irritation of the eyes is possible.

Substances	CAS Number	Skin Sensitization
Borate Salts		Did not cause sensitization on laboratory animals (guinea pig) (similar substances)
Crystalline silica, quartz	14808-60-7	No information available.

Substances	CAS Number	Respiratory Sensitization
Borate Salts		No information available
Crystalline silica, quartz	14808-60-7	No information available

Substances	CAS Number	Mutagenic Effects
Borate Salts		In vitro tests did not show mutagenic effects (similar substances)
Crystalline silica, quartz	14808-60-7	Not regarded as mutagenic.

Substances	CAS Number	Carcinogenic Effects
Borate Salts		Did not show carcinogenic effects in animal experiments (similar substances)
Crystalline silica, quartz	14808-60-7	Contains crystalline silica which may cause silicosis, a delayed and progressive lung disease. The IARC and NTP have determined there is sufficient evidence in humans of the carcinogenicity of crystalline silica with repeated respiratory exposure. Based on available scientific evidence, this substance is a threshold carcinogen with a mode of action involving indirect genotoxicity secondary to lung injury.

Substances	CAS Number	Reproductive toxicity
Borate Salts		Experiments have shown reproductive toxicity effects on laboratory animals (similar substances)
Crystalline silica, quartz	14808-60-7	No information available

Substances	CAS Number	STOT - single exposure
Borate Salts		None under normal use conditions
Crystalline silica, quartz	14808-60-7	No significant toxicity observed in animal studies at concentration requiring classification.

Substances	CAS Number	STOT - repeated exposure
Borate Salts		None under normal use conditions
Crystalline silica, quartz	14808-60-7	Causes damage to organs through prolonged or repeated exposure if inhaled: (Lungs)

Substances	CAS Number	Aspiration hazard
Borate Salts		Not applicable
Crystalline silica, quartz	14808-60-7	Not applicable

12. Ecological Information

Ecotoxicity

Product Ecotoxicity Data

No data available

Substance Ecotoxicity Data

Substances	CAS Number	Toxicity to Algae	Toxicity to Fish	Toxicity to Microorganisms	Toxicity to Invertebrates
Borate Salts	Proprietary	EC50 (72h) 1398.64 mg/L (Skeletonema costatum)	LC50 (96h) > 320 mg/L (Scophthalmus maximus) LC50 (96h) > 1100 mg/L (Oncorhynchus mykiss) LC50 (96h) > 1021 mg/L (Lepomis macrochirus) LD50 (28d) 65 mg/L (Oncorhynchus mykiss)	No information available	EC50 (48h) 7341.67 mg/L (Acartia tonsa) EC50 (48h) 133 mg/L (Daphnia magna)
Crystalline silica, quartz	14808-60-7	No information available	LL0 (96h) 10,000 mg/L (Danio rerio) (similar substance)	No information available	LL50 (24h) > 10,000 mg/L (Daphnia magna) (similar substance)

12.2. Persistence and degradability

Substances	CAS Number	Persistence and Degradability
Borate Salts	Proprietary	The methods for determining biodegradability are not applicable to inorganic substances.
Crystalline silica, quartz	14808-60-7	No information available

12.3. Bioaccumulative potential

Substances	CAS Number	Log Pow
Borate Salts	Proprietary	0.175
Crystalline silica, quartz	14808-60-7	No information available

12.4. Mobility in soil

Substances	CAS Number	Mobility
Borate Salts	Proprietary	No information available
Crystalline silica, quartz	14808-60-7	No information available

12.6. Other adverse effects

Endocrine Disruptor Information

This product does not contain any known or suspected endocrine disruptors

13. Disposal Considerations

Safe handling and disposal methods

Disposal should be made in accordance with federal, state, and local regulations.

Disposal of any contaminated packaging
Follow all applicable national or local regulations.

Environmental regulations
Not applicable

14. Transport Information

Transportation Information

UN Number:	Not restricted
UN Proper Shipping Name:	Not restricted
Transport Hazard Class(es):	Not applicable
Packing Group:	Not applicable
Environmental Hazards:	Not applicable

Special precautions during transport
None

HazChem Code
None Allocated

15. Regulatory Information

Safety, health and environmental regulations specific for the product

International Inventories

Australian AICS Inventory	All components listed on inventory or are exempt.
New Zealand Inventory of Chemicals	Product contains one or more components not listed on inventory.
EINECS Inventory	This product, and all its components, complies with EINECS
US TSCA Inventory	All components listed on inventory or are exempt.
Canadian DSL Inventory	All components listed on inventory or are exempt.

Poisons Schedule number
None Allocated

16. Other information

Date of preparation or review

Revision Date: 03-Apr-2015

Revision Note Revision Note
SDS sections updated: 2

Full text of R-phrases referred to under Sections 2 and 3
R36 - Irritating to eyes
R49 May cause cancer by inhalation.
R48/20 Harmful: danger of serious damage to health by prolonged exposure through inhalation.
R62 Possible risk of impaired fertility.

Full text of H-Statements referred to under sections 2 and 3
H319 - Causes serious eye irritation
H350i - May cause cancer by inhalation
H360 - May damage fertility or the unborn child
H372 - Causes damage to organs through prolonged or repeated exposure if inhaled
H373 - May cause damage to organs through prolonged or repeated exposure if inhaled

Additional information

For additional information on the use of this product, contact your local Halliburton representative.

For questions about the Safety Data Sheet for this or other Halliburton products, contact Chemical Stewardship at 1-580-251-4335.

Key abreviations or acronyms used

bw – body weight CAS – Chemical Abstracts Service EC50 – Effective Concentration 50% LC50 – Lethal Concentration 50% LD50 – Lethal Dose 50% LL50 – Lethal Loading 50% mg/kg – milligram/kilogram mg/L – milligram/liter NOEC – No Observed Effect Concentration OEL – Occupational Exposure Limit PBT – Persistent Bioaccumulative and Toxic ppm – parts per million STEL – Short Term Exposure Limit TWA – Time-Weighted Average vPvB – very Persistent and very Bioaccumulative h - hour mg/m^3 - milligram/cubic meter mm - millimeter mmHg - millimeter mercury w/w - weight/weight d - day

Key literature references and sources for data

www.ChemADVISOR.com/
NZ CCID
OSHA
ECHA C&L

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End of Safety Data Sheet

HALLIBURTON

SAFETY DATA SHEET

Clayfix II Plus

Revision Date: 26-Oct-2017 **Revision Number:** 2

1. Product Identifier & Identity for the Chemical

Statement of Hazardous Nature Hazardous according to the criteria of the 3rd Revised Edition of the Globally Harmonised System of Classification and Labelling of Chemicals (GHS), Dangerous Goods according to the criteria of ADG.

1.1. Product Identifier

Product Name Clayfix II Plus

Other means of Identification

Synonyms None

Hazardous Material Number: HM006534

Recommended use of the chemical and restrictions on use

Recommended Use Clay Control

Uses advised against No information available

Supplier's name, address and phone number

Manufacturer/Supplier Halliburton Australia Pty. Ltd.
15 Marriott Road, Jandakot, WA 6164
Australia
ACN Number: 009 000 775
Telephone Number: + 61 1 800 686 951
Fax Number: 61 (08) 9455 5300

E-mail Address fdunexchem@halliburton.com

Emergency phone number

+ 61 1 800 686 951
Global Incident Response Access Code: 334305
Contract Number: 14012

Australian Poisons Information Centre
24 Hour Service: - 13 11 26
Police or Fire Brigade: - 000 (exchange): - 1100

2. Hazard Identification

Statement of Hazardous Nature Hazardous according to the criteria of the 3rd Revised Edition of the Globally Harmonised System of Classification and Labelling of Chemicals (GHS), Dangerous Goods according to the criteria of ADG.

Classification of the hazardous chemical

Acute Oral Toxicity	Category 3 - H301
Acute toxicity - Dermal	Category 3 - H311
Skin Corrosion/Irritation	Category 2 - H315
Acute Aquatic Toxicity	Category 2 - H401
Chronic Aquatic Toxicity	Category 1 - H410

Label elements, including precautionary statements

Hazard Pictograms

Signal Word DANGER

Hazard Statements:
H301 - Toxic if swallowed
H311 - Toxic in contact with skin
H315 - Causes skin irritation
H401 - Toxic to aquatic life
H410 - Very toxic to aquatic life with long lasting effects

Precautionary Statements

Prevention
P264 - Wash face, hands and any exposed skin thoroughly after handling
P270 - Do not eat, drink or smoke when using this product
P273 - Avoid release to the environment
P280 - Wear protective gloves/eye protection/face protection

Response
P301 + P310 - IF SWALLOWED: Immediately call a POISON CENTER or doctor/physician
P330 - Rinse mouth
P302 + P352 - IF ON SKIN: Wash with plenty of water.
P312 - Call a POISON CENTER/doctor/physician if you feel unwell
P361 - Take off immediately all contaminated clothing.
P391 - Collect spillage

Storage
P405 - Store locked up

Disposal
P501 - Dispose of contents/container in accordance with local/regional/national/international regulations

Contains

Substances	**CAS Number**
Tetramethyl ammonium chloride	75-57-0

Other hazards which do not result in classification
None known

For the full text of the H-phrases mentioned in this Section, see Section 16

3. Composition/information on Ingredients

Substances	CAS Number	PERCENT (w/w)	GHS Classification - Australia
Tetramethyl ammonium chloride	75-57-0	60 - 100%	Acute Tox. 2 (H300) Acute Tox. 3 (H311) Skin Irrit. 2 (H315) Aquatic Acute 2 (H401) Aquatic Chronic 1 (H410)

4. First aid measures

Description of necessary first aid measures

Inhalation If inhaled, move victim to fresh air and seek medical attention.

Eyes Immediately flush eyes with large amounts of water for at least 15 minutes. Get immediate medical attention.

Skin In case of contact, immediately flush skin with plenty of soap and water for at least

	15 minutes. Get medical attention.
Ingestion	Do NOT induce vomiting. Give nothing by mouth. Obtain immediate medical attention.

Symptoms caused by exposure

Causes skin irritation. Toxic if swallowed. Toxic in contact with skin.

Medical Attention and Special Treatment

Notes to Physician Treat symptomatically

5. Fire Fighting Measures

Suitable extinguishing equipment

Suitable Extinguishing Media

Water fog, carbon dioxide, foam, dry chemical.

Extinguishing media which must not be used for safety reasons

None known.

Specific hazards arising from the chemical

Special exposure hazards in a fire

Decomposition in fire may produce harmful gases. Use water spray to cool fire exposed surfaces.

Special protective equipment and precautions for fire fighters

Special protective equipment for firefighters

Full protective clothing and approved self-contained breathing apparatus required for fire fighting personnel.

6. Accidental release measures

6.1. Personal precautions, protective equipment and emergency procedures

Use appropriate protective equipment.

6.2. Environmental precautions

Prevent from entering sewers, waterways, or low areas.

6.3. Methods and material for containment and cleaning up

Isolate spill and stop leak where safe. Contain spill with sand or other inert materials. Scoop up and remove.

7. Handling and storage

7.1. Precautions for safe handling

Handling Precautions

Wash hands after use. Launder contaminated clothing before reuse. Avoid contact with eyes, skin, or clothing. Avoid breathing vapors. Do NOT consume food, drink, or tobacco in contaminated areas.

Hygiene Measures

Handle in accordance with good industrial hygiene and safety practice.

7.2. Conditions for safe storage, including any incompatibilities

Storage Information

Store away from oxidizers. Store in a cool well ventilated area. Keep container closed when not in use. Store locked up. Product has a shelf life of 24 months.

Other Guidelines

No information available

8. Exposure Controls/Personal Protection

Control parameters - exposure standards, biological monitoring

Exposure Limits

Substances	CAS Number	Australia NOHSC	ACGIH TLV-TWA

Tetramethyl ammonium chloride	75-57-0	Not applicable	Not applicable

Appropriate engineering controls

Engineering Controls Use in a well ventilated area.

Personal protective equipment (PPE)

Personal Protective Equipment If engineering controls and work practices cannot prevent excessive exposures, the selection and proper use of personal protective equipment should be determined by an industrial hygienist or other qualified professional based on the specific application of this product.

Respiratory Protection If engineering controls and work practices cannot keep exposure below occupational exposure limits or if exposure is unknown, wear a NIOSH certified, European Standard EN 149, AS/NZS 1715:2009, or equivalent respirator when using this product. Selection of and instruction on using all personal protective equipment, including respirators, should be performed by an Industrial Hygienist or other qualified professional.
Organic vapor/acid gas respirator with a dust/mist filter.

Hand Protection Impervious rubber gloves.

Skin Protection Rubber apron.

Eye Protection Chemical goggles; also wear a face shield if splashing hazard exists.

Other Precautions None known.

Environmental Exposure Controls No information available

9. Physical and Chemical Properties

9.1. Information on basic physical and chemical properties

Physical State: Liquid
Color Colorless
Odor: Mild amine
Odor Threshold: No information available

Property Remarks/ - Method	Values
pH:	4- 9
Freezing Point / Range	
Melting Point / Range	No data available
Boiling Point / Range	100 °C / 212 °F
Flash Point	> 93 °C / > 200 °F PMCC
Evaporation rate	No data available
Vapor Pressure	No data available
Vapor Density	No data available
Specific Gravity	1.035
Water Solubility	Soluble in water
Solubility in other solvents	No data available
Partition coefficient: n-octanol/water	No data available
Autoignition Temperature	No data available
Decomposition Temperature	No data available
Viscosity	No data available
Explosive Properties	No information available
Oxidizing Properties	No information available

9.2. Other information

VOC Content (%) No data available

10. Stability and Reactivity

10.1. Reactivity

Not expected to be reactive.

10.2. Chemical stability

Stable

10.3. Possibility of hazardous reactions

Will Not Occur

10.4. Conditions to avoid

None anticipated

10.5. Incompatible materials
Strong oxidizers.
10.6. Hazardous decomposition products
Chlorine. Hydrogen chloride. Oxides of nitrogen. Carbon monoxide and carbon dioxide.

11. Toxicological Information

Information on routes of exposure
Principle Route of Exposure Eye or skin contact, inhalation. Ingestion.

Symptoms related to exposure
Most Important Symptoms/Effects
Causes skin irritation. Toxic if swallowed. Toxic in contact with skin.

Toxicology data for the components

Substances	CAS Number	LD50 Oral	LD50 Dermal	LC50 Inhalation
Tetramethyl ammonium chloride	75-57-0	47 mg/kg (Rat)	200 mg/kg - 500 mg/kg (rat)	No data available

Immediate, delayed and chronic health effects from exposure
Inhalation May cause respiratory irritation.
Eye Contact Non-irritating to rabbit's eye
Skin Contact Toxic in contact with skin. Causes skin irritation.
Ingestion Toxic if swallowed.

Chronic Effects/Carcinogenicity No data available to indicate product or components present at greater than 0.1% are chronic health hazards.

Exposure Levels
No data available

Interactive effects
Eye ailments. Skin disorders.

Data limitations
No data available

Substances	CAS Number	Skin corrosion/irritation
Tetramethyl ammonium chloride	75-57-0	Causes moderate skin irritation.

Substances	CAS Number	Serious eye damage/irritation
Tetramethyl ammonium chloride	75-57-0	Non-irritating to rabbit's eye

Substances	CAS Number	Skin Sensitization
Tetramethyl ammonium chloride	75-57-0	Did not cause sensitization on laboratory animals (mouse)

Substances	CAS Number	Respiratory Sensitization
Tetramethyl ammonium chloride	75-57-0	No information available

Substances	CAS Number	Mutagenic Effects
Tetramethyl ammonium chloride	75-57-0	In vitro tests did not show mutagenic effects. (similar substances)

Substances	CAS Number	Carcinogenic Effects
Tetramethyl ammonium chloride	75-57-0	No information available

Substances	CAS Number	Reproductive toxicity
Tetramethyl ammonium chloride	75-57-0	Animal testing did not show any effects on fertility. Did not show teratogenic effects in animal experiments. (similar substances)

Substances	CAS Number	STOT - single exposure
Tetramethyl ammonium chloride	75-57-0	No significant toxicity observed in animal studies at concentration requiring classification.

Substances	CAS Number	STOT - repeated exposure
Tetramethyl ammonium chloride	75-57-0	No data of sufficient quality are available.

Substances	CAS Number	Aspiration hazard
Tetramethyl ammonium chloride	75-57-0	Not applicable

12. Ecological Information

Ecotoxicity

Substance Ecotoxicity Data

Substances	CAS Number	Toxicity to Algae	Toxicity to Fish	Toxicity to Microorganisms	Toxicity to Invertebrates
Tetramethyl ammonium chloride	75-57-0	No information available	LC50 (96h) 462 mg/L (Pimephales promelas)	No information available	LC50 (48h) 1.86 mg/L (Daphnia magna) NOEL (11d) 0.03 mg/L (Daphnia magna)

12.2. Persistence and degradability

Substances	CAS Number	Persistence and Degradability
Tetramethyl ammonium chloride	75-57-0	No information available

12.3. Bioaccumulative potential

Substances	CAS Number	Log Pow
Tetramethyl ammonium chloride	75-57-0	No information available

12.4. Mobility in soil

Substances	CAS Number	Mobility
Tetramethyl ammonium chloride	75-57-0	No information available

12.6. Other adverse effects

Endocrine Disruptor Information

This product does not contain any known or suspected endocrine disruptors

13. Disposal Considerations

Safe handling and disposal methods

Disposal should be made in accordance with federal, state, and local regulations.

Disposal of any contaminated packaging

Follow all applicable national or local regulations. Contaminated packaging may be disposed of by: rendering packaging incapable of containing any substance, or treating packaging to remove residual contents, or treating packaging to make sure the residual contents are no longer hazardous, or by disposing of packaging into commercial waste collection.

Environmental regulations

Not applicable

14. Transport Information

Transportation Information

Australia ADG

UN Number	UN2810
UN proper shipping name:	Toxic Liquid, Organic, N.O.S. (Contains Tetramethylammonium Chloride)
Transport Hazard Class(es):	6.1
Packing Group:	III
Environmental Hazards:	Marine Pollutant

IMDG/IMO

UN Number	UN2810
UN proper shipping name:	Toxic Liquid, Organic, N.O.S. (Contains Tetramethylammonium Chloride)
Transport Hazard Class(es):	6.1
Packing Group:	III
Environmental Hazards:	Marine Pollutant
EMS:	EmS F-A, S-A

IATA/ICAO

UN Number	UN2810
UN proper shipping name:	Toxic Liquid, Organic, N.O.S. (Contains Tetramethylammonium Chloride)
Transport Hazard Class(es):	6.1
Packing Group:	III
Environmental Hazards:	Marine Pollutant

Special precautions during transport

None

HazChem Code

2X

15. Regulatory Information

Safety, health and environmental regulations specific for the product

International Inventories

Australian AICS Inventory	All components are listed on the AICS or are subject to a relevant exemption, permit, or assessment certificate.
New Zealand Inventory of Chemicals	All components are listed on the NZIoC or are subject to a relevant exemption, permit, or assessment certificate.
EINECS (European Inventory of Existing Chemical Substances)	This product, and all its components, complies with EINECS
US TSCA Inventory	All components listed on inventory or are exempt.
Canadian Domestic Substances List (DSL)	All components listed on inventory or are exempt.

Poisons Schedule number

None Allocated

International Agreements

Montreal Protocol - Ozone Depleting Substances:	Does not apply
Stockholm Convention - Persistent Organic Pollutants:	Does not apply
Rotterdam Convention - Prior Informed Consent:	Does not apply
Basel Convention - Hazardous Waste:	Does not apply

16. Other information

Date of preparation or review

Revision Date: 26-Oct-2017

Revision Note

Full text of H-Statements referred to under sections 2 and 3
H300 - Fatal if swallowed
H301 - Toxic if swallowed
H311 - Toxic in contact with skin
H315 - Causes skin irritation
H401 - Toxic to aquatic life
H410 - Very toxic to aquatic life with long lasting effects

Additional information

For additional information on the use of this product, contact your local Halliburton representative.

For questions about the Safety Data Sheet for this or other Halliburton products, contact Chemical Stewardship at 1-580-251-4335.

Key abreviations or acronyms used
bw – body weight
CAS – Chemical Abstracts Service
EC50 – Effective Concentration 50%
LC50 – Lethal Concentration 50%
LD50 – Lethal Dose 50%
LL50 – Lethal Loading 50%
mg/kg – milligram/kilogram
mg/L – milligram/liter
NOEC – No Observed Effect Concentration
OEL – Occupational Exposure Limit
PBT – Persistent Bioaccumulative and Toxic
ppm – parts per million
STEL – Short Term Exposure Limit
TWA – Time-Weighted Average
vPvB – very Persistent and very Bioaccumulative
h - hour
mg/m^3 - milligram/cubic meter
mm - millimeter
mmHg - millimeter mercury
w/w - weight/weight
d - day

Key literature references and sources for data
www.ChemADVISOR.com/
NZ CCID

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End of Safety Data Sheet

HALLIBURTON

SAFETY DATA SHEET

CLSAU352

Revision Date: 04-Mar-2015 **Revision Number:** 8

1. Product Identifier & Identity for the Chemical

Statement of Hazardous Nature Hazardous according to the criteria of the 3rd Revised Edition of the Globally Harmonised System of Classification and Labelling of Chemicals (GHS), Non-Dangerous Goods according to the criteria of ADG.

1.1. Product Identifier

Product Name CLSAU352

Other means of Identification

Synonyms: None

Product Code: HM007421

Recommended use of the chemical and restrictions on use

Recommended Use Surfactant

Uses Advised Against No information available

Supplier's name, address and phone number

Manufacturer/Supplier

Halliburton Australia Pty. Ltd.
15 Marriott Road
Jandakot
WA 6164
Australia

ACN Number: 009 000 775
Telephone Number: 61 (08) 9455 8300
Fax Number: 61 (08) 9455 5300

E-Mail address: fdunexchem@halliburton.com

Emergency phone number

61 (08) 9455 8300

Australian Poisons Information Centre

24 Hour Service: - 13 11 26

Police or Fire Brigade: - 000 (exchange): - 1100

2. Hazard Identification

Statement of Hazardous Nature Hazardous according to the criteria of the 3rd Revised Edition of the Globally Harmonised System of Classification and Labelling of Chemicals (GHS), Non-Dangerous Goods according to the criteria of ADG.

Classification of the hazardous chemical

Skin Corrosion / irritation	Category 2 - H315
Serious Eye Damage / Eye Irritation	Category 1 - H318

Label elements, including precautionary statements

Hazard Pictograms

Signal Word
Danger

Hazard Statements
H315 - Causes skin irritation
H318 - Causes serious eye damage

Precautionary Statements

Prevention
P264 - Wash face, hands and any exposed skin thoroughly after handling
P280 - Wear protective gloves/eye protection/face protection

Response
P302 + P352 - IF ON SKIN: Wash with plenty of soap and water
P332 + P313 - If skin irritation occurs: Get medical advice/attention
P362 - Take off contaminated clothing and wash before reuse
P305 + P351 + P338 - IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing
P310 - Immediately call a POISON CENTER or doctor/physician

Storage
None

Disposal
None

Contains

Substances	**CAS Number**
Sodium lauryl sulfate	151-21-3

Other hazards which do not result in classification
None known

Australia Classification
For the full text of the R/H-phrases mentioned in this Section, see Section 16

Classification
Xi - Irritant.

Risk Phrases
R41 Risk of serious damage to eyes.
R38 Irritating to skin.

3. Composition/information on Ingredients

Substances	CAS Number	PERCENT (w/w)	GHS Classification - Australia

Sodium lauryl sulfate	151-21-3	10 - 30%	Acute Tox. 4 (H302) Acute Tox. 4 (H312) Skin Irrit. 2 (H315) Eye Irrit. 1 (H318) STOT SE 3 (H335) Aquatic Acute 2 (H401) Aquatic Chronic 3 (H412)

4. First aid measures

Description of necessary first aid measures

Inhalation If inhaled, remove from area to fresh air. Get medical attention if respiratory irritation develops or if breathing becomes difficult.

Eyes In case of contact, or suspected contact, immediately flush eyes with plenty of water for at least 15 minutes and get medical attention immediately after flushing.

Skin Wash with soap and water. Get medical attention if irritation persists.

Ingestion If swallowed, give at least 3-4 glasses of water, but do not induce vomiting. Do not give anything by mouth to an unconscious or convulsing person. Get medical attention.

Symptoms caused by exposure

May cause severe eye irritation. May cause skin irritation.

Medical Attention and Special Treatment

Notes to Physician Treat symptomatically

5. Fire Fighting Measures

Suitable extinguishing equipment

Suitable Extinguishing Media

Water fog, carbon dioxide, foam, dry chemical.

Extinguishing media which must not be used for safety reasons

None known.

Specific hazards arising from the chemical

Special Exposure Hazards

Decomposition in fire may produce toxic gases.

Special protective equipment and precautions for fire fighters

Special Protective Equipment for Fire-Fighters

Full protective clothing and approved self-contained breathing apparatus required for fire fighting personnel.

6. Accidental release measures

6.1. Personal precautions, protective equipment and emergency procedures

Use appropriate protective equipment.

6.2. Environmental precautions

Prevent from entering sewers, waterways, or low areas.

6.3. Methods and material for containment and cleaning up

Do NOT spread spilled product with water. Isolate spill and stop leak where safe. Contain spill with sand or other inert materials. Scoop up and remove.

7. Handling and storage

7.1. Precautions for Safe Handling

Handling Precautions

Avoid breathing vapors. Wash hands after use. Launder contaminated clothing before reuse. Avoid breathing mist. Avoid contact with eyes, skin, or clothing.

Hygiene Measures

Handle in accordance with good industrial hygiene and safety practice.

7.2. Conditions for safe storage, including any incompatibilities

Storage Information

Store away from oxidizers. Keep from freezing. Keep container closed when not in use. Product has a shelf life of 24 months.

Other Guidelines

No information available

8. Exposure Controls/Personal Protection

Control parameters - exposure standards, biological monitoring

Exposure Limits

Substances	CAS Number	Australia NOHSC	ACGIH TLV-TWA
Sodium lauryl sulfate	151-21-3	Not applicable	Not applicable

Appropriate engineering controls

Engineering Controls Use in a well ventilated area. Local exhaust ventilation should be used in areas without good cross ventilation.

Personal protective equipment (PPE)

Respiratory Protection If engineering controls and work practices cannot keep exposure below occupational exposure limits or if exposure is unknown, wear a NIOSH certified, European Standard EN 149, AS/NZS 1715:2009, or equivalent respirator when using this product. Selection of and instruction on using all personal protective equipment, including respirators, should be performed by an Industrial Hygienist or other qualified professional.
Dust/mist respirator. (N95, P2/P3)

Hand Protection Chemical-resistant protective gloves (EN 374) Suitable materials for longer, direct contact (recommended: protection index 6, corresponding to > 480 minutes permeation time as per EN 374): Nitrile gloves. (>= 0.35 mm thickness)
This information is based on literature references and on information provided by glove manufacturers, or is derived by analogy with similar substances. Please note that in practice the working life of chemical-resistant protective gloves may be considerably shorter than the permeation time determined in accordance with EN 374 as a result of the many influencing factors (e.g. temperature). If signs of wear and tear are noticed then the gloves should be replaced. Manufacturer's directions for use should be observed because of great diversity of types.

Skin Protection Wear impervious protective clothing, including boots, gloves, lab coat, apron, rain jacket, pants or coverall, as appropriate, to prevent skin contact.

Eye Protection Chemical goggles; also wear a face shield if splashing hazard exists.

Other Precautions Eyewash fountains and safety showers must be easily accessible.

Environmental Exposure Controls No information available

9. Physical and Chemical Properties

9.1. Information on basic physical and chemical properties

Physical State: Liquid
Color: Off white
Odor: Odorless
Odor Threshold: No information available

Property Remarks/ - Method	Values
pH:	No data available
Freezing Point/Range	No data available
Melting Point/Range	No data available
Boiling Point/Range	100 °C / 212 °F
Flash Point	No data available

Evaporation rate	No data available
Vapor Pressure	No data available
Vapor Density	No data available
Specific Gravity	0.98
Water Solubility	Soluble in water
Solubility in other solvents	No data available
Partition coefficient: n-octanol/water	No data available
Autoignition Temperature	No data available
Decomposition Temperature	No data available
Viscosity	No data available
Explosive Properties	No information available
Oxidizing Properties	No information available

9.2. Other information

VOC Content (%) No data available

10. Stability and Reactivity

10.1. Reactivity

Not applicable

10.2. Chemical Stability

Stable

10.3. Possibility of Hazardous Reactions

Will Not Occur

10.4. Conditions to Avoid

None anticipated

10.5. Incompatible Materials

Strong oxidizers.

10.6. Hazardous Decomposition Products

Oxides of sulfur. Sodium oxides. Carbon monoxide and carbon dioxide.

11. Toxicological Information

Information on routes of exposure

Principle Route of Exposure Eye or skin contact, inhalation.

Sympotoms related to exposure

Most Important Symptoms/Effects

May cause severe eye irritation. May cause skin irritation.

Numerical measures of toxicity

Toxicology data for the components

Substances	CAS Number	LD50 Oral	LD50 Dermal	LC50 Inhalation
Sodium lauryl sulfate	151-21-3	1288 mg/kg (Rat) 1200 mg/kg (Rat)	> 2000 mg/kg (Rabbit) (similar substance)	3900 mg/m³ (Rat) 1 h

Immediate, delayed and chronic health effects from exposure

Inhalation	May cause respiratory irritation. May cause allergic respiratory reaction.
Eye Contact	May cause severe eye irritation.
Skin Contact	May cause an allergic skin reaction. Prolonged or repeated contact may cause skin irritation.
Ingestion	Irritation of the mouth, throat, and stomach.

Exposure Levels

No data available

Interactive effects

Eye ailments. Skin disorders. Respiratory disorders.

Data limitations
No data available

Substances	CAS Number	Skin corrosion/irritation
Sodium lauryl sulfate	151-21-3	Irritating to skin. (rabbit)

Substances	CAS Number	Eye damage/irritation
Sodium lauryl sulfate	151-21-3	Causes severe eye irritation. (rabbit)

Substances	CAS Number	Skin Sensitization
Sodium lauryl sulfate	151-21-3	Did not cause sensitization on laboratory animals (guinea pig) (similar substances)

Substances	CAS Number	Respiratory Sensitization
Sodium lauryl sulfate	151-21-3	No information available

Substances	CAS Number	Mutagenic Effects
Sodium lauryl sulfate	151-21-3	In vitro tests did not show mutagenic effects In vivo tests did not show mutagenic effects. (similar substances)

Substances	CAS Number	Carcinogenic Effects
Sodium lauryl sulfate	151-21-3	Did not show carcinogenic effects in animal experiments (similar substances)

Substances	CAS Number	Reproductive toxicity
Sodium lauryl sulfate	151-21-3	No significant toxicity observed in animal studies at concentration requiring classification. (similar substances)

Substances	CAS Number	STOT - single exposure
Sodium lauryl sulfate	151-21-3	No significant toxicity observed in animal studies at concentration requiring classification.

Substances	CAS Number	STOT - repeated exposure
Sodium lauryl sulfate	151-21-3	No significant toxicity observed in animal studies at concentration requiring classification.

Substances	CAS Number	Aspiration hazard
Sodium lauryl sulfate	151-21-3	Not applicable

12. Ecological Information

Ecotoxicity
Product Ecotoxicity Data
No data available

Substance Ecotoxicity Data

Substances	CAS Number	Toxicity to Algae	Toxicity to Fish	Toxicity to Microorganisms	Toxicity to Invertebrates
Sodium lauryl sulfate	151-21-3	EC50(72h): > 120 mg/L (growth rate) (Desmodesmus subspicatus)	LC50(96h): 29 mg/L (Pimephales promelas) LC50(96h): 4.5 mg/L (Lepomis macrochirus) NOEC(28d): < 3.8 mg/L (Pimephales promelas)	EC50(3h): 135 mg/L (activated sludge)	LC50(48h): 5.55 mg/L (Ceriodaphnia dubia) NOEC(7d): 0.88 mg/L (Ceriodaphnia dubia)

12.2. Persistence and degradability

Substances	CAS Number	Persistence and Degradability
Sodium lauryl sulfate	151-21-3	Readily biodegradable (95% @ 28d)

12.3. Bioaccumulative potential

Substances	CAS Number	Log Pow
Sodium lauryl sulfate	151-21-3	<= -2.03

12.4. Mobility in soil
No information available

12.6. Other adverse effects
Endocrine Disruptor Information
This product does not contain any known or suspected endocrine disruptors

13. Disposal Considerations

Safe handling and disposal methods
Disposal should be made in accordance with federal, state, and local regulations.

Disposal of any contaminated packaging
Follow all applicable national or local regulations.

Environmental regulations
Not applicable

14. Transport Information

Transportation Information
UN Number: Not restricted
UN Proper Shipping Name: Not restricted
Transport Hazard Class(es): Not applicable
Packing Group: Not applicable
Environmental Hazards: Not applicable

Special precautions during transport
None

HazChem Code
None Allocated

15. Regulatory Information

Safety, health and environmental regulations specific for the product

International Inventories
Australian AICS Inventory All components listed on inventory or are exempt.
New Zealand Inventory of Chemicals All components listed on inventory or are exempt.
EINECS Inventory This product, and all its components, complies with EINECS
US TSCA Inventory All components listed on inventory or are exempt.
Canadian DSL Inventory All components listed on inventory or are exempt.

Poisons Schedule number
None Allocated

16. Other information

Date of preparation or review

Revision Date: 04-Mar-2015

Revision Note
SDS sections updated SECTION: 2

Full text of R-phrases referred to under Sections 2 and 3
R22 Harmful if swallowed.
R38 Irritating to skin.
R41 Risk of serious damage to eyes.
R52/53 Harmful to aquatic organisms, may cause long-term adverse effects in the aquatic environment.

Full text of H-Statements referred to under sections 2 and 3
H302 - Harmful if swallowed
H315 - Causes skin irritation
H318 - Causes serious eye damage
H412 - Harmful to aquatic life with long lasting effects

Additional information

For additional information on the use of this product, contact your local Halliburton representative.

For questions about the Safety Data Sheet for this or other Halliburton products, contact Chemical Stewardship at 1-580-251-4335.

Key abreviations or acronyms used
Not applicable

Key literature references and sources for data
www.ChemADVISOR.com/

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End of Safety Data Sheet

HALLIBURTON

SAFETY DATA SHEET

D-AIR 3000L

Revision Date: 17-Feb-2015 **Revision Number:** 16

1. Product Identifier & Identity for the Chemical

Statement of Hazardous Nature Non-Hazardous according to the criteria of NOHSC, Non-Dangerous Goods according to the criteria of ADG.

1.1. Product Identifier

Product Name D-AIR 3000L

Other means of Identification

Synonyms: None

Product Code: HM003191

Recommended use of the chemical and restrictions on use

Recommended Use Defoamer

Uses Advised Against No information available

Supplier's name, address and phone number

Manufacturer/Supplier Halliburton Australia Pty. Ltd.
15 Marriott Road
Jandakot
WA 6164
Australia

ACN Number: 009 000 775
Telephone Number: 61 (08) 9455 8300
Fax Number: 61 (08) 9455 5300

E-Mail address: fdunexchem@halliburton.com

Emergency phone number

61 (08) 9455 8300

Australian Poisons Information Centre

24 Hour Service: - 13 11 26
Police or Fire Brigade: - 000 (exchange): - 1100

2. Hazard Identification

Statement of Hazardous Nature Non-Hazardous according to the criteria of NOHSC, Non-Dangerous Goods according to the criteria of ADG.

Classification of the hazardous chemical

Not classified

Label elements, including precautionary statements

Hazard Pictograms

Signal Word
Not Hazardous

Hazard Statements
Not Classified

Precautionary Statements

Prevention None

Response None

Storage None

Disposal None

Contains

Substances	**CAS Number**
Alkenes	Proprietary

Other hazards which do not result in classification
None known

Australia Classification
For the full text of the R/H-phrases mentioned in this Section, see Section 16

Classification Not Classified
Risk Phrases None

3. Composition/information on Ingredients

Substances	CAS Number	PERCENT (w/w)	GHS Classification - Australia
Alkenes	Proprietary	60 - 100%	

4. First aid measures

Description of necessary first aid measures

Inhalation If inhaled, remove from area to fresh air. Get medical attention if respiratory irritation develops or if breathing becomes difficult.

Eyes In case of contact, immediately flush eyes with plenty of water for at least 15 minutes and get medical attention if irritation persists.

Skin Wash with soap and water. Get medical attention if irritation persists.

Ingestion Get medical attention! If vomiting occurs, keep head lower than hips to prevent aspiration.

Symptoms caused by exposure
May cause lung damage if swallowed.

Medical Attention and Special Treatment
Notes to Physician Treat symptomatically

5. Fire Fighting Measures

Suitable extinguishing equipment

Suitable Extinguishing Media
Water fog, carbon dioxide, foam, dry chemical.
Extinguishing media which must not be used for safety reasons
None known.

Specific hazards arising from the chemical
Special Exposure Hazards
Decomposition in fire may produce toxic gases.

Special protective equipment and precautions for fire fighters
Special Protective Equipment for Fire-Fighters
Full protective clothing and approved self-contained breathing apparatus required for fire fighting personnel.

6. Accidental release measures

6.1. Personal precautions, protective equipment and emergency procedures
Use appropriate protective equipment.

6.2. Environmental precautions
None known.

6.3. Methods and material for containment and cleaning up
Isolate spill and stop leak where safe. Contain spill with sand or other inert materials. Scoop up and remove.

7. Handling and storage

7.1. Precautions for Safe Handling
Handling Precautions
Avoid contact with eyes, skin, or clothing. Avoid breathing vapors.
Hygiene Measures
Handle in accordance with good industrial hygiene and safety practice.

7.2. Conditions for safe storage, including any incompatibilities
Storage Information
Store away from oxidizers. Keep container closed when not in use. Product has a shelf life of 24 months.
Other Guidelines
No information available

8. Exposure Controls/Personal Protection

Control parameters - exposure standards, biological monitoring
Exposure Limits

Substances	CAS Number	Australia NOHSC	ACGIH TLV-TWA
Alkenes	Proprietary	Not applicable	Not applicable

Appropriate engineering controls
Engineering Controls Use in a well ventilated area.

Personal protective equipment (PPE)
Respiratory Protection Not normally necessary.

Hand Protection None known.
Skin Protection Normal work coveralls.
Eye Protection Wear safety glasses or goggles to protect against exposure.
Other Precautions None known.
Environmental Exposure Controls No information available

9. Physical and Chemical Properties

9.1. Information on basic physical and chemical properties

Physical State: Liquid
Color: Opaque
Odor: Hydrocarbon
Odor Threshold: No information available

Property Remarks/ - Method	Values
pH:	5.5-7.9
Freezing Point/Range	No data available
Melting Point/Range	No data available
Boiling Point/Range	No data available
Flash Point	> 121 °C PMCC
Evaporation rate	No data available
Vapor Pressure	No data available
Vapor Density	No data available
Specific Gravity	0.92
Water Solubility	Insoluble in water
Solubility in other solvents	No data available
Partition coefficient: n-octanol/water	No data available
Autoignition Temperature	No data available
Decomposition Temperature	No data available
Viscosity	No data available
Explosive Properties	No information available
Oxidizing Properties	No information available

9.2. Other information

VOC Content (%) No data available

10. Stability and Reactivity

10.1. Reactivity
Not applicable
10.2. Chemical Stability
Stable
10.3. Possibility of Hazardous Reactions
Will Not Occur
10.4. Conditions to Avoid
None anticipated
10.5. Incompatible Materials
Strong oxidizers.
10.6. Hazardous Decomposition Products
Carbon monoxide and carbon dioxide.

11. Toxicological Information

Information on routes of exposure
Principle Route of Exposure Eye or skin contact, inhalation.

Sympotoms related to exposure
Most Important Symptoms/Effects
May cause lung damage if swallowed.

Numerical measures of toxicity

Toxicology data for the components

Substances	CAS Number	LD50 Oral	LD50 Dermal	LC50 Inhalation
Alkenes	Proprietary	> 5000 mg/kg (Rat) (similar substance)	> 2000 mg/kg (Rat) (similar substance)	> 2.1 mg/L (Rat)

Immediate, delayed and chronic health effects from exposure

Inhalation May cause central nervous system depression including headache, dizziness, drowsiness, incoordination, slowed reaction time, slurred speech, giddiness and unconsciousness.

Eye Contact May cause mild eye irritation.

Skin Contact May cause mild skin irritation.

Ingestion May cause abdominal pain, vomiting, nausea, and diarrhea. Aspiration into the lungs may cause chemical pneumonitis including coughing, difficulty breathing, wheezing, coughing up blood and pneumonia, which can be fatal.

Chronic Effects/Carcinogenicity No data available to indicate product or components present at greater than 1% are chronic health hazards.

Exposure Levels
No data available

Interactive effects
None known.

Data limitations
No data available

12. Ecological Information

Ecotoxicity
Product Ecotoxicity Data
No data available

Substance Ecotoxicity Data

Substances	CAS Number	Toxicity to Algae	Toxicity to Fish	Toxicity to Microorganisms	Toxicity to Invertebrates
Alkenes	Proprietary	EC50(72h): > 1000 mg/L (Selenastrum capicomutum) (similar substance)	LL50(96h): > 1000 mg/L (Oncorhynchus mykiss) (similar substance) LL50(96h): > 10000 mg/L (Scopthalmus maximus) (similar substance)	No information available	EC50(48h): > 1000 mg/L (Daphnia magna) (similar substance)

12.2. Persistence and degradability

Substances	CAS Number	Persistence and Degradability
Alkenes	Proprietary	Readily biodegradable (77 - 81% @ 28d)

12.3. Bioaccumulative potential

Substances	CAS Number	Log Pow
Alkenes	Proprietary	> 7

12.4. Mobility in soil
No information available

12.6. Other adverse effects
Endocrine Disruptor Information
This product does not contain any known or suspected endocrine disruptors

13. Disposal Considerations

Safe handling and disposal methods
Disposal should be made in accordance with federal, state, and local regulations. Incineration recommended in approved incinerator according to federal, state, and local regulations.

Disposal of any contaminated packaging
Follow all applicable national or local regulations.

Environmental regulations
Not applicable

14. Transport Information

Transportation Information

UN Number:	Not restricted
UN Proper Shipping Name:	Not restricted
Transport Hazard Class(es):	Not applicable
Packing Group:	Not applicable
Environmental Hazards:	Not applicable

Special precautions during transport
None

HazChem Code
None Allocated

15. Regulatory Information

Safety, health and environmental regulations specific for the product

International Inventories

Australian AICS Inventory	All components listed on inventory or are exempt.
New Zealand Inventory of Chemicals	All components listed on inventory or are exempt.
EINECS Inventory	This product, and all its components, complies with EINECS
US TSCA Inventory	All components listed on inventory or are exempt.
Canadian DSL Inventory	All components listed on inventory or are exempt.

Poisons Schedule number
None Allocated

16. Other information

Date of preparation or review

Revision Date: 17-Feb-2015

Revision Note
Update to Format SECTION: 2

Full text of R-phrases referred to under Sections 2 and 3
None

Full text of H-Statements referred to under sections 2 and 3
None

Additional information

For additional information on the use of this product, contact your local Halliburton representative.

For questions about the Safety Data Sheet for this or other Halliburton products, contact Chemical Stewardship at 1-580-251-4335.

Key abreviations or acronyms used
Not applicable

Key literature references and sources for data
www.ChemADVISOR.com/
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End of Safety Data Sheet

HALLIBURTON

SAFETY DATA SHEET

DCA-11001

Revision Date: 23-Jan-2017 **Revision Number:** 19

1. Product Identifier & Identity for the Chemical

Statement of Hazardous Nature Hazardous according to the criteria of the 3rd Revised Edition of the Globally Harmonised System of Classification and Labelling of Chemicals (GHS), Non-Dangerous Goods according to the criteria of ADG.

1.1. Product Identifier

Product Name DCA-11001

Other means of Identification

Synonyms None

Hazardous Material Number: HM007644

Recommended use of the chemical and restrictions on use

Recommended Use Additive

Uses advised against No information available

Supplier's name, address and phone number

Manufacturer/Supplier

Multi-Chem Mintech
1 Ward Road
East Rockingham
WA 6168
Australia

Telephone Number: 61 (08) 9419 5300
Fax Number: 61 (08) 9439 1055
Emergency Telephone Number: + 61 1 800 686 951

E-mail Address fdunexchem@halliburton.com

Emergency phone number

+ 61 1 800 686 951
Global Incident Response Access Code: 334305
Contract Number: 14012

Australian Poisons Information Centre
24 Hour Service: - 13 11 26
Police or Fire Brigade: - 000 (exchange): - 1100

2. Hazard Identification

Statement of Hazardous Nature Hazardous according to the criteria of the 3rd Revised Edition of the Globally Harmonised System of Classification and Labelling of Chemicals (GHS), Non-Dangerous Goods according to the criteria of ADG.

Classification of the hazardous chemical

Skin Corrosion/Irritation	Category 2 - H315
Serious Eye Damage/Irritation	Category 1 - H318
Specific Target Organ Toxicity - (Repeated Exposure)	Category 2 - H373
Acute Aquatic Toxicity	Category 3 - H402

Label elements, including precautionary statements

Hazard Pictograms

Signal Word DANGER

Hazard Statements:
H315 - Causes skin irritation
H318 - Causes serious eye damage
H373 - May cause damage to organs through prolonged or repeated exposure
H402 - Harmful to aquatic life

Precautionary Statements

Prevention
P260 - Do not breathe dust/fume/gas/mist/vapors/spray
P264 - Wash face, hands and any exposed skin thoroughly after handling
P273 - Avoid release to the environment
P280 - Wear protective gloves/eye protection/face protection

Response
P302 + P352 - IF ON SKIN: Wash with plenty of soap and water
P332 + P313 - If skin irritation occurs: Get medical advice/attention
P362 + P364 - Take off contaminated clothing and wash before reuse
P305 + P351 + P338 - IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing
P310 - Immediately call a POISON CENTER or doctor/physician
P314 - Get medical attention/advice if you feel unwell

Storage None

Disposal P501 - Dispose of contents/container in accordance with local/regional/national/international regulations

Contains Substances	**CAS Number**
Diethanolamine	111-42-2

Other hazards which do not result in classification
This mixture contains no substance considered to be persistent, bioaccumulating nor toxic (PBT).
This mixture contains no substance considered to be very persistent nor very bioaccumulating (vPvB).

For the full text of the H-phrases mentioned in this Section, see Section 16

3. Composition/information on Ingredients

Substances	CAS Number	PERCENT (w/w)	GHS Classification - Australia
Diethanolamine	111-42-2	10 - 30%	Acute Tox. 4 (H302) Skin Irrit. 2 (H315) Eye Corr. 1 (H318) STOT RE 2 (H373) Aquatic Acute 2 (H401) Aquatic Chronic 3 (H412)

4. First aid measures

Description of necessary first aid measures

Inhalation	If inhaled, move victim to fresh air and seek medical attention.
Eyes	In case of contact, immediately flush eyes with plenty of water for at least 30 minutes. Remove contact lenses after the first 5 minutes and continue washing. Seek immediate medical attention/advice. Suitable emergency eye wash facility should be immediately available
Skin	Remove contaminated clothing and launder before reuse. In case of contact, immediately flush skin with plenty of soap and water for at least 30 minutes and remove contaminated clothing, shoes and leather goods immediately. Get medical attention immediately.
Ingestion	Do NOT induce vomiting. Give nothing by mouth. Obtain immediate medical attention.

Symptoms caused by exposure

Causes severe eye irritation which may damage tissue. Causes skin irritation. Prolonged or repeated exposure may cause damage to organs.

Medical Attention and Special Treatment

Notes to Physician Treat symptomatically

5. Fire Fighting Measures

Suitable extinguishing equipment

Suitable Extinguishing Media

Carbon dioxide, dry chemical, foam.

Extinguishing media which must not be used for safety reasons

None known.

Specific hazards arising from the chemical

Special exposure hazards in a fire

Decomposition in fire may produce harmful gases.

Special protective equipment and precautions for fire fighters

Special protective equipment for firefighters

Full protective clothing and approved self-contained breathing apparatus required for fire fighting personnel.

6. Accidental release measures

6.1. Personal precautions, protective equipment and emergency procedures

Use appropriate protective equipment. Avoid contact with skin, eyes and clothing. Avoid breathing vapors. Ensure adequate ventilation. Evacuate all persons from the area.

6.2. Environmental precautions

Prevent from entering sewers, waterways, or low areas. Consult local authorities.

6.3. Methods and material for containment and cleaning up

Isolate spill and stop leak where safe. Contain spill with sand or other inert materials. Scoop up and remove.

7. Handling and storage

7.1. Precautions for safe handling

Handling Precautions

Avoid contact with eyes, skin, or clothing. Avoid breathing vapors. Wash hands after use. Launder contaminated clothing before reuse. Ensure adequate ventilation. Use appropriate protective equipment.

Hygiene Measures

Handle in accordance with good industrial hygiene and safety practice.

7.2. Conditions for safe storage, including any incompatibilities

Storage Information

Store away from oxidizers. Store in a cool well ventilated area. Keep container closed when not in use. Product has a shelf life of

12 months.

Other Guidelines

No information available

8. Exposure Controls/Personal Protection

Control parameters - exposure standards, biological monitoring

Exposure Limits

Substances	CAS Number	Australia NOHSC	ACGIH TLV-TWA
Diethanolamine	111-42-2	TWA: 3 ppm TWA: 13 mg/m^3	TWA: 1 mg/m^3

Appropriate engineering controls

Engineering Controls Use in a well ventilated area. Local exhaust ventilation should be used in areas without good cross ventilation.

Personal protective equipment (PPE)

Personal Protective Equipment If engineering controls and work practices cannot prevent excessive exposures, the selection and proper use of personal protective equipment should be determined by an industrial hygienist or other qualified professional based on the specific application of this product.

Respiratory Protection Wear a NIOSH certified, European Standard EN 149 (FFP2/FFP3), AS/NZS 1715, or equivalent respirator when using this product.

Hand Protection Chemical-resistant protective gloves (EN 374) Suitable materials for longer, direct contact (recommended: protection index 6, corresponding to > 480 minutes permeation time as per EN 374): Butyl rubber gloves. (>= 0.7 mm thickness)
This information is based on literature references and on information provided by glove manufacturers, or is derived by analogy with similar substances. Please note that in practice the working life of chemical-resistant protective gloves may be considerably shorter than the permeation time determined in accordance with EN 374 as a result of the many influencing factors (e.g. temperature). If signs of wear and tear are noticed then the gloves should be replaced. Manufacturer's directions for use should be observed because of great diversity of types.

Skin Protection Rubber apron.

Eye Protection Chemical goggles; also wear a face shield if splashing hazard exists.

Other Precautions Eyewash fountains and safety showers must be easily accessible.

Environmental Exposure Controls Do not allow material to contaminate ground water system

9. Physical and Chemical Properties

9.1. Information on basic physical and chemical properties

Physical State: Liquid
Color Water white
Odor: Characteristic
Odor Threshold: No information available

Property Remarks/ - Method	Values
pH:	10.5
Freezing Point / Range	16 °C
Melting Point / Range	No data available
Boiling Point / Range	250 °C / 482 °F
Flash Point	194 °C / 382 °F PMCC
Upper flammability limit	8.5
Lower flammability limit	1.3
Evaporation rate	No data available
Vapor Pressure	0.01 mmHg
Vapor Density	No data available
Specific Gravity	1.11
Water Solubility	Soluble in water
Solubility in other solvents	No data available
Partition coefficient: n-octanol/water	No data available

Autoignition Temperature	315 °C / 600 °F
Decomposition Temperature	No data available
Viscosity	No data available
Explosive Properties	No information available
Oxidizing Properties	No information available

9.2. Other information

VOC Content (%)	No data available

10. Stability and Reactivity

10.1. Reactivity
Not expected to be reactive.
10.2. Chemical stability
Stable
10.3. Possibility of hazardous reactions
Will Not Occur
10.4. Conditions to avoid
None anticipated
10.5. Incompatible materials
Strong oxidizers. Violent, explosive reaction with sulfur trioxide, decaborane, silver perchlorate, triethenyl aluminum, and hydrogen in presence of nickel catalyst at temperatures above 200 C.
10.6. Hazardous decomposition products
Oxides of nitrogen. Carbon monoxide and carbon dioxide.

11. Toxicological Information

Information on routes of exposure
Principle Route of Exposure Eye or skin contact, inhalation.

Symptoms related to exposure
Most Important Symptoms/Effects
Causes severe eye irritation which may damage tissue. Causes skin irritation. Prolonged or repeated exposure may cause damage to organs.

Numerical measures of toxicity

Toxicology data for the components

Substances	CAS Number	LD50 Oral	LD50 Dermal	LC50 Inhalation
Diethanolamine	111-42-2	620 µL/kg (Rat) 1600 mg/kg (Rat)	7640 µL/kg (Rabbit) 13,000 mg/kg (Rabbit)	3.35 mg/L (Rat)

Immediate, delayed and chronic health effects from exposure

Inhalation	May cause respiratory irritation.
Eye Contact	Causes severe eye irritation which may damage tissue.
Skin Contact	Causes skin irritation.
Ingestion	Irritation of the mouth, throat, and stomach.

Chronic Effects/Carcinogenicity Repeated overexposure may cause liver and kidney effects. Amines may form nitrosamines, a suspect carcinogen, if product is mixed with nitrates, nitrites, nitrogen oxides or other nitrosamines.

Exposure Levels
No data available

Interactive effects
Skin disorders.

Data limitations
No data available

Substances	CAS Number	Skin corrosion/irritation
Diethanolamine	111-42-2	Causes moderate skin irritation. (Rabbit)

Substances	CAS Number	Serious eye damage/irritation
Diethanolamine	111-42-2	Causes severe eye irritation (Rabbit)

Substances	CAS Number	Skin Sensitization
Diethanolamine	111-42-2	Did not cause sensitization on laboratory animals (guinea pig)

Substances	CAS Number	Respiratory Sensitization
Diethanolamine	111-42-2	No information available

Substances	CAS Number	Mutagenic Effects
Diethanolamine	111-42-2	In vivo tests did not show mutagenic effects.

Substances	CAS Number	Carcinogenic Effects
Diethanolamine	111-42-2	No data of sufficient quality are available.

Substances	CAS Number	Reproductive toxicity
Diethanolamine	111-42-2	Animal testing did not show any effects on fertility. (similar substances) Did not show teratogenic effects in animal experiments.

Substances	CAS Number	STOT - single exposure
Diethanolamine	111-42-2	No information available

Substances	CAS Number	STOT - repeated exposure
Diethanolamine	111-42-2	Causes damage to organs through prolonged or repeated exposure if swallowed: (Liver) (Blood) (Kidney)

Substances	CAS Number	Aspiration hazard
Diethanolamine	111-42-2	Not applicable

12. Ecological Information

Ecotoxicity

Substance Ecotoxicity Data

Substances	CAS Number	Toxicity to Algae	Toxicity to Fish	Toxicity to Microorganisms	Toxicity to Invertebrates
Diethanolamine	111-42-2	EC50 7.8 mg/L (Desmodesmus subspicatus) EC50 (96h) 2.2 mg/L (growth rate) (Selenastrum capricornutum)	LC50 4460-4980 mg/L (Pimephales promelas) LC50 (96h) 1460 mg/L (Pimephales promelas)	EC20 >1000 mg/L (respiration rate) (activated sludge) EC90 (30min) > 1000 mg/L (Activated sludge)	EC50 (48h) 30.1 mg/L (Ceriodaphnia dubia) EC50 (48h) 55 mg/L (Daphnia magna) NOEC (21d) 0.78 mg/L (Daphnia magna) (Reproduction)

12.2. Persistence and degradability

Substances	CAS Number	Persistence and Degradability
Diethanolamine	111-42-2	Readily biodegradable (88 - 97% @ 28d)

12.3. Bioaccumulative potential

Substances	CAS Number	Log Pow
Diethanolamine	111-42-2	-1.71

12.4. Mobility in soil

Substances	CAS Number	Mobility
Diethanolamine	111-42-2	No information available

12.6. Other adverse effects

Endocrine Disruptor Information

This product does not contain any known or suspected endocrine disruptors

13. Disposal Considerations

Safe handling and disposal methods

Disposal should be made in accordance with federal, state, and local regulations.

Disposal of any contaminated packaging

Follow all applicable national or local regulations.

Environmental regulations

Not applicable

14. Transport Information

Transportation Information

Australia ADG

UN Number	Not restricted
UN proper shipping name:	Not restricted
Transport Hazard Class(es):	Not applicable
Packing Group:	Not applicable
Environmental Hazards:	Not applicable

IMDG/IMO

UN Number	Not restricted
UN proper shipping name:	Not restricted
Transport Hazard Class(es):	Not applicable
Packing Group:	Not applicable
Environmental Hazards:	Not applicable

IATA/ICAO

UN Number	Not restricted
UN proper shipping name:	Not restricted
Transport Hazard Class(es):	Not applicable
Packing Group:	Not applicable
Environmental Hazards:	Not applicable

Special precautions during transport

None

HazChem Code

None Allocated

15. Regulatory Information

Safety, health and environmental regulations specific for the product

International Inventories

Australian AICS Inventory	All components are listed on the AICS or are subject to a relevant exemption, permit, or assessment certificate.
New Zealand Inventory of Chemicals	All components are listed on the NZIoC or are subject to a relevant exemption, permit, or assessment certificate.
EINECS (European Inventory of Existing Chemical Substances)	This product, and all its components, complies with EINECS
US TSCA Inventory	All components listed on inventory or are exempt.
Canadian Domestic Substances List (DSL)	All components listed on inventory or are exempt.

Poisons Schedule number
None Allocated

International Agreements

Montreal Protocol - Ozone Depleting Substances:	Does not apply
Stockholm Convention - Persistent Organic Pollutants:	Does not apply
Rotterdam Convention - Prior Informed Consent:	Does not apply
Basel Convention - Hazardous Waste:	Does not apply

16. Other information

Date of preparation or review

Revision Date: 23-Jan-2017

Revision Note

Full text of H-Statements referred to under sections 2 and 3
H302 - Harmful if swallowed
H315 - Causes skin irritation
H318 - Causes serious eye damage
H373 - May cause damage to organs through prolonged or repeated exposure if swallowed
H401 - Toxic to aquatic life
H402 - Harmful to aquatic life
H412 - Harmful to aquatic life with long lasting effects

Additional information

For additional information on the use of this product, contact your local Halliburton representative.

For questions about the Safety Data Sheet for this or other Halliburton products, contact Chemical Stewardship at 1-580-251-4335.

Key abreviations or acronyms used
bw – body weight
CAS – Chemical Abstracts Service
EC50 – Effective Concentration 50%
LC50 – Lethal Concentration 50%
LD50 – Lethal Dose 50%
LL50 – Lethal Loading 50%
mg/kg – milligram/kilogram
mg/L – milligram/liter
NOEC – No Observed Effect Concentration
OEL – Occupational Exposure Limit
PBT – Persistent Bioaccumulative and Toxic
ppm – parts per million
STEL – Short Term Exposure Limit
TWA – Time-Weighted Average
vPvB – very Persistent and very Bioaccumulative
h - hour
mg/m^3 - milligram/cubic meter
mm - millimeter
mmHg - millimeter mercury
w/w - weight/weight
d - day

Key literature references and sources for data
www.ChemADVISOR.com/

Disclaimer Statement
This information is furnished without warranty, expressed or implied, as to accuracy or completeness. The information is obtained from various sources including the manufacturer and other third party sources. The information may not be valid under all

conditions nor if this material is used in combination with other materials or in any process. Final determination of suitability of any material is the sole responsibility of the user.

End of Safety Data Sheet

HALLIBURTON

SAFETY DATA SHEET

DCA-13002

Revision Date: 21-Sep-2017 **Revision Number:** 22

1. Product Identifier & Identity for the Chemical

Statement of Hazardous Nature Hazardous according to the criteria of the 3rd Revised Edition of the Globally Harmonised System of Classification and Labelling of Chemicals (GHS), Dangerous Goods according to the criteria of ADG.

1.1. Product Identifier

Product Name DCA-13002

Other means of Identification

Synonyms None

Hazardous Material Number: HM007647

Recommended use of the chemical and restrictions on use

Recommended Use Breaker

Uses advised against No information available

Supplier's name, address and phone number

Manufacturer/Supplier Halliburton Australia Pty. Ltd.
15 Marriott Road, Jandakot, WA 6164
Australia
ACN Number: 009 000 775
Telephone Number: + 61 1 800 686 951
Fax Number: 61 (08) 9455 5300

E-mail Address fdunexchem@halliburton.com

Emergency phone number

+ 61 1 800 686 951
Global Incident Response Access Code: 334305
Contract Number: 14012

Australian Poisons Information Centre
24 Hour Service: - 13 11 26
Police or Fire Brigade: - 000 (exchange): - 1100

2. Hazard Identification

Statement of Hazardous Nature Hazardous according to the criteria of the 3rd Revised Edition of the Globally Harmonised System of Classification and Labelling of Chemicals (GHS), Dangerous Goods according to the criteria of ADG.

Classification of the hazardous chemical

Acute Oral Toxicity	Category 4 - H302
Skin Corrosion/Irritation	Category 2 - H315
Serious Eye Damage/Irritation	Category 2 - H319
Respiratory Sensitization	Category 1 - H334
Skin Sensitization	Category 1 - H317
Specific Target Organ Toxicity - (Single Exposure)	Category 3 - H335
Oxidizing solids.	Category 3 - H272

Label elements, including precautionary statements

Hazard Pictograms

Signal Word DANGER

Hazard Statements:
H272 - May intensify fire; oxidizer
H302 - Harmful if swallowed
H315 - Causes skin irritation
H317 - May cause an allergic skin reaction
H319 - Causes serious eye irritation
H334 - May cause allergy or asthma symptoms or breathing difficulties if inhaled
H335 - May cause respiratory irritation

Precautionary Statements

Prevention
P210 - Keep away from heat, hot surfaces, sparks, open flames and other ignition sources. No smoking.
P221 - Take any precaution to avoid mixing with combustibles
P261 - Avoid breathing dust/fume/gas/mist/vapors/spray
P264 - Wash face, hands and any exposed skin thoroughly after handling
P270 - Do not eat, drink or smoke when using this product
P271 - Use only outdoors or in a well-ventilated area
P272 - Contaminated work clothing should not be allowed out of the workplace
P280 - Wear protective gloves/protective clothing/eye protection/face protection
P285 - In case of inadequate ventilation wear respiratory protection

Response
P301 + P312 - IF SWALLOWED: Call a POISON CENTER or doctor/physician if you feel unwell
P330 - Rinse mouth
P302 + P352 - IF ON SKIN: Wash with plenty of water.
P332 + P313 - If skin irritation occurs: Get medical advice/attention
P333 + P313 - If skin irritation or rash occurs: Get medical advice/attention
P362 + P364 - Take off contaminated clothing and wash before reuse
P304 + P341 - IF INHALED: If breathing is difficult, remove to fresh air and keep at rest in a position comfortable for breathing
P342 + P311 - If experiencing respiratory symptoms: Call a POISON CENTER or doctor/physician
P305 + P351 + P338 - IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing
P337 + P313 - If eye irritation persists: Get medical advice/attention
P370 + P378 - In case of fire: Use water spray for extinction

Storage
P403 + P233 - Store in a well-ventilated place. Keep container tightly closed
P405 - Store locked up

Disposal
P501 - Dispose of contents/container in accordance with local/regional/national/international regulations

Contains Substances	**CAS Number**
Sodium persulfate	7775-27-1

Other hazards which do not result in classification

This substance is not considered to be persistent, bioaccumulating nor toxic (PBT).
This substance is not considered to be very persistent nor very bioaccumulating (vPvB).

For the full text of the H-phrases mentioned in this Section, see Section 16

3. Composition/information on Ingredients

Substances	CAS Number	PERCENT (w/w)	GHS Classification - Australia
Sodium persulfate	7775-27-1	60 - 100%	Acute Tox. 4 (H302) Skin Irrit. 2 (H315) Eye Irrit. 2 (H319) Resp. Sens. 1 (H334) Skin Sens. 1 (H317) STOT SE 3 (H335) Ox. Sol. 3 (H272)

4. First aid measures

Description of necessary first aid measures

Inhalation If inhaled, remove from area to fresh air. Get medical attention if respiratory irritation develops or if breathing becomes difficult.

Eyes In case of contact, immediately flush eyes with plenty of water for at least 15 minutes and get medical attention if irritation persists.

Skin Wash off immediately with soap and plenty of water for at least 15 minutes while removing all contaminated clothing and shoes.

Ingestion Do NOT induce vomiting. Give nothing by mouth. Obtain immediate medical attention.

Symptoms caused by exposure

Causes eye irritation. Causes skin irritation. May cause allergic skin reaction. May cause allergic respiratory reaction. May cause respiratory irritation. Harmful if swallowed.

Medical Attention and Special Treatment

Notes to Physician Treat symptomatically

5. Fire Fighting Measures

Suitable extinguishing equipment

Suitable Extinguishing Media

Water fog, carbon dioxide, foam, dry chemical.

Extinguishing media which must not be used for safety reasons

None known.

Specific hazards arising from the chemical

Special exposure hazards in a fire

Oxidizer. May ignite combustibles. Decomposition in fire may produce harmful gases.

Special protective equipment and precautions for fire fighters

Special protective equipment for firefighters

Full protective clothing and approved self-contained breathing apparatus required for fire fighting personnel.

6. Accidental release measures

6.1. Personal precautions, protective equipment and emergency procedures

Remove sources of ignition. Use appropriate protective equipment. Avoid creating and breathing dust. Avoid contact with skin, eyes and clothing. Ensure adequate ventilation. Evacuate all persons from the area.

6.2. Environmental precautions

Prevent from entering sewers, waterways, or low areas. Consult local authorities.

6.3. Methods and material for containment and cleaning up

Scoop up and remove.

7. Handling and storage

7.1. Precautions for safe handling

Handling Precautions

Remove sources of ignition. Avoid contact with eyes, skin, or clothing. Avoid creating or inhaling dust. Avoid dust accumulations. Ensure adequate ventilation. Wash hands after use. Launder contaminated clothing before reuse. Use appropriate protective equipment.

Hygiene Measures

Handle in accordance with good industrial hygiene and safety practice.

7.2. Conditions for safe storage, including any incompatibilities

Storage Information

Store away from combustibles. Store in a cool well ventilated area. Keep container closed when not in use. Product has a shelf life of 12 months.

Other Guidelines

No information available

8. Exposure Controls/Personal Protection

Control parameters - exposure standards, biological monitoring

Exposure Limits

Substances	CAS Number	Australia NOHSC	ACGIH TLV-TWA
Sodium persulfate	7775-27-1	0.01 mg/m^3	TWA: 0.1 mg/m^3

Appropriate engineering controls

Engineering Controls Use in a well ventilated area. Localized ventilation should be used to control dust levels.

Personal protective equipment (PPE)

Personal Protective Equipment If engineering controls and work practices cannot prevent excessive exposures, the selection and proper use of personal protective equipment should be determined by an industrial hygienist or other qualified professional based on the specific application of this product.

Respiratory Protection If engineering controls and work practices cannot keep exposure below occupational exposure limits or if exposure is unknown, wear a NIOSH certified, European Standard EN 149, AS/NZS 1715:2009, or equivalent respirator when using this product. Selection of and instruction on using all personal protective equipment, including respirators, should be performed by an Industrial Hygienist or other qualified professional.
Dust/mist respirator. (N95, P2/P3)

Hand Protection Chemical-resistant protective gloves (EN 374) Suitable materials for longer, direct contact (recommended: protection index 6, corresponding to > 480 minutes permeation time as per EN 374): Butyl rubber gloves. (>= 0.7 mm thickness)
This information is based on literature references and on information provided by glove manufacturers, or is derived by analogy with similar substances. Please note that in practice the working life of chemical-resistant protective gloves may be considerably shorter than the permeation time determined in accordance with EN 374 as a result of the many influencing factors (e.g. temperature). If signs of wear and tear are noticed then the gloves should be replaced. Manufacturer's directions for use should be observed because of great diversity of types.

Skin Protection Rubber apron.

Eye Protection Dust proof goggles.

Other Precautions None known.

Environmental Exposure Controls Do not allow material to contaminate ground water system

9. Physical and Chemical Properties

9.1. Information on basic physical and chemical properties

Physical State: Solid
Color White
Odor: Odorless
Odor Threshold: No information available

Property Remarks/ - Method	Values
pH:	6
Freezing Point / Range	No data available
Melting Point / Range	No data available
Boiling Point / Range	No data available
Flash Point	No data available
Evaporation rate	No data available
Vapor Pressure	No data available
Vapor Density	No data available
Specific Gravity	2.47
Water Solubility	Soluble in water
Solubility in other solvents	No data available
Partition coefficient: n-octanol/water	No data available
Autoignition Temperature	No data available
Decomposition Temperature	No data available
Viscosity	No data available
Explosive Properties	No information available
Oxidizing Properties	No information available

9.2. Other information

Molecular Weight	238.1 g/mol
VOC Content (%)	No data available

10. Stability and Reactivity

10.1. Reactivity
Not expected to be reactive.
10.2. Chemical stability
Stable
10.3. Possibility of hazardous reactions
Will Not Occur
10.4. Conditions to avoid
Avoid contact with readily oxidizable materials.
10.5. Incompatible materials
Avoid halogens. Contact with acids. Strong alkalis. Combustible materials.
10.6. Hazardous decomposition products
Oxides of sulfur. Oxygen. Sulfuric acid.

11. Toxicological Information

Information on routes of exposure
Principle Route of Exposure Eye or skin contact, inhalation.

Symptoms related to exposure
Most Important Symptoms/Effects
Causes eye irritation. Causes skin irritation. May cause allergic skin reaction. May cause allergic respiratory reaction. May cause respiratory irritation. Harmful if swallowed.

Toxicology data for the components

Substances	CAS Number	LD50 Oral	LD50 Dermal	LC50 Inhalation

Sodium persulfate	7775-27-1	895 mg/kg (Rat) 1200 mg/kg 930 mg/kg 1000 mg/kg 920 mg/kg	> 10000 mg/kg (Rat)	19.0 mg/L (Rat) 4h > 5.1 mg/L (Rat) 4h

Immediate, delayed and chronic health effects from exposure

Inhalation May cause respiratory irritation. May cause allergy or asthma symptoms or breathing difficulties if inhaled

Eye Contact Causes eye irritation.

Skin Contact Causes skin irritation. May cause an allergic skin reaction.

Ingestion Harmful if swallowed. Irritation of the mouth, throat, and stomach.

Chronic Effects/Carcinogenicity No data available to indicate product or components present at greater than 0.1% are chronic health hazards.

Exposure Levels
No data available

Interactive effects
Lung disorders.

Data limitations
No data available

Substances	CAS Number	Skin corrosion/irritation
Sodium persulfate	7775-27-1	Causes skin irritation. (Rabbit)

Substances	CAS Number	Serious eye damage/irritation
Sodium persulfate	7775-27-1	Causes severe eye irritation (Rabbit)

Substances	CAS Number	Skin Sensitization
Sodium persulfate	7775-27-1	Skin sensitizer in guinea pig.

Substances	CAS Number	Respiratory Sensitization
Sodium persulfate	7775-27-1	May cause sensitization by inhalation

Substances	CAS Number	Mutagenic Effects
Sodium persulfate	7775-27-1	In vitro tests did not show mutagenic effects. In vivo tests did not show mutagenic effects.

Substances	CAS Number	Carcinogenic Effects
Sodium persulfate	7775-27-1	Did not show carcinogenic effects in animal experiments (similar substances)

Substances	CAS Number	Reproductive toxicity
Sodium persulfate	7775-27-1	Animal testing did not show any effects on fertility. Did not show teratogenic effects in animal experiments. (similar substances)

Substances	CAS Number	STOT - single exposure
Sodium persulfate	7775-27-1	May cause respiratory irritation.

Substances	CAS Number	STOT - repeated exposure
Sodium persulfate	7775-27-1	No significant toxicity observed in animal studies at concentration requiring classification.

Substances	CAS Number	Aspiration hazard
Sodium persulfate	7775-27-1	Not applicable

12. Ecological Information

Ecotoxicity

Substance Ecotoxicity Data

Substances	CAS Number	Toxicity to Algae	Toxicity to Fish	Toxicity to Microorganisms	Toxicity to Invertebrates
Sodium persulfate	7775-27-1	EC50 (72h) 116 mg/L (biomass) (Pseudokirchnerella subcapitata)	LC50 (96h) 163 mg/L (Oncorhynchus mykiss)	EC10 (18h) 36 mg/L (Pseudomonas putida)	EC50 (48h) 133 mg/L (Daphnia magna)

12.2. Persistence and degradability

Substances	CAS Number	Persistence and Degradability
Sodium persulfate	7775-27-1	The methods for determining biodegradability are not applicable to inorganic substances.

12.3. Bioaccumulative potential

Substances	CAS Number	Log Pow
Sodium persulfate	7775-27-1	No information available

12.4. Mobility in soil

Substances	CAS Number	Mobility
Sodium persulfate	7775-27-1	No information available

12.6. Other adverse effects

Endocrine Disruptor Information

This product does not contain any known or suspected endocrine disruptors

13. Disposal Considerations

Safe handling and disposal methods

Disposal should be made in accordance with federal, state, and local regulations.

Disposal of any contaminated packaging

This bag may contain residue of a hazardous material. Some authorities may regulate such containers as hazardous waste. Dispose of container according to national or local regulations.

Environmental regulations

Not applicable

14. Transport Information

Transportation Information

Australia ADG

UN Number UN1505
UN proper shipping name: Sodium Persulfate
Transport Hazard Class(es): 5.1
Packing Group: III
Environmental Hazards: Not applicable

IMDG/IMO

UN Number UN1505
UN proper shipping name: Sodium Persulfate
Transport Hazard Class(es): 5.1
Packing Group: III
Environmental Hazards: Not applicable
EMS: EmS F-A, S-Q

IATA/ICAO

UN Number UN1505
UN proper shipping name: Sodium Persulfate
Transport Hazard Class(es): 5.1

Packing Group: III
Environmental Hazards: Not applicable

Special precautions during transport
None

HazChem Code
1Z

15. Regulatory Information

Safety, health and environmental regulations specific for the product

International Inventories

Australian AICS Inventory	All components are listed on the AICS or are subject to a relevant exemption, permit, or assessment certificate.
New Zealand Inventory of Chemicals	All components are listed on the NZIoC or are subject to a relevant exemption, permit, or assessment certificate.
EINECS (European Inventory of Existing Chemical Substances)	This product, and all its components, complies with EINECS
US TSCA Inventory	All components listed on inventory or are exempt.
Canadian Domestic Substances List (DSL)	All components listed on inventory or are exempt.

Poisons Schedule number
None Allocated

International Agreements

Montreal Protocol - Ozone Depleting Substances:	Does not apply
Stockholm Convention - Persistent Organic Pollutants:	Does not apply
Rotterdam Convention - Prior Informed Consent:	Does not apply
Basel Convention - Hazardous Waste:	Does not apply

16. Other information

Date of preparation or review

Revision Date: 21-Sep-2017

Revision Note
SDS sections updated:
2

Full text of H-Statements referred to under sections 2 and 3
H272 - May intensify fire; oxidizer
H302 - Harmful if swallowed
H315 - Causes skin irritation
H317 - May cause an allergic skin reaction
H319 - Causes serious eye irritation
H334 - May cause allergy or asthma symptoms or breathing difficulties if inhaled
H335 - May cause respiratory irritation

Additional information For additional information on the use of this product, contact your local Halliburton representative.

For questions about the Safety Data Sheet for this or other Halliburton products, contact Chemical Stewardship at 1-580-251-4335.

Key abreviations or acronyms used
bw – body weight

CAS – Chemical Abstracts Service
EC50 – Effective Concentration 50%
LC50 – Lethal Concentration 50%
LD50 – Lethal Dose 50%
LL50 – Lethal Loading 50%
mg/kg – milligram/kilogram
mg/L – milligram/liter
NOEC – No Observed Effect Concentration
OEL – Occupational Exposure Limit
PBT – Persistent Bioaccumulative and Toxic
ppm – parts per million
STEL – Short Term Exposure Limit
TWA – Time-Weighted Average
vPvB – very Persistent and very Bioaccumulative
h - hour
mg/m^3 - milligram/cubic meter
mm - millimeter
mmHg - millimeter mercury
w/w - weight/weight
d - day

Key literature references and sources for data
www.ChemADVISOR.com/
OSHA
ECHA C&L

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End of Safety Data Sheet

HALLIBURTON

SAFETY DATA SHEET

DCA-13003

Revision Date: 05-Jul-2016 **Revision Number:** 13

1. Product Identifier & Identity for the Chemical

Statement of Hazardous Nature Hazardous according to the criteria of the 3rd Revised Edition of the Globally Harmonised System of Classification and Labelling of Chemicals (GHS), Dangerous Goods according to the criteria of ADG.

1.1. Product Identifier

Product Name DCA-13003

Other means of Identification

Synonyms None

Hazardous Material Number: HM007648

Recommended use of the chemical and restrictions on use

Recommended Use Breaker

Uses advised against No information available

Supplier's name, address and phone number

Manufacturer/Supplier

Halliburton Australia Pty. Ltd.
15 Marriott Road
Jandakot
WA 6164
Australia

ACN Number: 009 000 775
Telephone Number: + 61 1 800 686 951
Fax Number: 61 (08) 9455 5300

E-mail Address fdunexchem@halliburton.com

Emergency phone number

+ 61 1 800 686 951

Australian Poisons Information Centre
24 Hour Service: - 13 11 26
Police or Fire Brigade: - 000 (exchange): - 1100

2. Hazard Identification

Statement of Hazardous Nature Hazardous according to the criteria of the 3rd Revised Edition of the Globally Harmonised System of Classification and Labelling of Chemicals (GHS), Dangerous Goods according to the criteria of ADG.

Classification of the hazardous chemical

Acute toxicity - Dermal	Category 4 - H312
Acute inhalation toxicity - vapor	Category 4 - H332
Skin Corrosion/Irritation	Category 1 - H314
Serious Eye Damage/Irritation	Category 1 - H318
Acute Aquatic Toxicity	Category 2 - H401

Label elements, including precautionary statements

Hazard pictograms

Signal Word Danger

Hazard Statements:
H312 - Harmful in contact with skin
H314 - Causes severe skin burns and eye damage
H318 - Causes serious eye damage
H332 - Harmful if inhaled
H401 - Toxic to aquatic life

Precautionary Statements

Prevention
P260 - Do not breathe dust/fume/gas/mist/vapors/spray
P271 - Use only outdoors or in a well-ventilated area
P273 - Avoid release to the environment
P280 - Wear protective gloves/protective clothing/eye protection/face protection

Response
P301 + P330 + P331 - IF SWALLOWED: rinse mouth. Do NOT induce vomiting
P303 + P361 + P353 - IF ON SKIN (or hair): Take off immediately all contaminated clothing. Rinse skin with water/shower
P304 + P340 - IF INHALED: Remove victim to fresh air and keep at rest in a position comfortable for breathing
P310 - Immediately call a POISON CENTER or doctor/physician
P305 + P351 + P338 - IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing

Storage
P405 - Store locked up

Disposal
P501 - Dispose of contents/container in accordance with local/regional/national/international regulations

Contains

Substances	**CAS Number**
Chlorous acid, sodium salt	7758-19-2
Sodium chloride	7647-14-5

Other hazards which do not result in classification
This mixture contains no substance considered to be persistent, bioaccumulating nor toxic (PBT).
This mixture contains no substance considered to be very persistent nor very bioaccumulating (vPvB).

For the full text of the H-phrases mentioned in this Section, see Section 16

3. Composition/information on Ingredients

Substances	CAS Number	PERCENT (w/w)	GHS Classification - Australia
Chlorous acid, sodium salt	7758-19-2	5 - 10%	Acute Tox. 3 (H301) Acute Tox. 2 (H310) Acute Tox. 2 (H330) Skin Corr. 1B (H314) Eye Corr. 1 (H318) STOT SE 3 (H335) STOT RE 2 (H373) Aquatic Acute 1 (H400) Aquatic Chronic 3 (H412) Ox. Sol. 2 (H272)

Sodium chloride	7647-14-5	10 - 30%	Not Classified

4. First aid measures

Description of necessary first aid measures

Inhalation If inhaled, move victim to fresh air and seek medical attention.

Eyes In case of contact, immediately flush eyes with plenty of water for at least 30 minutes. Remove contact lenses after the first 5 minutes and continue washing. Seek immediate medical attention/advice. Suitable emergency eye wash facility should be immediately available

Skin In case of contact, immediately flush skin with plenty of soap and water for at least 30 minutes and remove contaminated clothing, shoes and leather goods immediately. Get medical attention immediately.

Ingestion Do NOT induce vomiting. Give nothing by mouth. Obtain immediate medical attention.

Symptoms caused by exposure

Causes severe eye irritation which may damage tissue. Causes severe skin irritation with tissue destruction. Harmful in contact with skin. Harmful if inhaled.

Medical Attention and Special Treatment

Notes to Physician Treat symptomatically

5. Fire Fighting Measures

Suitable extinguishing equipment

Suitable Extinguishing Media

Water fog, carbon dioxide, foam, dry chemical.

Extinguishing media which must not be used for safety reasons

None known.

Specific hazards arising from the chemical

Special exposure hazards in a fire

Product is not expected to burn unless all the water is boiled away. Use water spray to cool fire exposed surfaces. Decomposition in fire may produce harmful gases. If allowed to dry, this product is an oxidizer.

Special protective equipment and precautions for fire fighters

Special protective equipment for firefighters

Full protective clothing and approved self-contained breathing apparatus required for fire fighting personnel.

6. Accidental release measures

6.1. Personal precautions, protective equipment and emergency procedures

Use appropriate protective equipment. Wear self-contained breathing apparatus in enclosed areas. Avoid contact with skin, eyes and clothing. Avoid breathing vapors. Ensure adequate ventilation. Evacuate all persons from the area.

6.2. Environmental precautions

Prevent from entering sewers, waterways, or low areas.

6.3. Methods and material for containment and cleaning up

Isolate spill and stop leak where safe. Contain spill with sand or other inert materials. Scoop up and remove.

7. Handling and storage

7.1. Precautions for safe handling

Handling Precautions

Avoid contact with eyes, skin, or clothing. Avoid breathing vapors. Ensure adequate ventilation. Wash hands after use. Launder

contaminated clothing before reuse. Use appropriate protective equipment.

Hygiene Measures

Handle in accordance with good industrial hygiene and safety practice.

7.2. Conditions for safe storage, including any incompatibilities

Storage Information

Store away from acids. Store away from reducing agents. Store away from direct sunlight. Keep from excessive heat. Product has a shelf life of 24 months.

Other Guidelines

No information available

8. Exposure Controls/Personal Protection

Control parameters - exposure standards, biological monitoring

Exposure Limits

Substances	CAS Number	Australia NOHSC	ACGIH TLV-TWA
Chlorous acid, sodium salt	7758-19-2	Not applicable	Not applicable
Sodium chloride	7647-14-5	Not applicable	Not applicable

Appropriate engineering controls

Engineering Controls Use in a well ventilated area.

Personal protective equipment (PPE)

Personal Protective Equipment If engineering controls and work practices cannot prevent excessive exposures, the selection and proper use of personal protective equipment should be determined by an industrial hygienist or other qualified professional based on the specific application of this product.

Respiratory Protection If engineering controls and work practices cannot keep exposure below occupational exposure limits or if exposure is unknown, wear a NIOSH certified, European Standard EN 149, AS/NZS 1715:2009, or equivalent respirator when using this product. Selection of and instruction on using all personal protective equipment, including respirators, should be performed by an Industrial Hygienist or other qualified professional.
Organic vapor/acid gas/chlorine respirator.

Hand Protection Chemical-resistant protective gloves (EN 374) Suitable materials for longer, direct contact (recommended: protection index 6, corresponding to > 480 minutes permeation time as per EN 374): Butyl rubber gloves. (>= 0.7 mm thickness)
This information is based on literature references and on information provided by glove manufacturers, or is derived by analogy with similar substances. Please note that in practice the working life of chemical-resistant protective gloves may be considerably shorter than the permeation time determined in accordance with EN 374 as a result of the many influencing factors (e.g. temperature). If signs of wear and tear are noticed then the gloves should be replaced. Manufacturer's directions for use should be observed because of great diversity of types.

Skin Protection Full protective chemical resistant clothing.

Eye Protection Chemical goggles; also wear a face shield if splashing hazard exists.

Other Precautions Eyewash fountains and safety showers must be easily accessible.

Environmental Exposure Controls Do not allow material to contaminate ground water system

9. Physical and Chemical Properties

9.1. Information on basic physical and chemical properties

Physical State: Liquid
Color Clear tan
Odor: Mild chlorine
Odor Threshold: No information available

Property	Values	Remarks/ - Method
pH:	11.5-12.5	
Freezing Point / Range	3-4 °C	
Melting Point / Range	No data available	
Boiling Point / Range	106 - 108 °C	
Flash Point	No data available	

Evaporation rate	No data available
Vapor Pressure	No data available
Vapor Density	No data available
Specific Gravity	1.17 - 1.23
Water Solubility	Soluble in water
Solubility in other solvents	No data available
Partition coefficient: n-octanol/water	No data available
Autoignition Temperature	No data available
Decomposition Temperature	No data available
Viscosity	No data available
Explosive Properties	No information available
Oxidizing Properties	No information available

9.2. Other information

VOC Content (%) No data available

10. Stability and Reactivity

10.1. Reactivity

Not expected to be reactive.

10.2. Chemical stability

Stable

10.3. Possibility of hazardous reactions

10.4. Conditions to avoid

Keep away from heat, sparks and flame. Avoid contact with organic materials. Avoid friction.

10.5. Incompatible materials

Prolonged contact with aluminum. Contact with metals. Organic matter. Contact with ammonia. All flammables, especially petroleum products, asphalt & other volatile flammables. Ammonium compounds. Strong acids.

10.6. Hazardous decomposition products

Chlorine.

11. Toxicological Information

Information on routes of exposure

Principle Route of Exposure Eye or skin contact, inhalation.

Symptoms related to exposure

Most Important Symptoms/Effects

Causes severe eye irritation which may damage tissue. Causes severe skin irritation with tissue destruction. Harmful in contact with skin. Harmful if inhaled.

Numerical measures of toxicity

Toxicology data for the components

Substances	CAS Number	LD50 Oral	LD50 Dermal	LC50 Inhalation
Chlorous acid, sodium salt	7758-19-2	165 mg/kg (Rat) 390 - 500 mg/kg (Rat) 212 – 284 mg/kg (Rat)	315 mg/kg (Rat) 134 mg/kg (Rabbit)	0.29 mg/L (Rat) 4h 230 mg/m³ (Rat) 4h
Sodium chloride	7647-14-5	3000 mg/kg-bw (rat)	No data available	No data available

Immediate, delayed and chronic health effects from exposure

Inhalation	Harmful if inhaled. Causes severe respiratory irritation.
Eye Contact	Causes severe eye irritation which may damage tissue.
Skin Contact	Harmful in contact with skin. Causes severe burns.
Ingestion	Causes burns of the mouth, throat and stomach. May cause abdominal pain, vomiting, nausea, and diarrhea.

Chronic Effects/Carcinogenicity Prolonged or repeated exposure may cause adverse effects on the blood.

Exposure Levels

No data available

Interactive effects
Blood disorders.

Data limitations
No data available

Substances	CAS Number	Skin corrosion/irritation
Chlorous acid, sodium salt	7758-19-2	Corrosive to skin (Rabbit)
Sodium chloride	7647-14-5	Non-irritating to the skin (Rabbit) Not a dermal irritant

Substances	CAS Number	Serious eye damage/irritation
Chlorous acid, sodium salt	7758-19-2	Corrosive to eyes (Rabbit)
Sodium chloride	7647-14-5	May cause mild eye irritation. (Rabbit)

Substances	CAS Number	Skin Sensitization
Chlorous acid, sodium salt	7758-19-2	Did not cause sensitization on laboratory animals (guinea pig)
Sodium chloride	7647-14-5	No information available Not confirmed to cause skin or respiratory sensitization.

Substances	CAS Number	Respiratory Sensitization
Chlorous acid, sodium salt	7758-19-2	No information available
Sodium chloride	7647-14-5	No information available

Substances	CAS Number	Mutagenic Effects
Chlorous acid, sodium salt	7758-19-2	Not regarded as mutagenic.
Sodium chloride	7647-14-5	No information available

Substances	CAS Number	Carcinogenic Effects
Chlorous acid, sodium salt	7758-19-2	Did not show carcinogenic effects in animal experiments
Sodium chloride	7647-14-5	Did not show carcinogenic effects in animal experiments

Substances	CAS Number	Reproductive toxicity
Chlorous acid, sodium salt	7758-19-2	Animal testing did not show any effects on fertility. (fetotoxic and teratogenic effects).
Sodium chloride	7647-14-5	Animal testing did not show any effects on fertility. Did not show teratogenic effects in animal experiments.

Substances	CAS Number	STOT - single exposure
Chlorous acid, sodium salt	7758-19-2	May cause respiratory irritation.
Sodium chloride	7647-14-5	No information available

Substances	CAS Number	STOT - repeated exposure
Chlorous acid, sodium salt	7758-19-2	Causes damage to organs through prolonged or repeated exposure if swallowed: (spleen) (Blood)
Sodium chloride	7647-14-5	No significant toxicity observed in animal studies at concentration requiring classification.

Substances	CAS Number	Aspiration hazard
Chlorous acid, sodium salt	7758-19-2	Not applicable
Sodium chloride	7647-14-5	Not applicable

12. Ecological Information

Ecotoxicity
Product Ecotoxicity Data
No data available

Substance Ecotoxicity Data

Substances	CAS Number	Toxicity to Algae	Toxicity to Fish	Toxicity to Microorganisms	Toxicity to Invertebrates
Chlorous acid, sodium salt	7758-19-2	EC50 (72h) 9.09 mg/L (Skeletonema costatum) EC50 (72h) 0.2 mg/L (Pseudokirchnerella	LC50 (96h) 210 mg/L (Scophthalmus maximus) TLM96 290 mg/L (Oncorhynchus mykiss)	EC50 (3h) > 75 mg/L (activated sludge)	LC50 (48h) 50.67 mg/L (Acartia tonsa) TLM96 0.29 mg/L (Daphnia magna)

		subcapitata)	TLM96 208 mg/L (Lepomis macrochirus)		NOEC (22d) 25 ug/L (Daphnia magna)
Sodium chloride	7647-14-5	EC50 (120h) 2430 mg/L (Nitzschia sp.)	TLM96 > 1000 mg/L (Oncorhynchus mykiss) LC50 (96h) 5840 mg/L (Lepomis macrochirus) NOEC (33d) 252 mg/L (Pimephales promelas)	NOEC 5000 – 8000 mg/L (activated sludge) NOEC 292-584 mg/L (Escherichia coli)	TLM96 > 1,000,000 ppm (Mysidopsis bahia) LC50 (48h) 874-4136 mg/L (Daphnia magna) NOEC (21d) 314 mg/L (Daphnia pulex)

12.2. Persistence and degradability

Substances	CAS Number	Persistence and Degradability
Chlorous acid, sodium salt	7758-19-2	The methods for determining biodegradability are not applicable to inorganic substances.
Sodium chloride	7647-14-5	No information available

12.3. Bioaccumulative potential

Substances	CAS Number	Log Pow
Chlorous acid, sodium salt	7758-19-2	No information available
Sodium chloride	7647-14-5	No information available

12.4. Mobility in soil

Substances	CAS Number	Mobility
Chlorous acid, sodium salt	7758-19-2	No information available
Sodium chloride	7647-14-5	No information available

12.6. Other adverse effects

Endocrine Disruptor Information

This product does not contain any known or suspected endocrine disruptors

13. Disposal Considerations

Safe handling and disposal methods

Disposal should be made in accordance with federal, state, and local regulations.

Disposal of any contaminated packaging

Follow all applicable national or local regulations.

Environmental regulations

Not applicable

14. Transport Information

Transportation Information

Australia ADG

UN Number UN1908
UN proper shipping name: Chlorite Solution (14% Available Chlorine)
Transport Hazard Class(es): 8
Packing Group: III
Environmental Hazards: Not applicable

IMDG/IMO

UN Number UN1908
UN proper shipping name: Chlorite Solution (14% Available Chlorine)
Transport Hazard Class(es): 8
Packing Group: III
Environmental Hazards: Not applicable
EMS: EmS F-A, S-B

IATA/ICAO

UN Number	UN1908
UN proper shipping name:	Chlorite Solution (14% Available Chlorine)
Transport Hazard Class(es):	8
Packing Group:	III
Environmental Hazards:	Not applicable

Special precautions during transport
None

HazChem Code
2X

15. Regulatory Information

Safety, health and environmental regulations specific for the product

International Inventories

Australian AICS Inventory	All components are listed on the AICS or are subject to a relevant exemption, permit, or assessment certificate.
New Zealand Inventory of Chemicals	All components are listed on the NZIoC or are subject to a relevant exemption, permit, or assessment certificate.
EINECS (European Inventory of Existing Chemical Substances)	This product, and all its components, complies with EINECS
US TSCA Inventory	All components listed on inventory or are exempt.
Canadian Domestic Substances List (DSL)	All components listed on inventory or are exempt.

Poisons Schedule number
None Allocated

International Agreements

Montreal Protocol - Ozone Depleting Substances:	Does not apply
Stolkhom Convention - Persistent Organic Pollutants:	Does not apply
Rotterdam Convention - Prior Informed Consent:	Does not apply
Basel Convention - Hazardous Waste:	Does not apply

16. Other information

Date of preparation or review

Revision Date: 05-Jul-2016

Revision Note
SDS sections updated: 2

Full text of H-Statements referred to under sections 2 and 3
H272 - May intensify fire; oxidizer
H301 - Toxic if swallowed
H310 - Fatal in contact with skin
H312 - Harmful in contact with skin
H314 - Causes severe skin burns and eye damage
H318 - Causes serious eye damage
H320 - Causes eye irritation
H330 - Fatal if inhaled
H332 - Harmful if inhaled
H335 - May cause respiratory irritation
H373 - May cause damage to organs through prolonged or repeated exposure if inhaled
H400 - Very toxic to aquatic life
H412 - Harmful to aquatic life with long lasting effects

Additional information

For additional information on the use of this product, contact your local Halliburton representative.

For questions about the Safety Data Sheet for this or other Halliburton products, contact Chemical Stewardship at 1-580-251-4335.

Key abreviations or acronyms used

bw – body weight
CAS – Chemical Abstracts Service
EC50 – Effective Concentration 50%
LC50 – Lethal Concentration 50%
LD50 – Lethal Dose 50%
LL50 – Lethal Loading 50%
mg/kg – milligram/kilogram
mg/L – milligram/liter
NOEC – No Observed Effect Concentration
OEL – Occupational Exposure Limit
PBT – Persistent Bioaccumulative and Toxic
ppm – parts per million
STEL – Short Term Exposure Limit
TWA – Time-Weighted Average
vPvB – very Persistent and very Bioaccumulative
h - hour
mg/m^3 - milligram/cubic meter
mm - millimeter
mmHg - millimeter mercury
w/w - weight/weight
d - day

Key literature references and sources for data

www.ChemADVISOR.com/
OSHA
ECHA C&L

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End of Safety Data Sheet

HALLIBURTON

SAFETY DATA SHEET

DCA-14003

Revision Date: 27-Sep-2016 **Revision Number:** 11

1. Product Identifier & Identity for the Chemical

Statement of Hazardous Nature Non-Hazardous according to the criteria of the 3rd Revised Edition of the Globally Harmonised System of Classification and Labelling of Chemicals (GHS), Non-Dangerous Goods according to the criteria of ADG.

1.1. Product Identifier

Product Name DCA-14003

Other means of Identification

Synonyms None

Hazardous Material Number: HM007651

Recommended use of the chemical and restrictions on use

Recommended Use Buffer

Uses advised against No information available

Supplier's name, address and phone number

Manufacturer/Supplier Halliburton Australia Pty. Ltd.
15 Marriott Road, Jandakot, WA 6164
Australia
ACN Number: 009 000 775
Telephone Number: + 61 1 800 686 951
Fax Number: 61 (08) 9455 5300

E-mail Address fdunexchem@halliburton.com

Emergency phone number

+ 61 1 800 686 951

Australian Poisons Information Centre
24 Hour Service: - 13 11 26
Police or Fire Brigade: - 000 (exchange): - 1100

2. Hazard Identification

Statement of Hazardous Nature Non-Hazardous according to the criteria of the 3rd Revised Edition of the Globally Harmonised System of Classification and Labelling of Chemicals (GHS), Non-Dangerous Goods according to the criteria of ADG.

Classification of the hazardous chemical

Not classified

Label elements, including precautionary statements

Hazard pictograms

Signal Word Not Hazardous

Hazard Statements: Not Classified

Precautionary Statements

Prevention	None
Response	None
Storage	None
Disposal	None

Contains Substances	**CAS Number**
Contains no hazardous substances in concentrations above cut-off values according to the competent authority	NA

Other hazards which do not result in classification
This substance is not considered to be persistent, bioaccumulating nor toxic (PBT).
This substance is not considered to be very persistent nor very bioaccumulating (vPvB).

For the full text of the H-phrases mentioned in this Section, see Section 16

3. Composition/information on Ingredients

Substances	CAS Number	PERCENT (w/w)	GHS Classification - Australia
Contains no hazardous substances in concentrations above cut-off values according to the competent authority	NA	60 - 100%	Not Applicable

4. First aid measures

Description of necessary first aid measures

Inhalation	If inhaled, remove from area to fresh air. Get medical attention if respiratory irritation develops or if breathing becomes difficult.
Eyes	In case of contact, immediately flush eyes with plenty of water for at least 15 minutes and get medical attention if irritation persists.
Skin	Wash with soap and water. Get medical attention if irritation persists.
Ingestion	Under normal conditions, first aid procedures are not required.

Symptoms caused by exposure
No significant hazards expected.

Medical Attention and Special Treatment
Notes to Physician Treat symptomatically

5. Fire Fighting Measures

Suitable extinguishing equipment
Suitable Extinguishing Media
All standard fire fighting media
Extinguishing media which must not be used for safety reasons
None known.

Specific hazards arising from the chemical
Special exposure hazards in a fire
None anticipated

Special protective equipment and precautions for fire fighters
Special protective equipment for firefighters
Full protective clothing and approved self-contained breathing apparatus required for fire fighting personnel.

6. Accidental release measures

6.1. Personal precautions, protective equipment and emergency procedures
Use appropriate protective equipment. Avoid creating and breathing dust. Ensure adequate ventilation. Avoid contact with skin, eyes and clothing.

6.2. Environmental precautions
Prevent from entering sewers, waterways, or low areas.

6.3. Methods and material for containment and cleaning up
Scoop up and remove.

7. Handling and storage

7.1. Precautions for safe handling
Handling Precautions
Avoid creating or inhaling dust. Ensure adequate ventilation. Avoid contact with eyes, skin, or clothing. Wash hands after use. Launder contaminated clothing before reuse. Use appropriate protective equipment.
Hygiene Measures
Handle in accordance with good industrial hygiene and safety practice.

7.2. Conditions for safe storage, including any incompatibilities
Storage Information
Store away from acids. Store in a dry location.
Other Guidelines
No information available

8. Exposure Controls/Personal Protection

Control parameters - exposure standards, biological monitoring
Exposure Limits

Substances	CAS Number	Australia NOHSC	ACGIH TLV-TWA
Contains no hazardous substances in concentrations above cut-off values according to the competent authority	NA	Not applicable	Not applicable

Appropriate engineering controls

Engineering Controls	A well ventilated area to control dust levels. Local exhaust ventilation should be used in areas without good cross ventilation.

Personal protective equipment (PPE)

Personal Protective Equipment	If engineering controls and work practices cannot prevent excessive exposures, the selection and proper use of personal protective equipment should be determined by an industrial hygienist or other qualified professional based on the specific application of this product.
Respiratory Protection	Not normally needed. But if significant exposures are possible then the following respirator is recommended: Dust/mist respirator. (N95, P2/P3)
Hand Protection	Normal work gloves.
Skin Protection	Normal work coveralls.
Eye Protection	Wear safety glasses or goggles to protect against exposure.
Other Precautions	None known.
Environmental Exposure Controls	Do not allow material to contaminate ground water system

9. Physical and Chemical Properties

9.1. Information on basic physical and chemical properties

Physical State:	Solid	**Color**	White
Odor:	Odorless	**Odor Threshold:**	No information available

Property Remarks/ - Method	Values
pH:	8
Freezing Point / Range	No data available
Melting Point / Range	No data available
Boiling Point / Range	No data available
Flash Point	No data available
Evaporation rate	No data available
Vapor Pressure	No data available
Vapor Density	No data available
Specific Gravity	1.87
Water Solubility	Soluble in water
Solubility in other solvents	No data available
Partition coefficient: n-octanol/water	No data available
Autoignition Temperature	No data available
Decomposition Temperature	No data available
Viscosity	No data available
Explosive Properties	No information available
Oxidizing Properties	No information available

9.2. Other information

VOC Content (%) No data available

10. Stability and Reactivity

10.1. Reactivity

Not expected to be reactive.

10.2. Chemical stability

Stable

10.3. Possibility of hazardous reactions

Will Not Occur

10.4. Conditions to avoid

None anticipated

10.5. Incompatible materials

Strong acids.

10.6. Hazardous decomposition products

Carbon monoxide and carbon dioxide.

11. Toxicological Information

Information on routes of exposure

Principle Route of Exposure Eye or skin contact, inhalation.

Symptoms related to exposure

Most Important Symptoms/Effects

No significant hazards expected.

Numerical measures of toxicity

Toxicology data for the components

Substances	CAS Number	LD50 Oral	LD50 Dermal	LC50 Inhalation
Contains no hazardous substances in concentrations above cut-off values according to the competent authority	NA	No data available	No data available	No data available

Immediate, delayed and chronic health effects from exposure

Inhalation May cause mild respiratory irritation.

Eye Contact May cause mechanical irritation to eye.
Skin Contact None known.
Ingestion None known.

Chronic Effects/Carcinogenicity No data available to indicate product or components present at greater than 0.1% are chronic health hazards.

Exposure Levels
No data available

Interactive effects
None known.

Data limitations
No data available

12. Ecological Information

Ecotoxicity
Product Ecotoxicity Data
No data available

Substance Ecotoxicity Data

Substances	CAS Number	Toxicity to Algae	Toxicity to Fish	Toxicity to Microorganisms	Toxicity to Invertebrates
Contains no hazardous substances in concentrations above cut-off values according to the competent authority	NA	No information available	No information available	No information available	No information available

12.2. Persistence and degradability

Substances	CAS Number	Persistence and Degradability
Contains no hazardous substances in concentrations above cut-off values according to the competent authority	NA	No information available

12.3. Bioaccumulative potential

Substances	CAS Number	Log Pow
Contains no hazardous substances in concentrations above cut-off values according to the competent authority	NA	No information available

12.4. Mobility in soil

Substances	CAS Number	Mobility
Contains no hazardous substances in concentrations above cut-off values according to the competent authority	NA	No information available

12.6. Other adverse effects

Endocrine Disruptor Information

This product does not contain any known or suspected endocrine disruptors

13. Disposal Considerations

Safe handling and disposal methods

Bury in a licensed landfill according to federal, state, and local regulations.

Disposal of any contaminated packaging

Follow all applicable national or local regulations.

Environmental regulations

Not applicable

14. Transport Information

Transportation Information

Australia ADG

UN Number	Not restricted
UN proper shipping name:	Not restricted
Transport Hazard Class(es):	Not applicable
Packing Group:	Not applicable
Environmental Hazards:	Not applicable

IMDG/IMO

UN Number	Not restricted
UN proper shipping name:	Not restricted
Transport Hazard Class(es):	Not applicable
Packing Group:	Not applicable
Environmental Hazards:	Not applicable

IATA/ICAO

UN Number	Not restricted
UN proper shipping name:	Not restricted
Transport Hazard Class(es):	Not applicable
Packing Group:	Not applicable
Environmental Hazards:	Not applicable

Special precautions during transport

None

HazChem Code

None Allocated

15. Regulatory Information

Safety, health and environmental regulations specific for the product

International Inventories

Australian AICS Inventory	All components are listed on the AICS or are subject to a relevant exemption, permit, or assessment certificate.
New Zealand Inventory of Chemicals	All components are listed on the NZIoC or are subject to a relevant exemption, permit, or assessment certificate.
EINECS (European Inventory of Existing Chemical Substances)	This product, and all its components, complies with EINECS
US TSCA Inventory	All components listed on inventory or are exempt.
Canadian Domestic Substances List (DSL)	All components listed on inventory or are exempt.

Poisons Schedule number
None Allocated

International Agreements

Montreal Protocol - Ozone Depleting Substances:	Does not apply
Stockholm Convention - Persistent Organic Pollutants:	Does not apply
Rotterdam Convention - Prior Informed Consent:	Does not apply
Basel Convention - Hazardous Waste:	Does not apply

16. Other information

Date of preparation or review

Revision Date: 27-Sep-2016

Revision Note
SDS sections updated: 2

Full text of H-Statements referred to under sections 2 and 3
None

Additional information

For additional information on the use of this product, contact your local Halliburton representative.

For questions about the Safety Data Sheet for this or other Halliburton products, contact Chemical Stewardship at 1-580-251-4335.

Key abreviations or acronyms used
bw – body weight
CAS – Chemical Abstracts Service
EC50 – Effective Concentration 50%
LC50 – Lethal Concentration 50%
LD50 – Lethal Dose 50%
LL50 – Lethal Loading 50%
mg/kg – milligram/kilogram
mg/L – milligram/liter
NOEC – No Observed Effect Concentration
OEL – Occupational Exposure Limit
PBT – Persistent Bioaccumulative and Toxic
ppm – parts per million
STEL – Short Term Exposure Limit
TWA – Time-Weighted Average
vPvB – very Persistent and very Bioaccumulative
h - hour
mg/m^3 - milligram/cubic meter
mm - millimeter
mmHg - millimeter mercury
w/w - weight/weight
d - day

Key literature references and sources for data
www.ChemADVISOR.com/

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End of Safety Data Sheet

HALLIBURTON

SAFETY DATA SHEET

DCA-14004

Revision Date: 30-May-2017 **Revision Number:** 6

1. Product Identifier & Identity for the Chemical

Statement of Hazardous Nature Hazardous according to the criteria of the 3rd Revised Edition of the Globally Harmonised System of Classification and Labelling of Chemicals (GHS), Non-Dangerous Goods according to the criteria of ADG.

1.1. Product Identifier

Product Name DCA-14004

Other means of Identification

Synonyms None

Hazardous Material Number: HM007652

Recommended use of the chemical and restrictions on use

Recommended Use Additive

Uses advised against No information available

Supplier's name, address and phone number

Manufacturer/Supplier Halliburton Australia Pty. Ltd.
15 Marriott Road, Jandakot, WA 6164
Australia
ACN Number: 009 000 775
Telephone Number: + 61 1 800 686 951
Fax Number: 61 (08) 9455 5300

E-mail Address fdunexchem@halliburton.com

Emergency phone number

+ 61 1 800 686 951
Global Incident Response Access Code: 334305
Contract Number: 14012

Australian Poisons Information Centre
24 Hour Service: - 13 11 26
Police or Fire Brigade: - 000 (exchange): - 1100

2. Hazard Identification

Statement of Hazardous Nature Hazardous according to the criteria of the 3rd Revised Edition of the Globally Harmonised System of Classification and Labelling of Chemicals (GHS), Non-Dangerous Goods according to the criteria of ADG.

Classification of the hazardous chemical

Serious Eye Damage/Irritation	Category 2 - H319

Label elements, including precautionary statements

Hazard Pictograms

Signal Word WARNING

Hazard Statements: H319 - Causes serious eye irritation

Precautionary Statements

Prevention P264 - Wash face, hands and any exposed skin thoroughly after handling
P280 - Wear eye protection/face protection

Response P305 + P351 + P338 - IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing
P337 + P313 - If eye irritation persists: Get medical advice/attention

Storage None

Disposal None

Contains

Substances	**CAS Number**
Sodium carbonate	497-19-8

Other hazards which do not result in classification

This substance is not considered to be persistent, bioaccumulating nor toxic (PBT).
This substance is not considered to be very persistent nor very bioaccumulating (vPvB).

For the full text of the H-phrases mentioned in this Section, see Section 16

3. Composition/information on Ingredients

Substances	CAS Number	PERCENT (w/w)	GHS Classification - Australia
Sodium carbonate	497-19-8	60 - 100%	Eye Irrit. 2 (H319)

4. First aid measures

Description of necessary first aid measures

Inhalation If inhaled, remove from area to fresh air. Get medical attention if respiratory irritation develops or if breathing becomes difficult.

Eyes In case of contact, or suspected contact, immediately flush eyes with plenty of water for at least 15 minutes and get medical attention immediately after flushing.

Skin Wash with soap and water. Get medical attention if irritation persists.

Ingestion Do NOT induce vomiting. Give nothing by mouth. Obtain immediate medical attention.

Symptoms caused by exposure

Causes eye irritation.

Medical Attention and Special Treatment

Notes to Physician Treat symptomatically

5. Fire Fighting Measures

Suitable extinguishing equipment

Suitable Extinguishing Media

Water fog, carbon dioxide, foam, dry chemical.

Extinguishing media which must not be used for safety reasons

None known.

Specific hazards arising from the chemical

Special exposure hazards in a fire

Decomposition in fire may produce harmful gases.

Special protective equipment and precautions for fire fighters

Special protective equipment for firefighters

Full protective clothing and approved self-contained breathing apparatus required for fire fighting personnel.

6. Accidental release measures

6.1. Personal precautions, protective equipment and emergency procedures

Use appropriate protective equipment. Avoid creating and breathing dust. Ensure adequate ventilation. Avoid contact with skin, eyes and clothing.

6.2. Environmental precautions

Prevent from entering sewers, waterways, or low areas.

6.3. Methods and material for containment and cleaning up

Scoop up and remove.

7. Handling and storage

7.1. Precautions for safe handling

Handling Precautions

Avoid contact with eyes, skin, or clothing. Avoid creating or inhaling dust. Ensure adequate ventilation. Wash hands after use. Launder contaminated clothing before reuse.

Hygiene Measures

Handle in accordance with good industrial hygiene and safety practice.

7.2. Conditions for safe storage, including any incompatibilities

Storage Information

Store away from acids. Store in a cool, dry location. Product has a shelf life of 24 months.

Other Guidelines

No information available

8. Exposure Controls/Personal Protection

Control parameters - exposure standards, biological monitoring

Exposure Limits

Substances	CAS Number	Australia NOHSC	ACGIH TLV-TWA
Sodium carbonate	497-19-8	Not applicable	Not applicable

Appropriate engineering controls

Engineering Controls Use in a well ventilated area. Localized ventilation should be used to control dust levels.

Personal protective equipment (PPE)

Personal Protective Equipment If engineering controls and work practices cannot prevent excessive exposures, the selection and proper use of personal protective equipment should be determined by an industrial hygienist or other qualified professional based on the specific application of this product.

Respiratory Protection Dust/mist respirator. (N95, P2/P3)

Hand Protection Normal work gloves.

Skin Protection Normal work coveralls.

Eye Protection Dust proof goggles.

Other Precautions None known.
Environmental Exposure Controls Do not allow material to contaminate ground water system

9. Physical and Chemical Properties

9.1. Information on basic physical and chemical properties

Physical State: Powder
Color White
Odor: Odorless
Odor Threshold: No information available

Property Remarks/ - Method	Values
pH:	11.4
Freezing Point / Range	No data available
Melting Point / Range	No data available
Boiling Point / Range	No data available
Flash Point	No data available
Evaporation rate	No data available
Vapor Pressure	No data available
Vapor Density	No data available
Specific Gravity	2.5
Water Solubility	Insoluble in water
Solubility in other solvents	No data available
Partition coefficient: n-octanol/water	No data available
Autoignition Temperature	No data available
Decomposition Temperature	No data available
Viscosity	No data available
Explosive Properties	No information available
Oxidizing Properties	No information available

9.2. Other information

Molecular Weight	105.99 g/mol
VOC Content (%)	No data available

10. Stability and Reactivity

10.1. Reactivity
Not expected to be reactive.
10.2. Chemical stability
Stable
10.3. Possibility of hazardous reactions
Will Not Occur
10.4. Conditions to avoid
None anticipated
10.5. Incompatible materials
Strong acids.
10.6. Hazardous decomposition products
Carbon monoxide and carbon dioxide.

11. Toxicological Information

Information on routes of exposure
Principle Route of Exposure Eye or skin contact, inhalation.

Symptoms related to exposure
Most Important Symptoms/Effects
Causes eye irritation.

Numerical measures of toxicity

Toxicology data for the components

Substances	CAS Number	LD50 Oral	LD50 Dermal	LC50 Inhalation
Sodium carbonate	497-19-8	4090 mg/kg (Rat) 2800 mg/kg (Rat)	2210 mg/kg (Mouse) > 2000 mg/kg (Rabbit)	2.3 mg/L (Rat) 2h

Immediate, delayed and chronic health effects from exposure

Inhalation May cause mild respiratory irritation.
Eye Contact Causes eye irritation.
Skin Contact Not irritating to skin in rabbits.
Ingestion Irritation of the mouth, throat, and stomach.

Chronic Effects/Carcinogenicity No data available to indicate product or components present at greater than 0.1% are chronic health hazards.

Exposure Levels
No data available

Interactive effects
None known.

Data limitations
No data available

Substances	CAS Number	Skin corrosion/irritation
Sodium carbonate	497-19-8	Non-irritating to the skin

Substances	CAS Number	Serious eye damage/irritation
Sodium carbonate	497-19-8	Irritating to eyes

Substances	CAS Number	Skin Sensitization
Sodium carbonate	497-19-8	Not classified

Substances	CAS Number	Respiratory Sensitization
Sodium carbonate	497-19-8	No information available

Substances	CAS Number	Mutagenic Effects
Sodium carbonate	497-19-8	In vivo tests did not show mutagenic effects.

Substances	CAS Number	Carcinogenic Effects
Sodium carbonate	497-19-8	No information available

Substances	CAS Number	Reproductive toxicity
Sodium carbonate	497-19-8	Did not show teratogenic effects in animal experiments.

Substances	CAS Number	STOT - single exposure
Sodium carbonate	497-19-8	No significant toxicity observed in animal studies at concentration requiring classification.

Substances	CAS Number	STOT - repeated exposure
Sodium carbonate	497-19-8	No significant toxicity observed in animal studies at concentration requiring classification.

Substances	CAS Number	Aspiration hazard
Sodium carbonate	497-19-8	Not applicable

12. Ecological Information

Ecotoxicity

Substance Ecotoxicity Data

Substances	CAS Number	Toxicity to Algae	Toxicity to Fish	Toxicity to Microorganisms	Toxicity to Invertebrates
Sodium carbonate	497-19-8	EC50 242 mg/L (Nitzschia)	TLM24 385 mg/L (Lepomis macrochirus)	No information available	EC50 265 mg/L (Daphnia magna)

			LC50 310-1220 mg/L (Pimephales promelas) LC50 (96h) 300 mg/L (Lepomis macrochirus)		EC50 (48h) 200 – 227 mg/L (Ceriodaphnia sp.)

12.2. Persistence and degradability

Substances	CAS Number	Persistence and Degradability
Sodium carbonate	497-19-8	The methods for determining biodegradability are not applicable to inorganic substances.

12.3. Bioaccumulative potential

Substances	CAS Number	Log Pow
Sodium carbonate	497-19-8	No information available

12.4. Mobility in soil

Substances	CAS Number	Mobility
Sodium carbonate	497-19-8	No information available

12.6. Other adverse effects

Endocrine Disruptor Information

This product does not contain any known or suspected endocrine disruptors

13. Disposal Considerations

Safe handling and disposal methods

Bury in a licensed landfill according to federal, state, and local regulations.

Disposal of any contaminated packaging

Follow all applicable national or local regulations. Contaminated packaging may be disposed of by: rendering packaging incapable of containing any substance, or treating packaging to remove residual contents, or treating packaging to make sure the residual contents are no longer hazardous, or by disposing of packaging into commercial waste collection.

Environmental regulations

Not applicable

14. Transport Information

Transportation Information

Australia ADG

UN Number Not restricted
UN proper shipping name: Not restricted
Transport Hazard Class(es): Not applicable
Packing Group: Not applicable
Environmental Hazards: Not applicable

IMDG/IMO

UN Number Not restricted
UN proper shipping name: Not restricted
Transport Hazard Class(es): Not applicable
Packing Group: Not applicable
Environmental Hazards: Not applicable

IATA/ICAO

UN Number Not restricted
UN proper shipping name: Not restricted
Transport Hazard Class(es): Not applicable
Packing Group: Not applicable
Environmental Hazards: Not applicable

Special precautions during transport
None

HazChem Code
None Allocated

15. Regulatory Information

Safety, health and environmental regulations specific for the product

International Inventories

Australian AICS Inventory	All components are listed on the AICS or are subject to a relevant exemption, permit, or assessment certificate.
New Zealand Inventory of Chemicals	All components are listed on the NZIoC or are subject to a relevant exemption, permit, or assessment certificate.
EINECS (European Inventory of Existing Chemical Substances)	This product, and all its components, complies with EINECS
US TSCA Inventory	All components listed on inventory or are exempt.
Canadian Domestic Substances List (DSL)	All components listed on inventory or are exempt.

Poisons Schedule number
None Allocated

International Agreements

Montreal Protocol - Ozone Depleting Substances:	Does not apply
Stockholm Convention - Persistent Organic Pollutants:	Does not apply
Rotterdam Convention - Prior Informed Consent:	Does not apply
Basel Convention - Hazardous Waste:	Does not apply

16. Other information

Date of preparation or review

Revision Date: 30-May-2017

Revision Note
SDS sections updated:
2

Full text of H-Statements referred to under sections 2 and 3
H319 - Causes serious eye irritation

Additional information

For additional information on the use of this product, contact your local Halliburton representative.

For questions about the Safety Data Sheet for this or other Halliburton products, contact Chemical Stewardship at 1-580-251-4335.

Key abreviations or acronyms used
bw – body weight
CAS – Chemical Abstracts Service
EC50 – Effective Concentration 50%
LC50 – Lethal Concentration 50%
LD50 – Lethal Dose 50%
LL50 – Lethal Loading 50%
mg/kg – milligram/kilogram
mg/L – milligram/liter
NOEC – No Observed Effect Concentration

OEL – Occupational Exposure Limit
PBT – Persistent Bioaccumulative and Toxic
ppm – parts per million
STEL – Short Term Exposure Limit
TWA – Time-Weighted Average
vPvB – very Persistent and very Bioaccumulative
h - hour
mg/m^3 - milligram/cubic meter
mm - millimeter
mmHg - millimeter mercury
w/w - weight/weight
d - day

Key literature references and sources for data
www.ChemADVISOR.com/
NZ CCID

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End of Safety Data Sheet

HALLIBURTON

SAFETY DATA SHEET

DCA-16001

Revision Date: 05-Jul-2017 **Revision Number:** 11

1. Product Identifier & Identity for the Chemical

Statement of Hazardous Nature Non-Hazardous according to the criteria of the 3rd Revised Edition of the Globally Harmonised System of Classification and Labelling of Chemicals (GHS), Non-Dangerous Goods according to the criteria of ADG.

1.1. Product Identifier

Product Name DCA-16001

Other means of Identification

Synonyms None

Hazardous Material Number: HM007655

Recommended use of the chemical and restrictions on use

Recommended Use Clay Stabilization Agent

Uses advised against No information available

Supplier's name, address and phone number

Manufacturer/Supplier Halliburton Australia Pty. Ltd.
15 Marriott Road, Jandakot, WA 6164
Australia
ACN Number: 009 000 775
Telephone Number: + 61 1 800 686 951
Fax Number: 61 (08) 9455 5300

E-mail Address fdunexchem@halliburton.com

Emergency phone number

+ 61 1 800 686 951
Global Incident Response Access Code: 334305
Contract Number: 14012

Australian Poisons Information Centre
24 Hour Service: - 13 11 26
Police or Fire Brigade: - 000 (exchange): - 1100

2. Hazard Identification

Statement of Hazardous Nature Non-Hazardous according to the criteria of the 3rd Revised Edition of the Globally Harmonised System of Classification and Labelling of Chemicals (GHS), Non-Dangerous Goods according to the criteria of ADG.

Classification of the hazardous chemical

Not classified

Label elements, including precautionary statements

Hazard Pictograms

Signal Word Not Hazardous

Hazard Statements: Not Classified

Precautionary Statements

Prevention	None
Response	None
Storage	None
Disposal	None

Contains

Substances	**CAS Number**
Contains no hazardous substances in concentrations above cut-off values according to the competent authority	NA

Other hazards which do not result in classification

This mixture contains no substance considered to be persistent, bioaccumulating nor toxic (PBT).
This mixture contains no substance considered to be very persistent nor very bioaccumulating (vPvB).

For the full text of the H-phrases mentioned in this Section, see Section 16

3. Composition/information on Ingredients

Substances	CAS Number	PERCENT (w/w)	GHS Classification - Australia
Contains no hazardous substances in concentrations above cut-off values according to the competent authority	NA	60 - 100%	Not classified

4. First aid measures

Description of necessary first aid measures

Inhalation	If inhaled, remove from area to fresh air. Get medical attention if respiratory irritation develops or if breathing becomes difficult.
Eyes	In case of contact, immediately flush eyes with plenty of water for at least 15 minutes and get medical attention if irritation persists.
Skin	Wash with soap and water. Get medical attention if irritation persists.
Ingestion	Do NOT induce vomiting. Give nothing by mouth. Obtain immediate medical attention.

Symptoms caused by exposure

No significant hazards expected.

Medical Attention and Special Treatment

Notes to Physician	Treat symptomatically

5. Fire Fighting Measures

Suitable extinguishing equipment

Suitable Extinguishing Media

All standard fire fighting media

Extinguishing media which must not be used for safety reasons

None known.

Specific hazards arising from the chemical

Special exposure hazards in a fire

Not applicable

Special protective equipment and precautions for fire fighters

Special protective equipment for firefighters

Full protective clothing and approved self-contained breathing apparatus required for fire fighting personnel.

6. Accidental release measures

6.1. Personal precautions, protective equipment and emergency procedures
Use appropriate protective equipment. Avoid contact with skin, eyes and clothing. Avoid breathing vapors. Ensure adequate ventilation.

6.2. Environmental precautions
Prevent from entering sewers, waterways, or low areas.

6.3. Methods and material for containment and cleaning up
Isolate spill and stop leak where safe. Contain spill with sand or other inert materials. Scoop up and remove.

7. Handling and storage

7.1. Precautions for safe handling
Handling Precautions
Avoid contact with eyes, skin, or clothing. Avoid breathing vapors. Ensure adequate ventilation. Wash hands after use. Launder contaminated clothing before reuse. Use appropriate protective equipment.
Hygiene Measures
Handle in accordance with good industrial hygiene and safety practice.

7.2. Conditions for safe storage, including any incompatibilities
Storage Information
Store in a cool, dry location. Keep container closed when not in use. Product has a shelf life of 24 months.
Other Guidelines
No information available

8. Exposure Controls/Personal Protection

Control parameters - exposure standards, biological monitoring
Exposure Limits

Substances	CAS Number	Australia NOHSC	ACGIH TLV-TWA
Contains no hazardous substances in concentrations above cut-off values according to the competent authority	NA	Not applicable	Not applicable

Appropriate engineering controls
Engineering Controls Use in a well ventilated area.

Personal protective equipment (PPE)
Personal Protective Equipment If engineering controls and work practices cannot prevent excessive exposures, the selection and proper use of personal protective equipment should be determined by an industrial hygienist or other qualified professional based on the specific application of this product.
Respiratory Protection Not normally necessary.

Hand Protection Rubber gloves.
Skin Protection Normal work coveralls.
Eye Protection Wear safety glasses or goggles to protect against exposure.
Other Precautions None known.
Environmental Exposure Controls Do not allow material to contaminate ground water system

9. Physical and Chemical Properties

9.1. Information on basic physical and chemical properties

Physical State:	Liquid	**Color**	White
Odor:	Mild amine	**Odor Threshold:**	No information available

Property Remarks/ - Method	Values
pH:	7-9
Freezing Point / Range	No data available
Melting Point / Range	No data available
Boiling Point / Range	No data available
Flash Point	No data available
Evaporation rate	No data available
Vapor Pressure	No data available
Vapor Density	No data available
Specific Gravity	1.07 - 1.091
Water Solubility	Soluble in water
Solubility in other solvents	No data available
Partition coefficient: n-octanol/water	No data available
Autoignition Temperature	No data available
Decomposition Temperature	No data available
Viscosity	No data available
Explosive Properties	No information available
Oxidizing Properties	No information available

9.2. Other information

VOC Content (%) No data available

10. Stability and Reactivity

10.1. Reactivity

Not expected to be reactive.

10.2. Chemical stability

Stable

10.3. Possibility of hazardous reactions

Will Not Occur

10.4. Conditions to avoid

Avoid contact with metals such as aluminum, tin, lead, brass, bronze, copper, and zinc.

10.5. Incompatible materials

Strong oxidizers.

10.6. Hazardous decomposition products

Oxides of nitrogen. Hydrogen chloride. Carbon monoxide and carbon dioxide.

11. Toxicological Information

Information on routes of exposure

Symptoms related to exposure

Most Important Symptoms/Effects

No significant hazards expected.

Toxicology data for the components

Substances	CAS Number	LD50 Oral	LD50 Dermal	LC50 Inhalation
Contains no hazardous substances in concentrations above cut-off values according to the competent authority	NA	No data available	No data available	No data available

Immediate, delayed and chronic health effects from exposure

Inhalation None known.

Eye Contact None known.
Skin Contact None known.
Ingestion None known.

Chronic Effects/Carcinogenicity No data available to indicate product or components present at greater than 0.1% are chronic health hazards.

Exposure Levels
No data available

Interactive effects
None known.

Data limitations
No data available

12. Ecological Information

Ecotoxicity

Substance Ecotoxicity Data

Substances	CAS Number	Toxicity to Algae	Toxicity to Fish	Toxicity to Microorganisms	Toxicity to Invertebrates
Contains no hazardous substances in concentrations above cut-off values according to the competent authority	NA	No information available	No information available	No information available	No information available

12.2. Persistence and degradability
Expected to be readily biodegradable

Substances	CAS Number	Persistence and Degradability
Contains no hazardous substances in concentrations above cut-off values according to the competent authority	NA	No information available

12.3. Bioaccumulative potential
Does not bioaccumulate.

Substances	CAS Number	Log Pow
Contains no hazardous substances in concentrations above cut-off values according to the competent authority	NA	No information available

12.4. Mobility in soil

Substances	CAS Number	Mobility
Contains no hazardous substances in concentrations above cut-off values according to the competent authority	NA	No information available

12.6. Other adverse effects
Endocrine Disruptor Information

This product does not contain any known or suspected endocrine disruptors

13. Disposal Considerations

Safe handling and disposal methods
Disposal should be made in accordance with federal, state, and local regulations.

Disposal of any contaminated packaging
Follow all applicable national or local regulations.

Environmental regulations
Not applicable

14. Transport Information

Transportation Information

Australia ADG

UN Number	Not restricted
UN proper shipping name:	Not restricted
Transport Hazard Class(es):	Not applicable
Packing Group:	Not applicable
Environmental Hazards:	Not applicable

IMDG/IMO

UN Number	Not restricted
UN proper shipping name:	Not restricted
Transport Hazard Class(es):	Not applicable
Packing Group:	Not applicable
Environmental Hazards:	Not applicable

IATA/ICAO

UN Number	Not restricted
UN proper shipping name:	Not restricted
Transport Hazard Class(es):	Not applicable
Packing Group:	Not applicable
Environmental Hazards:	Not applicable

Special precautions during transport
None

HazChem Code
None Allocated

15. Regulatory Information

Safety, health and environmental regulations specific for the product

International Inventories

Australian AICS Inventory	All components are listed on the AICS or are subject to a relevant exemption, permit, or assessment certificate.
New Zealand Inventory of Chemicals	All components are listed on the NZIoC or are subject to a relevant exemption, permit, or assessment certificate.
EINECS (European Inventory of Existing Chemical Substances)	This product, and all its components, complies with EINECS
US TSCA Inventory	All components listed on inventory or are exempt.
Canadian Domestic Substances List (DSL)	All components listed on inventory or are exempt.

Poisons Schedule number
None Allocated

International Agreements

Montreal Protocol - Ozone Depleting Substances:	Does not apply
Stockholm Convention - Persistent Organic Pollutants:	Does not apply
Rotterdam Convention - Prior Informed Consent:	Does not apply
Basel Convention - Hazardous Waste:	Does not apply

16. Other information

Date of preparation or review

Revision Date: 05-Jul-2017

Revision Note
SDS sections updated:
2

Full text of H-Statements referred to under sections 2 and 3
None

Additional information

For additional information on the use of this product, contact your local Halliburton representative.

For questions about the Safety Data Sheet for this or other Halliburton products, contact Chemical Stewardship at 1-580-251-4335.

Key abreviations or acronyms used
bw – body weight
CAS – Chemical Abstracts Service
EC50 – Effective Concentration 50%
LC50 – Lethal Concentration 50%
LD50 – Lethal Dose 50%
LL50 – Lethal Loading 50%
mg/kg – milligram/kilogram
mg/L – milligram/liter
NOEC – No Observed Effect Concentration
OEL – Occupational Exposure Limit
PBT – Persistent Bioaccumulative and Toxic
ppm – parts per million
STEL – Short Term Exposure Limit
TWA – Time-Weighted Average
vPvB – very Persistent and very Bioaccumulative
h - hour
mg/m^3 - milligram/cubic meter
mm - millimeter
mmHg - millimeter mercury
w/w - weight/weight
d - day

Key literature references and sources for data
www.ChemADVISOR.com/

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End of Safety Data Sheet

HALLIBURTON

SAFETY DATA SHEET

DCA-17001

Revision Date: 09-Nov-2017 **Revision Number:** 16

1. Product Identifier & Identity for the Chemical

Statement of Hazardous Nature Hazardous according to the criteria of the 3rd Revised Edition of the Globally Harmonised System of Classification and Labelling of Chemicals (GHS), Dangerous Goods according to the criteria of ADG.

1.1. Product Identifier

Product Name DCA-17001

Other means of Identification

Synonyms None

Hazardous Material Number: HM007659

Recommended use of the chemical and restrictions on use

Recommended Use Corrosion Inhibitor

Uses advised against No information available

Supplier's name, address and phone number

Manufacturer/Supplier Halliburton Australia Pty. Ltd.
15 Marriott Road, Jandakot, WA 6164
Australia
ACN Number: 009 000 775
Telephone Number: + 61 1 800 686 951
Fax Number: 61 (08) 9455 5300

E-mail Address fdunexchem@halliburton.com

Emergency phone number

+ 61 1 800 686 951
Global Incident Response Access Code: 334305
Contract Number: 14012

Australian Poisons Information Centre
24 Hour Service: - 13 11 26
Police or Fire Brigade: - 000 (exchange): - 1100

2. Hazard Identification

Statement of Hazardous Nature Hazardous according to the criteria of the 3rd Revised Edition of the Globally Harmonised System of Classification and Labelling of Chemicals (GHS), Dangerous Goods according to the criteria of ADG.

Classification of the hazardous chemical

Acute Oral Toxicity	Category 4 - H302
Skin Corrosion/Irritation	Category 2 - H315
Serious Eye Damage/Irritation	Category 1 - H318
Skin Sensitization	Category 1 - H317
Reproductive Toxicity	Category 1B - H360
Specific Target Organ Toxicity - (Single Exposure)	Category 1 - H370
Specific Target Organ Toxicity - (Repeated Exposure)	Category 2 - H373
Acute Aquatic Toxicity	Category 2 - H401
Flammable liquids.	Category 3 - H226

Label elements, including precautionary statements

Hazard Pictograms

Signal Word DANGER

Hazard Statements:
H226 - Flammable liquid and vapor
H302 - Harmful if swallowed
H315 - Causes skin irritation
H317 - May cause an allergic skin reaction
H318 - Causes serious eye damage
H360 - May damage fertility or the unborn child
H370 - Causes damage to organs
H373 - May cause damage to organs through prolonged or repeated exposure
H401 - Toxic to aquatic life

Precautionary Statements

Prevention
P201 - Obtain special instructions before use
P202 - Do not handle until all safety precautions have been read and understood
P210 - Keep away from heat, hot surfaces, sparks, open flames and other ignition sources. No smoking.
P233 - Keep container tightly closed
P240 - Ground and bond container and receiving equipment.
P241 - Use explosion-proof electrical/ventilating/lighting/equipment
P242 - Use only non-sparking tools
P243 - Take action to prevent static discharges.
P260 - Do not breathe dust/fume/gas/mist/vapors/spray
P264 - Wash face, hands and any exposed skin thoroughly after handling
P270 - Do not eat, drink or smoke when using this product
P272 - Contaminated work clothing should not be allowed out of the workplace
P273 - Avoid release to the environment
P280 - Wear protective gloves/protective clothing/eye protection/face protection
P281 - Use personal protective equipment as required

Response
P301 + P312 - IF SWALLOWED: Call a POISON CENTER or doctor/physician if you feel unwell
P330 - Rinse mouth
P302 + P352 - IF ON SKIN: Wash with plenty of water.
P333 + P313 - If skin irritation or rash occurs: Get medical advice/attention
P362 + P364 - Take off contaminated clothing and wash before reuse
P305 + P351 + P338 - IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing
P310 - Immediately call a POISON CENTER or doctor/physician
P307 + P311 - IF exposed: Call a POISON CENTER or doctor/physician
P314 - Get medical attention/advice if you feel unwell
P370 + P378 - In case of fire: Use water spray for extinction

Storage
P403 + P235 - Store in a well-ventilated place. Keep cool
P405 - Store locked up

Disposal P501 - Dispose of contents/container in accordance with local/regional/national/international regulations

Contains

Substances	**CAS Number**
Diethylene glycol	111-46-6
Cinnamaldehyde	104-55-2
Amine oxides, cocoalkyldimethyl	61788-90-7
Methanol	67-56-1
Benzaldehyde	100-52-7
Alcohols, C12-16, ethoxylated	68551-12-2
Sodium iodide	7681-82-5

Other hazards which do not result in classification

This mixture contains no substance considered to be persistent, bioaccumulating nor toxic (PBT).
This mixture contains no substance considered to be very persistent nor very bioaccumulating (vPvB).

For the full text of the H-phrases mentioned in this Section, see Section 16

3. Composition/information on Ingredients

Substances	CAS Number	PERCENT (w/w)	GHS Classification - Australia
Diethylene glycol	111-46-6	30 - 60%	Acute Tox. 4 (H302) STOT RE 2 (H373)
Cinnamaldehyde	104-55-2	30 - 60%	Acute Tox. 4 (H312) Skin Irrit. 2 (H315) Skin Sens. 1 (H317) Aquatic Acute 2 (H401)
Amine oxides, cocoalkyldimethyl	61788-90-7	10 - 30%	Acute Tox. 4 (H302) Skin Irrit. 2 (H315) Eye Corr. 1 (H318) Aquatic Acute 1 (H400)
Methanol	67-56-1	10 - 30%	Acute Tox. 3 (H301) Acute Tox. 3 (H311) Acute Tox. 3 (H331) Repr. 1B (H360) STOT SE 1 (H370) Flam. Liq. 2 (H225)
Benzaldehyde	100-52-7	5 - 10%	Acute Tox. 4 (H302) Acute Tox. 4 (H332) Aquatic Acute 2 (H401) Flam. Liq. 4 (H227)
Alcohols, C12-16, ethoxylated	68551-12-2	1 - 5%	Acute Tox. 4 (H302) Skin Irrit. 2 (H315) Eye Corr. 1 (H318) Aquatic Acute 1 (H400) Aquatic Chronic 3 (H412)
Sodium iodide	7681-82-5	1 - 5%	Skin Irrit. 2 (H315) Eye Irrit. 2 (H319) STOT SE 3 (H335) STOT RE 1 (H372)

4. First aid measures

Description of necessary first aid measures

Inhalation If inhaled, move victim to fresh air and seek medical attention.

Eyes In case of contact, or suspected contact, immediately flush eyes with plenty of water for at least 15 minutes and get medical attention immediately after flushing.

Skin In case of contact, immediately flush skin with plenty of soap and water for at least 15 minutes. Get medical attention. Remove contaminated clothing and launder before reuse.

Ingestion Get immediate medical attention. Do NOT induce vomiting. Give nothing by mouth. Obtain immediate medical attention.

Symptoms caused by exposure

Causes severe eye irritation which may damage tissue. Causes skin irritation. May cause allergic skin reaction. Harmful if swallowed. May cause damage to internal organs. May cause damage to organs through prolonged or repeated exposure. Potential reproductive hazard. May cause birth defects.

Medical Attention and Special Treatment

Notes to Physician Treat symptomatically

5. Fire Fighting Measures

Suitable extinguishing equipment

Suitable Extinguishing Media

Carbon dioxide, dry chemical, foam.

Extinguishing media which must not be used for safety reasons

None known.

Specific hazards arising from the chemical

Special exposure hazards in a fire

May be ignited by heat, sparks or flames Use water spray to cool fire exposed surfaces. Closed containers may explode in fire. Decomposition in fire may produce harmful gases. Runoff to sewer may cause fire or explosion hazard.

Special protective equipment and precautions for fire fighters

Special protective equipment for firefighters

Full protective clothing and approved self-contained breathing apparatus required for fire fighting personnel.

6. Accidental release measures

6.1. Personal precautions, protective equipment and emergency procedures

Remove sources of ignition. Use appropriate protective equipment. Wear self-contained breathing apparatus in enclosed areas. Avoid breathing vapors. Avoid contact with skin, eyes and clothing. Ensure adequate ventilation.

6.2. Environmental precautions

Prevent from entering sewers, waterways, or low areas.

6.3. Methods and material for containment and cleaning up

Isolate spill and stop leak where safe. Remove ignition sources and work with non-sparking tools. Contain spill with sand or other inert materials. Scoop up and remove.

7. Handling and storage

7.1. Precautions for safe handling

Handling Precautions

Remove sources of ignition. Ensure adequate ventilation. Avoid breathing vapors. Avoid contact with eyes, skin, or clothing. Wash hands after use. Launder contaminated clothing before reuse. Ground and bond containers when transferring from one container to another. Use appropriate protective equipment.

Hygiene Measures

Handle in accordance with good industrial hygiene and safety practice.

7.2. Conditions for safe storage, including any incompatibilities

Storage Information

Store away from oxidizers. Keep from heat, sparks, and open flames. Store in a well ventilated area. Store locked up. Keep container closed when not in use. Product has a shelf life of 60 months.

Other Guidelines

No information available

8. Exposure Controls/Personal Protection

Control parameters - exposure standards, biological monitoring

Exposure Limits

Substances	CAS Number	Australia NOHSC	ACGIH TLV-TWA
Diethylene glycol	111-46-6	TWA: 23 ppm TWA: 100 mg/m³	Not applicable
Cinnamaldehyde	104-55-2	Not applicable	Not applicable
Amine oxides, cocoalkyldimethyl	61788-90-7	Not applicable	Not applicable
Methanol	67-56-1	TWA: 200 ppm TWA: 262 mg/m³ STEL: 250 ppm STEL: 328 mg/m³	TWA: 200 ppm STEL: 250 ppm
Benzaldehyde	100-52-7	Not applicable	Not applicable
Alcohols, C12-16, ethoxylated	68551-12-2	Not applicable	Not applicable
Sodium iodide	7681-82-5	Not applicable	TWA: 0.01 ppm

Appropriate engineering controls

Engineering Controls Use in a well ventilated area. Local exhaust ventilation should be used in areas without good cross ventilation.

Personal protective equipment (PPE)

Personal Protective Equipment If engineering controls and work practices cannot prevent excessive exposures, the selection and proper use of personal protective equipment should be determined by an industrial hygienist or other qualified professional based on the specific application of this product.

Respiratory Protection If engineering controls and work practices cannot keep exposure below occupational exposure limits or if exposure is unknown, wear a NIOSH certified, European Standard EN 149, AS/NZS 1715:2009, or equivalent respirator when using this product. Selection of and instruction on using all personal protective equipment, including respirators, should be performed by an Industrial Hygienist or other qualified professional.
Positive pressure self-contained breathing apparatus if methanol is released.

Hand Protection Chemical-resistant protective gloves (EN 374) Suitable materials for longer, direct contact (recommended: protection index 6, corresponding to > 480 minutes permeation time as per EN 374): Butyl rubber gloves. (>= 0.7 mm thickness)
This information is based on literature references and on information provided by glove manufacturers, or is derived by analogy with similar substances. Please note that in practice the working life of chemical-resistant protective gloves may be considerably shorter than the permeation time determined in accordance with EN 374 as a result of the many influencing factors (e.g. temperature). If signs of wear and tear are noticed then the gloves should be replaced. Manufacturer's directions for use should be observed because of great diversity of types.

Skin Protection Rubber apron.

Eye Protection Chemical goggles; also wear a face shield if splashing hazard exists.

Other Precautions Eyewash fountains and safety showers must be easily accessible.

Environmental Exposure Controls Do not allow material to contaminate ground water system

9. Physical and Chemical Properties

9.1. Information on basic physical and chemical properties

Physical State: Liquid
Color Yellow-orange
Odor: Cinnamon
Odor Threshold: No information available

Property Remarks/ - Method	Values
pH:	6.85 (10%)
Freezing Point / Range	-21 °C
Melting Point / Range	No data available
Boiling Point / Range	No data available
Flash Point	28.9 °C / 84 °F PMCC
Evaporation rate	No data available

Vapor Pressure	No data available
Vapor Density	No data available
Specific Gravity	1.015
Water Solubility	Soluble in water
Solubility in other solvents	No data available
Partition coefficient: n-octanol/water	No data available
Autoignition Temperature	No data available
Decomposition Temperature	No data available
Viscosity	No data available
Explosive Properties	No information available
Oxidizing Properties	No information available

9.2. Other information

VOC Content (%)	No data available

10. Stability and Reactivity

10.1. Reactivity
Not expected to be reactive.
10.2. Chemical stability
Stable
10.3. Possibility of hazardous reactions
Will Not Occur
10.4. Conditions to avoid
Keep away from heat, sparks and flame.
10.5. Incompatible materials
Strong oxidizers.
10.6. Hazardous decomposition products
Ammonia. Oxides of nitrogen. Hydrocarbons. Carbon monoxide and carbon dioxide.

11. Toxicological Information

Information on routes of exposure
Principle Route of Exposure Eye or skin contact, inhalation.

Symptoms related to exposure
Most Important Symptoms/Effects
Causes severe eye irritation which may damage tissue. Causes skin irritation. May cause allergic skin reaction. Harmful if swallowed. May cause damage to internal organs. May cause damage to organs through prolonged or repeated exposure. Potential reproductive hazard. May cause birth defects.

Toxicology data for the components

Substances	CAS Number	LD50 Oral	LD50 Dermal	LC50 Inhalation
Diethylene glycol	111-46-6	12565 - 19600 mg/kg (Rat)	11890 - 13300 mg/kg (Rabbit)	> 4.6 mg/L (Rat) 4h
Cinnamaldehyde	104-55-2	2220 mg/kg (rat)	620 mg/kg (rabbit)	No data available
Amine oxides, cocoalkyldimethyl	61788-90-7	846 - 3873 mg/kg (Rat) 1000-1250 mg/kg (Rat)	4290 mg/kg (Rabbit)	No data available
Methanol	67-56-1	300 mg/kg-bw (human) < 790 to 13,000 mg/kg (rat)	1000 mg/kg-bw (human) 17,100 mg/kg (rabbit)	10 mg/L (human, 4h, vapor)
Benzaldehyde	100-52-7	1430 mg/kg (rat)	No information available	>1 <5 mg/L air (Rat, 4h, mist)
Alcohols, C12-16, ethoxylated	68551-12-2	1600 mg/kg	No data available	No data available
Sodium iodide	7681-82-5	4340 mg/kg (Rat) 3118 mg/kg (Rats) (Similar substance)	No data available	LCLo: 50000 mg/m^3 (Mouse) 2h

Immediate, delayed and chronic health effects from exposure
Product Information Based on the collective toxicity of product ingredients, the mixture should be considered to cause the following:

Inhalation May cause respiratory irritation. May cause central nervous system depression including headache, dizziness, drowsiness, incoordination, slowed reaction time, slurred speech, giddiness and unconsciousness.

Eye Contact Causes severe eye irritation which may damage tissue.

Skin Contact Causes skin irritation. May cause an allergic skin reaction.

Ingestion Harmful if swallowed. May cause central nervous system depression including headache, dizziness, drowsiness, muscular weakness, incoordination, slowed reaction time, fatigue blurred vision, slurred speech, giddiness, tremors and convulsions. May cause liver and kidney damage.

Chronic Effects/Carcinogenicity Prolonged or repeated exposure may cause reproductive system damage. Prolonged or repeated exposure may cause embryo and fetus toxicity.

Exposure Levels
No data available

Interactive effects
Skin disorders. Eye ailments.

Data limitations
No data available

Substances	CAS Number	Skin corrosion/irritation
Diethylene glycol	111-46-6	Non-irritating to the skin (Rabbit)
Cinnamaldehyde	104-55-2	Causes severe irritation and or burns (human)
Amine oxides, cocoalkyldimethyl	61788-90-7	Skin, rabbit: Causes moderate skin irritation.
Methanol	67-56-1	Non-irritating to the skin (Rabbit)
Benzaldehyde	100-52-7	Non-irritating to the skin (Rabbit)
Alcohols, C12-16, ethoxylated	68551-12-2	Causes skin irritation.
Sodium iodide	7681-82-5	Moderate dermal irritant (Rabbit)

Substances	CAS Number	Serious eye damage/irritation
Diethylene glycol	111-46-6	Non-irritating to the eye (Rabbit)
Cinnamaldehyde	104-55-2	Mild eye irritant. (human) (8 % solution)
Amine oxides, cocoalkyldimethyl	61788-90-7	Corrosive to eyes
Methanol	67-56-1	Non-irritating to the eye (Rabbit)
Benzaldehyde	100-52-7	Non-irritating to the eye (Rabbit)
Alcohols, C12-16, ethoxylated	68551-12-2	Causes severe eye irritation which may damage tissue.
Sodium iodide	7681-82-5	Moderately irritating to the eyes (Rabbit)

Substances	CAS Number	Skin Sensitization
Diethylene glycol	111-46-6	Did not cause sensitization on laboratory animals (guinea pig)
Cinnamaldehyde	104-55-2	Skin sensitizer in guinea pig.
Amine oxides, cocoalkyldimethyl	61788-90-7	No information available
Methanol	67-56-1	Did not cause sensitization on laboratory animals (guinea pig)
Benzaldehyde	100-52-7	Not sensitizing in Guinea Pigs (Guinea Pig Maximisation Test and Open Epicutaneous Test, Sensitizing in Draize Test and Freund's Complete Adjuvant Test)
Alcohols, C12-16, ethoxylated	68551-12-2	Did not cause sensitization on laboratory animals
Sodium iodide	7681-82-5	Patch test on human volunteers did not demonstrate sensitization properties

Substances	CAS Number	Respiratory Sensitization
Diethylene glycol	111-46-6	No information available
Cinnamaldehyde	104-55-2	No information available
Amine oxides, cocoalkyldimethyl	61788-90-7	No information available
Methanol	67-56-1	No information available
Benzaldehyde	100-52-7	No information available
Alcohols, C12-16, ethoxylated	68551-12-2	No information available

Sodium iodide	7681-82-5	No information available

Substances	CAS Number	Mutagenic Effects
Diethylene glycol	111-46-6	In vitro tests did not show mutagenic effects. In vivo tests did not show mutagenic effects.
Cinnamaldehyde	104-55-2	In vitro tests did not show mutagenic effects.
Amine oxides, cocoalkyldimethyl	61788-90-7	In vitro tests did not show mutagenic effects. In vivo tests did not show mutagenic effects. (similar substances)
Methanol	67-56-1	The weight of evidence from available in vitro and in vivo studies indicates that this substance is not expected to be mutagenic.
Benzaldehyde	100-52-7	Not mutagenic in AMES Test. Negative in the chromosomal aberration assay In vitro tests have shown mutagenic effects In vivo tests did not show mutagenic effects.
Alcohols, C12-16, ethoxylated	68551-12-2	Not regarded as mutagenic.
Sodium iodide	7681-82-5	In vitro tests did not show mutagenic effects. (similar substances)

Substances	CAS Number	Carcinogenic Effects
Diethylene glycol	111-46-6	Did not show carcinogenic effects in animal experiments (Rat)
Cinnamaldehyde	104-55-2	No information available
Amine oxides, cocoalkyldimethyl	61788-90-7	No information available
Methanol	67-56-1	No data of sufficient quality are available.
Benzaldehyde	100-52-7	Did not show carcinogenic effects in animal experiments (Rat) There was some evidence of carcinogenic activity in the forestomachs of mice.
Alcohols, C12-16, ethoxylated	68551-12-2	Not regarded as carcinogenic.
Sodium iodide	7681-82-5	No information available

Substances	CAS Number	Reproductive toxicity
Diethylene glycol	111-46-6	Animal testing did not show any effects on fertility. Did not show teratogenic effects in animal experiments.
Cinnamaldehyde	104-55-2	Did not show teratogenic effects in animal experiments.
Amine oxides, cocoalkyldimethyl	61788-90-7	Did not show teratogenic effects in animal experiments. When tested at maternally toxic doses, no adverse effects on teratogenicity or development were observed.
Methanol	67-56-1	Experiments have shown reproductive toxicity effects on laboratory animals
Benzaldehyde	100-52-7	Animal testing did not show any effects on fertility. Did not show teratogenic effects in animal experiments. (similar substances)
Alcohols, C12-16, ethoxylated	68551-12-2	Not regarded as a reproductive and developmental toxicant.
Sodium iodide	7681-82-5	Animal testing did not show any effects on fertility.

Substances	CAS Number	STOT - single exposure
Diethylene glycol	111-46-6	No significant toxicity observed in animal studies at concentration requiring classification.
Cinnamaldehyde	104-55-2	No information available
Amine oxides, cocoalkyldimethyl	61788-90-7	May cause respiratory irritation.
Methanol	67-56-1	May cause disorder and damage to the Central Nervous System (CNS)
Benzaldehyde	100-52-7	May cause respiratory irritation.
Alcohols, C12-16, ethoxylated	68551-12-2	No significant toxicity observed in animal studies at concentration requiring classification.
Sodium iodide	7681-82-5	No information available

Substances	CAS Number	STOT - repeated exposure
Diethylene glycol	111-46-6	Causes damage to organs through prolonged or repeated exposure: Kidney
Cinnamaldehyde	104-55-2	No significant toxicity observed in animal studies at concentration requiring classification.
Amine oxides, cocoalkyldimethyl	61788-90-7	No data of sufficient quality are available.
Methanol	67-56-1	No data of sufficient quality are available.
Benzaldehyde	100-52-7	No significant toxicity observed in animal studies at concentration requiring classification.
Alcohols, C12-16, ethoxylated	68551-12-2	No significant toxicity observed in animal studies at concentration requiring classification.
Sodium iodide	7681-82-5	Causes damage to organs through prolonged or repeated exposure: (Thyroid)

Substances	CAS Number	Aspiration hazard
Diethylene glycol	111-46-6	No information available
Cinnamaldehyde	104-55-2	Not applicable
Amine oxides, cocoalkyldimethyl	61788-90-7	No information available

Methanol	67-56-1	Not applicable
Benzaldehyde	100-52-7	Not applicable
Alcohols, C12-16, ethoxylated	68551-12-2	Not applicable
Sodium iodide	7681-82-5	Not applicable

12. Ecological Information

Ecotoxicity

Substance Ecotoxicity Data

Substances	CAS Number	Toxicity to Algae	Toxicity to Fish	Toxicity to Microorganisms	Toxicity to Invertebrates
Diethylene glycol	111-46-6	TGK (8d) 2700 mg/L (Scenedesmus quadricauda)	LC50 75200 mg/L (Pimephales promelas)	EC20 (30m) > 1995 mg/L (domestic activated sludge)	EC50 84000 mg/L (Daphnia magna) EC50 >10000 mg/L (Daphnia magna)
Cinnamaldehyde	104-55-2	EC50 (72 h) 2.1 mg/L (Skeletonema costatum)	LC50 (96 h) 2.38 mg/L (Scophthalmus maximus)	IC50 (48h) 131.2 mg/L (Tetrahymena pyriformis)	LC50 (48 h) 1.4 mg/L (Acartia tonsa)
Amine oxides, cocoalkyldimethyl	61788-90-7	ErC50 (72h) 0.29 mg/L (Selenastrum capricornutum) ErC50 (72h) 0.0235 mg/L (Scendesmus subspicatus) (similar substance)	LC50 (96h) 1.0–3.4 mg/L (Brachydanio rerio) LC50 (96h) 13.0 (Salmo gairdneri) LC50 (96h) 0.1-1 mg/L (Brachydanio rerio)	EC50 (3h) 240 mg/L (Pseudomonas putida) EC50 (3h) 13 mg/L (Activated sludge)	EC50 (48h) 2.9 mg/L (Daphnia magna) EC50 (48h) 0.083 mg/L (Daphnia magna) (similar substance)
Methanol	67-56-1	EC50 (96 h) =22000 mg/L (Pseudokirchnerella subcapitata) NOEC (8 d) =8000 mg/L (Scenedesmus quadricauda)	LC50 (96 h) =15400 mg/L (Lepomis macrochirus) EC50 (200 h) =14536 mg/L (Oryzias latipes)	IC50 (3h) > 1000 mg/L (activated sludge)	EC50 (96 h) =18260 mg/L (Dapnia magna) NOEC (21 d) =208 mg/L (Dapnia magna)
Benzaldehyde	100-52-7	NOEC (8d) 20 mg/L (Microcystis aeruginosa) NOEC (8d) 132 mg/L	LC50 (96 h) 1.07 mg/L (Lepomis macrochirus)	IC50 (3 h) 740 mg/L (Activated sludge)	EC50 (24 h) 50 mg/L (Daphnia magna)
Alcohols, C12-16, ethoxylated	68551-12-2	EC50 0.7 mg/L (Selenastrum capricornutum)	No information available	No information available	0.39 mg/L (Daphnia Magna)
Sodium iodide	7681-82-5	7 d Tox threshold: 2370 mg/L (Scenedesmus quadricauda, biomass) EC50(72h): 2588.7 mg/L (Skeletonema costatum)	LC50(96h): 3780 mg/L (Oncorhynchus mykiss) LC50(96h): > 100 mg/L (Scopthalmus maximus)	No information available	EC50(48h): 1.27 mg/L (Daphnia magna) EC50(48h): 575 mg/L (Acartia tonsa)

12.2. Persistence and degradability

No data is available on the product itself

Substances	CAS Number	Persistence and Degradability
Diethylene glycol	111-46-6	Readily biodegradable (90-100% @ 28d)
Cinnamaldehyde	104-55-2	Predicted to be readily biodegradable.
Amine oxides, cocoalkyldimethyl	61788-90-7	Readily biodegradable (81% @ 28d)
Methanol	67-56-1	Readily biodegradable (95% @ 20d)
Benzaldehyde	100-52-7	Readily biodegradable (>=95% @ 28d)
Alcohols, C12-16, ethoxylated	68551-12-2	No information available
Sodium iodide	7681-82-5	Not applicable

12.3. Bioaccumulative potential

No data is available on the product itself

Substances	CAS Number	Log Pow
Diethylene glycol	111-46-6	BCF: 100 (Leuciscus idus melanotus)
Cinnamaldehyde	104-55-2	Log Pow =1.4
Amine oxides, cocoalkyldimethyl	61788-90-7	Log Kow = 7.5
Methanol	67-56-1	Not Bioaccumulative; BCF=1
Benzaldehyde	100-52-7	Log Pow =1.1
Alcohols, C12-16, ethoxylated	68551-12-2	No information available
Sodium iodide	7681-82-5	-1.301

12.4. Mobility in soil

Substances	CAS Number	Mobility
Diethylene glycol	111-46-6	No information available
Cinnamaldehyde	104-55-2	No information available
Amine oxides, cocoalkyldimethyl	61788-90-7	No information available
Methanol	67-56-1	No information available
Benzaldehyde	100-52-7	No information available
Alcohols, C12-16, ethoxylated	68551-12-2	No information available
Sodium iodide	7681-82-5	No information available

12.6. Other adverse effects

Endocrine Disruptor Information

This product does not contain any known or suspected endocrine disruptors

13. Disposal Considerations

Safe handling and disposal methods

Incineration recommended in approved incinerator according to federal, state, and local regulations. Substance should NOT be deposited into a sewage facility.

Disposal of any contaminated packaging

Follow all applicable national or local regulations. Contaminated packaging may be disposed of by: rendering packaging incapable of containing any substance, or treating packaging to remove residual contents, or treating packaging to make sure the residual contents are no longer hazardous, or by disposing of packaging into commercial waste collection.

Environmental regulations

Not applicable

14. Transport Information

Transportation Information

Australia ADG

UN Number UN1993
UN proper shipping name: Flammable Liquid, N.O.S. (Contains Methanol)
Transport Hazard Class(es): 3
Packing Group: III
Environmental Hazards: Not applicable

IMDG/IMO

UN Number UN1993
UN proper shipping name: Flammable Liquid, N.O.S. (Contains Methanol)
Transport Hazard Class(es): 3
Packing Group: III
Environmental Hazards: Not applicable
EMS: EmS F-E, S-E

IATA/ICAO

UN Number UN1993
UN proper shipping name: Flammable Liquid, N.O.S. (Contains Methanol)
Transport Hazard Class(es): 3
Packing Group: III
Environmental Hazards: Not applicable

Special precautions during transport

None

HazChem Code

•3Y

15. Regulatory Information

Safety, health and environmental regulations specific for the product

International Inventories

Australian AICS Inventory	All components are listed on the AICS or are subject to a relevant exemption, permit, or assessment certificate.
New Zealand Inventory of Chemicals	All components are listed on the NZIoC or are subject to a relevant exemption, permit, or assessment certificate.
EINECS (European Inventory of Existing Chemical Substances)	This product does not comply with EINECS
US TSCA Inventory	All components listed on inventory or are exempt.
Canadian Domestic Substances List (DSL)	All components listed on inventory or are exempt.

Poisons Schedule number

None Allocated

International Agreements

Montreal Protocol - Ozone Depleting Substances:	Does not apply
Stockholm Convention - Persistent Organic Pollutants:	Does not apply
Rotterdam Convention - Prior Informed Consent:	Does not apply
Basel Convention - Hazardous Waste:	Does not apply

16. Other information

Date of preparation or review

Revision Date: 09-Nov-2017

Revision Note

SDS sections updated:
14

Full text of H-Statements referred to under sections 2 and 3

H225 - Highly flammable liquid and vapor
H226 - Flammable liquid and vapor
H227 - Combustible liquid
H301 - Toxic if swallowed
H302 - Harmful if swallowed
H311 - Toxic in contact with skin
H312 - Harmful in contact with skin
H315 - Causes skin irritation
H317 - May cause an allergic skin reaction
H318 - Causes serious eye damage
H319 - Causes serious eye irritation
H331 - Toxic if inhaled
H332 - Harmful if inhaled
H335 - May cause respiratory irritation
H370 - Causes damage to organs
H372 - Causes damage to organs through prolonged or repeated exposure
H373 - May cause damage to organs through prolonged or repeated exposure
H400 - Very toxic to aquatic life
H401 - Toxic to aquatic life
H412 - Harmful to aquatic life with long lasting effects

Additional information

For additional information on the use of this product, contact your local Halliburton representative.

For questions about the Safety Data Sheet for this or other Halliburton products, contact Chemical Stewardship at 1-580-251-4335.

Key abreviations or acronyms used

bw – body weight
CAS – Chemical Abstracts Service
EC50 – Effective Concentration 50%
LC50 – Lethal Concentration 50%
LD50 – Lethal Dose 50%
LL50 – Lethal Loading 50%
mg/kg – milligram/kilogram
mg/L – milligram/liter
NOEC – No Observed Effect Concentration
OEL – Occupational Exposure Limit
PBT – Persistent Bioaccumulative and Toxic
ppm – parts per million
STEL – Short Term Exposure Limit
TWA – Time-Weighted Average
vPvB – very Persistent and very Bioaccumulative
h - hour
mg/m^3 - milligram/cubic meter
mm - millimeter
mmHg - millimeter mercury
w/w - weight/weight
d - day

Key literature references and sources for data

www.ChemADVISOR.com/
NZ CCID

Disclaimer Statement

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End of Safety Data Sheet

HALLIBURTON

SAFETY DATA SHEET

DCA-19001

Revision Date: 05-Jul-2016 **Revision Number:** 20

1. Product Identifier & Identity for the Chemical

Statement of Hazardous Nature Hazardous according to the criteria of the 3rd Revised Edition of the Globally Harmonised System of Classification and Labelling of Chemicals (GHS), Non-Dangerous Goods according to the criteria of ADG.

1.1. Product Identifier

Product Name DCA-19001

Other means of Identification

Synonyms None

Hazardous Material Number: HM007662

Recommended use of the chemical and restrictions on use

Recommended Use Crosslinker

Uses advised against No information available

Supplier's name, address and phone number

Manufacturer/Supplier Halliburton Australia Pty. Ltd.
15 Marriott Road
Jandakot
WA 6164
Australia

ACN Number: 009 000 775
Telephone Number: + 61 1 800 686 951
Fax Number: 61 (08) 9455 5300

E-mail Address fdunexchem@halliburton.com

Emergency phone number

+ 61 1 800 686 951

Australian Poisons Information Centre
24 Hour Service: - 13 11 26
Police or Fire Brigade: - 000 (exchange): - 1100

2. Hazard Identification

Statement of Hazardous Nature Hazardous according to the criteria of the 3rd Revised Edition of the Globally Harmonised System of Classification and Labelling of Chemicals (GHS), Non-Dangerous Goods according to the criteria of ADG.

Classification of the hazardous chemical

Serious Eye Damage/Irritation	Category 2 - H319
Reproductive Toxicity	Category 2 - H361

Label elements, including precautionary statements

Hazard pictograms

Signal Word Danger

Hazard Statements:
H319 - Causes serious eye irritation
H361 - Suspected of damaging fertility or the unborn child

Precautionary Statements

Prevention
P201 - Obtain special instructions before use
P202 - Do not handle until all safety precautions have been read and understood
P264 - Wash face, hands and any exposed skin thoroughly after handling
P280 - Wear eye protection/face protection
P281 - Use personal protective equipment as required

Response
P305 + P351 + P338 - IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing
P337 + P313 - If eye irritation persists: Get medical advice/attention
P308 + P313 - IF exposed or concerned: Get medical advice/attention

Storage
P405 - Store locked up

Disposal
P501 - Dispose of contents/container in accordance with local/regional/national/international regulations

Contains

Substances	**CAS Number**
Disodium octaborate tetrahydrate	12008-41-2

Other hazards which do not result in classification
This substance is not considered to be persistent, bioaccumulating nor toxic (PBT).
This substance is not considered to be very persistent nor very bioaccumulating (vPvB).

For the full text of the H-phrases mentioned in this Section, see Section 16

3. Composition/information on Ingredients

Substances	CAS Number	PERCENT (w/w)	GHS Classification - Australia
Disodium octaborate tetrahydrate	12008-41-2	60 - 100%	Eye Irrit. 2A (H319) Repr. 2 (H361)

4. First aid measures

Description of necessary first aid measures

Inhalation If inhaled, remove from area to fresh air. Get medical attention if respiratory irritation develops or if breathing becomes difficult.

Eyes In case of contact, immediately flush eyes with plenty of water for at least 15 minutes and get medical attention if irritation persists.

Skin Wash with soap and water. Get medical attention if irritation persists.

Ingestion Do NOT induce vomiting. Give nothing by mouth. Obtain immediate medical attention.

Symptoms caused by exposure
Causes eye irritation Potential reproductive hazard. May cause birth defects.

Medical Attention and Special Treatment
Notes to Physician Treat symptomatically

5. Fire Fighting Measures

Suitable extinguishing equipment
Suitable Extinguishing Media
Water fog, carbon dioxide, foam, dry chemical.
Extinguishing media which must not be used for safety reasons
None known.

Specific hazards arising from the chemical
Special exposure hazards in a fire
None anticipated

Special protective equipment and precautions for fire fighters
Special protective equipment for firefighters
Full protective clothing and approved self-contained breathing apparatus required for fire fighting personnel.

6. Accidental release measures

6.1. Personal precautions, protective equipment and emergency procedures
Use appropriate protective equipment. Avoid creating and breathing dust. Avoid contact with skin, eyes and clothing. Ensure adequate ventilation. Evacuate all persons from the area.

6.2. Environmental precautions
Prevent from entering sewers, waterways, or low areas.

6.3. Methods and material for containment and cleaning up
Scoop up and remove.

7. Handling and storage

7.1. Precautions for safe handling
Handling Precautions
Avoid creating or inhaling dust. Ensure adequate ventilation. Avoid contact with eyes, skin, or clothing. Use appropriate protective equipment.
Hygiene Measures
Handle in accordance with good industrial hygiene and safety practice.

7.2. Conditions for safe storage, including any incompatibilities
Storage Information
Store in a cool, dry location. Product has a shelf life of 60 months.
Other Guidelines
No information available

8. Exposure Controls/Personal Protection

Control parameters - exposure standards, biological monitoring
Exposure Limits

Substances	CAS Number	Australia NOHSC	ACGIH TLV-TWA
Disodium octaborate tetrahydrate	12008-41-2	Not applicable	2 mg/m^3

Appropriate engineering controls
Engineering Controls Use in a well ventilated area.

Personal protective equipment (PPE)

Personal Protective Equipment	If engineering controls and work practices cannot prevent excessive exposures, the selection and proper use of personal protective equipment should be determined by an industrial hygienist or other qualified professional based on the specific application of this product.
Respiratory Protection	If engineering controls and work practices cannot keep exposure below occupational exposure limits or if exposure is unknown, wear a NIOSH certified, European Standard EN 149, AS/NZS 1715:2009, or equivalent respirator when using this product. Selection of and instruction on using all personal protective equipment, including respirators, should be performed by an Industrial Hygienist or other qualified professional. Dust/mist respirator. (N95, P2/P3)
Hand Protection	Impervious rubber gloves.
Skin Protection	Normal work coveralls.
Eye Protection	Dust proof goggles.
Other Precautions	None known.
Environmental Exposure Controls	Do not allow material to contaminate ground water system

9. Physical and Chemical Properties

9.1. Information on basic physical and chemical properties

Physical State:	Solid	**Color**	White
Odor:	Odorless	**Odor Threshold:**	No information available

Property Remarks/ - Method	Values
pH:	7.3
Freezing Point / Range	No data available
Melting Point / Range	> 1000 °C
Boiling Point / Range	No data available
Flash Point	No data available
Evaporation rate	No data available
Vapor Pressure	9.9E-17 pa @ 25°C
Vapor Density	No data available
Specific Gravity	1.7
Water Solubility	Soluble in water
Solubility in other solvents	No data available
Partition coefficient: n-octanol/water	No data available
Autoignition Temperature	No data available
Decomposition Temperature	No data available
Viscosity	No data available
Explosive Properties	No information available
Oxidizing Properties	No information available

9.2. Other information

VOC Content (%)	No data available

10. Stability and Reactivity

10.1. Reactivity
Not expected to be reactive.
10.2. Chemical stability
Stable
10.3. Possibility of hazardous reactions
Will Not Occur
10.4. Conditions to avoid
None anticipated
10.5. Incompatible materials
None known.
10.6. Hazardous decomposition products
None known.

11. Toxicological Information

Information on routes of exposure

Principle Route of Exposure Eye or skin contact, inhalation.

Symptoms related to exposure

Most Important Symptoms/Effects

Causes eye irritation Potential reproductive hazard. May cause birth defects.

Numerical measures of toxicity

Toxicology data for the components

Substances	CAS Number	LD50 Oral	LD50 Dermal	LC50 Inhalation
Disodium octaborate tetrahydrate	12008-41-2	2550 mg/kg-bw (rat) (similar substance)	>2000 mg/kg-bw (rat) (similar substance)	>2 mg/L (dust, rat, 4 h) (similar substance)

Immediate, delayed and chronic health effects from exposure

Inhalation May cause respiratory irritation.

Eye Contact Causes eye irritation.

Skin Contact May cause mild skin irritation.

Ingestion May cause abdominal pain, vomiting, nausea, and diarrhea.

Chronic Effects/Carcinogenicity Prolonged or repeated exposure may cause reproductive system damage. Prolonged or repeated exposure may cause embryo and fetus toxicity.

Exposure Levels

No data available

Interactive effects

None known.

Data limitations

No data available

Substances	CAS Number	Skin corrosion/irritation
Disodium octaborate tetrahydrate	12008-41-2	Not irritating to skin in rabbits. (similar substances)

Substances	CAS Number	Serious eye damage/irritation
Disodium octaborate tetrahydrate	12008-41-2	Eye, rabbit: Causes moderate eye irritation

Substances	CAS Number	Skin Sensitization
Disodium octaborate tetrahydrate	12008-41-2	Did not cause sensitization on laboratory animals (guinea pig)

Substances	CAS Number	Respiratory Sensitization
Disodium octaborate tetrahydrate	12008-41-2	No information available

Substances	CAS Number	Mutagenic Effects
Disodium octaborate tetrahydrate	12008-41-2	In vitro tests did not show mutagenic effects. In vivo tests did not show mutagenic effects. (similar substances)

Substances	CAS Number	Carcinogenic Effects
Disodium octaborate tetrahydrate	12008-41-2	Did not show carcinogenic effects in animal experiments (similar substances)

Substances	CAS Number	Reproductive toxicity
Disodium octaborate tetrahydrate	12008-41-2	May impair fertility May cause birth defects (similar substances)

Substances	CAS Number	STOT - single exposure

Disodium octaborate tetrahydrate	12008-41-2	No significant toxicity observed in animal studies at concentration requiring classification. (similar substances)

Substances	CAS Number	STOT - repeated exposure
Disodium octaborate tetrahydrate	12008-41-2	No significant toxicity observed in animal studies at concentration requiring classification. (similar substances)

Substances	CAS Number	Aspiration hazard
Disodium octaborate tetrahydrate	12008-41-2	Not applicable

12. Ecological Information

Ecotoxicity

Product Ecotoxicity Data

No data available

Substance Ecotoxicity Data

Substances	CAS Number	Toxicity to Algae	Toxicity to Fish	Toxicity to Microorganisms	Toxicity to Invertebrates
Disodium octaborate tetrahydrate	12008-41-2	EC10 (3 d) 96.5 mg/L (Pseudokirchneriella subcapitata)	LC50 (96 h) 314.6 mg/L (Pimephales promelas) NOEC (34 d) 25.2 mg/L (Danio rerio)	EC50 (3 h) >39371 mg/L (activated sludge)	NOEC (21 d) 42.5 mg/L (Daphnia magna)

12.2. Persistence and degradability

Substances	CAS Number	Persistence and Degradability
Disodium octaborate tetrahydrate	12008-41-2	The methods for determining biodegradability are not applicable to inorganic substances.

12.3. Bioaccumulative potential

Substances	CAS Number	Log Pow
Disodium octaborate tetrahydrate	12008-41-2	No information available

12.4. Mobility in soil

Substances	CAS Number	Mobility
Disodium octaborate tetrahydrate	12008-41-2	No information available

12.6. Other adverse effects

Endocrine Disruptor Information

This product does not contain any known or suspected endocrine disruptors

13. Disposal Considerations

Safe handling and disposal methods

Bury in a licensed landfill according to federal, state, and local regulations.

Disposal of any contaminated packaging

Follow all applicable national or local regulations.

Environmental regulations

Not applicable

14. Transport Information

Transportation Information

Australia ADG

UN Number	Not restricted
UN proper shipping name:	Not restricted
Transport Hazard Class(es):	Not applicable
Packing Group:	Not applicable
Environmental Hazards:	Not applicable

IMDG/IMO

UN Number	Not restricted
UN proper shipping name:	Not restricted
Transport Hazard Class(es):	Not applicable
Packing Group:	Not applicable
Environmental Hazards:	Not applicable

IATA/ICAO

UN Number	Not restricted
UN proper shipping name:	Not restricted
Transport Hazard Class(es):	Not applicable
Packing Group:	Not applicable
Environmental Hazards:	Not applicable

Special precautions during transport
None

HazChem Code
None Allocated

15. Regulatory Information

Safety, health and environmental regulations specific for the product

International Inventories

Australian AICS Inventory	All components are listed on the AICS or are subject to a relevant exemption, permit, or assessment certificate.
New Zealand Inventory of Chemicals	All components are listed on the NZIoC or are subject to a relevant exemption, permit, or assessment certificate.
EINECS (European Inventory of Existing Chemical Substances)	This product, and all its components, complies with EINECS
US TSCA Inventory	All components listed on inventory or are exempt.
Canadian Domestic Substances List (DSL)	All components listed on inventory or are exempt.

Poisons Schedule number
S5

International Agreements

Montreal Protocol - Ozone Depleting Substances:	Does not apply
Stolkhom Convention - Persistent Organic Pollutants:	Does not apply
Rotterdam Convention - Prior Informed Consent:	Does not apply
Basel Convention - Hazardous Waste:	Does not apply

16. Other information

Date of preparation or review

Revision Date: 05-Jul-2016

Revision Note
SDS sections updated: 2

Full text of H-Statements referred to under sections 2 and 3
H319 - Causes serious eye irritation

H361 - Suspected of damaging fertility or the unborn child

Additional information

For additional information on the use of this product, contact your local Halliburton representative.

For questions about the Safety Data Sheet for this or other Halliburton products, contact Chemical Stewardship at 1-580-251-4335.

Key abreviations or acronyms used

bw – body weight
CAS – Chemical Abstracts Service
EC50 – Effective Concentration 50%
LC50 – Lethal Concentration 50%
LD50 – Lethal Dose 50%
LL50 – Lethal Loading 50%
mg/kg – milligram/kilogram
mg/L – milligram/liter
NOEC – No Observed Effect Concentration
OEL – Occupational Exposure Limit
PBT – Persistent Bioaccumulative and Toxic
ppm – parts per million
STEL – Short Term Exposure Limit
TWA – Time-Weighted Average
vPvB – very Persistent and very Bioaccumulative
h - hour
mg/m^3 - milligram/cubic meter
mm - millimeter
mmHg - millimeter mercury
w/w - weight/weight
d - day

Key literature references and sources for data

www.ChemADVISOR.com/
OSHA
ECHA C&L

Disclaimer Statement

This information is furnished without warranty, expressed or implied, as to accuracy or completeness. The information is obtained from various sources including the manufacturer and other third party sources. The information may not be valid under all conditions nor if this material is used in combination with other materials or in any process. Final determination of suitability of any material is the sole responsibility of the user.

End of Safety Data Sheet

HALLIBURTON

SAFETY DATA SHEET

DCA-19002

Revision Date: 05-Jul-2016 **Revision Number:** 19

1. Product Identifier & Identity for the Chemical

Statement of Hazardous Nature Hazardous according to the criteria of the 3rd Revised Edition of the Globally Harmonised System of Classification and Labelling of Chemicals (GHS), Non-Dangerous Goods according to the criteria of ADG.

1.1. Product Identifier

Product Name DCA-19002

Other means of Identification

Synonyms None

Hazardous Material Number: HM007663

Recommended use of the chemical and restrictions on use

Recommended Use Crosslinker

Uses advised against No information available

Supplier's name, address and phone number

Manufacturer/Supplier Halliburton Australia Pty. Ltd.
15 Marriott Road
Jandakot
WA 6164
Australia

ACN Number: 009 000 775
Telephone Number: + 61 1 800 686 951
Fax Number: 61 (08) 9455 5300

E-mail Address fdunexchem@halliburton.com

Emergency phone number

+ 61 1 800 686 951

Australian Poisons Information Centre
24 Hour Service: - 13 11 26
Police or Fire Brigade: - 000 (exchange): - 1100

2. Hazard Identification

Statement of Hazardous Nature Hazardous according to the criteria of the 3rd Revised Edition of the Globally Harmonised System of Classification and Labelling of Chemicals (GHS), Non-Dangerous Goods according to the criteria of ADG.

Classification of the hazardous chemical

Serious Eye Damage/Irritation	Category 2 - H319
Reproductive Toxicity	Category 1B - H360
Specific Target Organ Toxicity - (Repeated Exposure)	Category 1 - H372

Label elements, including precautionary statements

Hazard pictograms

Signal Word Danger

Hazard Statements:
H319 - Causes serious eye irritation
H360 - May damage fertility or the unborn child
H372 - Causes damage to organs through prolonged or repeated exposure

Precautionary Statements

Prevention
P201 - Obtain special instructions before use
P202 - Do not handle until all safety precautions have been read and understood
P260 - Do not breathe dust/fume/gas/mist/vapors/spray
P264 - Wash face, hands and any exposed skin thoroughly after handling
P270 - Do not eat, drink or smoke when using this product
P280 - Wear eye protection/face protection
P281 - Use personal protective equipment as required

Response
P305 + P351 + P338 - IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing
P337 + P313 - If eye irritation persists: Get medical advice/attention
P308 + P313 - IF exposed or concerned: Get medical advice/attention
P314 - Get medical attention/advice if you feel unwell

Storage
P405 - Store locked up

Disposal
P501 - Dispose of contents/container in accordance with local/regional/national/international regulations

Contains

Substances	**CAS Number**
Ulexite	1319-33-1
Ethylene glycol	107-21-1
Crystalline silica, quartz	14808-60-7

Other hazards which do not result in classification
This mixture contains no substance considered to be persistent, bioaccumulating nor toxic (PBT).
This mixture contains no substance considered to be very persistent nor very bioaccumulating (vPvB).

For the full text of the H-phrases mentioned in this Section, see Section 16

3. Composition/information on Ingredients

Substances	CAS Number	PERCENT (w/w)	GHS Classification - Australia
Ulexite	1319-33-1	30 - 60%	Eye Irrit. 2A (H319) Repr. 1 (H360)
Ethylene glycol	107-21-1	10 - 30%	Acute Tox. 4 (H302) STOT RE 1 (H372)
Crystalline silica, quartz	14808-60-7	1 - 5%	Carc. 2 (H351) STOT RE 1 (H372)

4. First aid measures

Description of necessary first aid measures

Inhalation If inhaled, move victim to fresh air and seek medical attention.

Eyes	Immediately flush eyes with large amounts of water for at least 15 minutes. Get immediate medical attention.
Skin	Wash off immediately with soap and plenty of water for at least 15 minutes while removing all contaminated clothing and shoes.
Ingestion	Do NOT induce vomiting. Give nothing by mouth. Obtain immediate medical attention.

Symptoms caused by exposure

Causes eye irritation Potential reproductive hazard. May cause birth defects. Prolonged or repeated exposure may cause damage to organs. Breathing crystalline silica can cause lung disease, including silicosis and lung cancer. Crystalline silica has also been associated with scleroderma and kidney disease.

Medical Attention and Special Treatment

Notes to Physician Treat symptomatically

5. Fire Fighting Measures

Suitable extinguishing equipment

Suitable Extinguishing Media

Water fog, carbon dioxide, foam, dry chemical.

Extinguishing media which must not be used for safety reasons

None known.

Specific hazards arising from the chemical

Special exposure hazards in a fire

Decomposition in fire may produce harmful gases.

Special protective equipment and precautions for fire fighters

Special protective equipment for firefighters

Full protective clothing and approved self-contained breathing apparatus required for fire fighting personnel.

6. Accidental release measures

6.1. Personal precautions, protective equipment and emergency procedures

Use appropriate protective equipment. Avoid contact with skin, eyes and clothing. Avoid breathing vapors. Ensure adequate ventilation. Evacuate all persons from the area.

6.2. Environmental precautions

Prevent from entering sewers, waterways, or low areas. Consult local authorities.

6.3. Methods and material for containment and cleaning up

Contain spill with sand or other inert materials. Scoop up and remove. Isolate spill and stop leak where safe.

7. Handling and storage

7.1. Precautions for safe handling

Handling Precautions

Avoid contact with eyes, skin, or clothing. Avoid breathing vapors. Avoid breathing mist. This product contains quartz, cristobalite, and/or tridymite which may become airborne without a visible cloud if this product becomes dry. Avoid breathing or creating dust. Use only with adequate ventilation to keep exposures below recommended exposure limits. Wear a NIOSH certified, European Standard EN 149, or equivalent respirator when using dried product. Ensure adequate ventilation. Material is slippery underfoot. Use appropriate protective equipment.

Hygiene Measures

Handle in accordance with good industrial hygiene and safety practice.

7.2. Conditions for safe storage, including any incompatibilities

Storage Information

Store away from oxidizers. Store in a cool well ventilated area. Keep container closed when not in use.

Other Guidelines

No information available

8. Exposure Controls/Personal Protection

Control parameters - exposure standards, biological monitoring

Exposure Limits

Substances	CAS Number	Australia NOHSC	ACGIH TLV-TWA
Ulexite	1319-33-1	Not applicable	Not applicable
Ethylene glycol	107-21-1	TWA: 10 mg/m³ TWA: 20 ppm TWA: 52 mg/m³ STEL: 40 ppm STEL: 104 mg/m³	Ceiling: 100 mg/m³ (aerosol only)
Crystalline silica, quartz	14808-60-7	TWA: 0.1 mg/m³	TWA: 0.025 mg/m³

Appropriate engineering controls

Engineering Controls Use in a well ventilated area.

Personal protective equipment (PPE)

Personal Protective Equipment If engineering controls and work practices cannot prevent excessive exposures, the selection and proper use of personal protective equipment should be determined by an industrial hygienist or other qualified professional based on the specific application of this product.

Respiratory Protection If engineering controls and work practices cannot keep exposure below occupational exposure limits or if exposure is unknown, wear a NIOSH certified, European Standard EN 149, AS/NZS 1715:2009, or equivalent respirator when using this product. Selection of and instruction on using all personal protective equipment, including respirators, should be performed by an Industrial Hygienist or other qualified professional.
Organic vapor respirator.

Hand Protection Rubber gloves.
Skin Protection Rubber apron.
Eye Protection Chemical goggles; also wear a face shield if splashing hazard exists.
Other Precautions None known.
Environmental Exposure Controls Do not allow material to contaminate ground water system

9. Physical and Chemical Properties

9.1. Information on basic physical and chemical properties

Physical State: Liquid
Odor: Odorless
Color Milky white
Odor Threshold: No information available

Property Remarks/ - Method	Values
pH:	6.5 - 7.5
Freezing Point / Range	-34 °C
Melting Point / Range	No data available
Boiling Point / Range	No data available
Flash Point	No data available
Evaporation rate	No data available
Vapor Pressure	No data available
Vapor Density	No data available
Specific Gravity	1.45
Water Solubility	Soluble in water
Solubility in other solvents	No data available
Partition coefficient: n-octanol/water	No data available
Autoignition Temperature	No data available
Decomposition Temperature	No data available
Viscosity	No data available
Explosive Properties	No information available
Oxidizing Properties	No information available

9.2. Other information

VOC Content (%) No data available

10. Stability and Reactivity

10.1. Reactivity

Not expected to be reactive.

10.2. Chemical stability

Stable

10.3. Possibility of hazardous reactions

Will Not Occur

10.4. Conditions to avoid

None anticipated

10.5. Incompatible materials

Strong oxidizers.

10.6. Hazardous decomposition products

Carbon monoxide and carbon dioxide.

11. Toxicological Information

Information on routes of exposure

Principle Route of Exposure Eye or skin contact, inhalation.

Symptoms related to exposure

Most Important Symptoms/Effects

Causes eye irritation Potential reproductive hazard. May cause birth defects. Prolonged or repeated exposure may cause damage to organs. Breathing crystalline silica can cause lung disease, including silicosis and lung cancer. Crystalline silica has also been associated with scleroderma and kidney disease.

Numerical measures of toxicity

Toxicology data for the components

Substances	CAS Number	LD50 Oral	LD50 Dermal	LC50 Inhalation
Ulexite	1319-33-1	3493-6080 mg/kg (Rat) (similar substance) 3450 mg/kg (Male Rat) (similar substance)	> 2000 mg/kg (Rabbit) (similar substance)	> 2 mg/L (Rat) 4h (similar substance) > 2.12 mg/L (Rat) 4h (similar substance) > 2.04 mg/L (Rat) 4h (similar substance)
Ethylene glycol	107-21-1	4000 mg/kg (Rat) 7712 mg/kg (Rat) > 10000 mg/kg (Rat) 1670 mg/kg (Cat) 1400 – 1600 mg/kg (Human)	9530 µL/kg (Rabbit) > 3500 mg/kg (Mouse)	> 2.5 mg/L (Rat) 6h (saturated concentration)
Crystalline silica, quartz	14808-60-7	> 15000 mg/kg (human)	No information available	No data available

Immediate, delayed and chronic health effects from exposure

Inhalation May cause respiratory irritation. In high air concentrations: May cause central nervous system depression including headache, dizziness, drowsiness, incoordination, slowed reaction time, slurred speech, giddiness and unconsciousness. Inhaled crystalline silica in the form of quartz or cristobalite from occupational sources is carcinogenic to humans (IARC, Group 1). There is sufficient evidence in experimental animals for the carcinogenicity of tridymite (IARC, Group 2A).

Breathing silica dust may cause irritation of the nose, throat, and respiratory passages. Breathing silica dust may not cause noticeable injury or illness even though permanent lung damage may be occurring. Inhalation of dust may also have serious chronic health effects (See "Chronic Effects/Carcinogenicity" subsection below).

Eye Contact Causes eye irritation.

Skin Contact May cause mild skin irritation.

Ingestion May be harmful if swallowed. In large amounts: May cause abdominal pain, vomiting,

nausea, and diarrhea. May cause heart, kidney and brain disorders.

Chronic Effects/Carcinogenicity Prolonged or repeated exposure may cause embryo and fetus toxicity. Prolonged or repeated exposure may cause reproductive system damage. Repeated overexposure may cause liver and kidney effects. Silicosis: Excessive inhalation of respirable crystalline silica dust may cause a progressive, disabling, and sometimes-fatal lung disease called silicosis. Symptoms include cough, shortness of breath, wheezing, non-specific chest illness, and reduced pulmonary function. This disease is exacerbated by smoking. Individuals with silicosis are predisposed to develop tuberculosis.

See "Inhalation" subsection above with respect to silicosis, cancer status and other data with possible relevance to human health. There is some evidence that breathing respirable crystalline silica or the disease silicosis is associated with an increased incidence of significant disease endpoints such as scleroderma (an immune system disorder manifested by scarring of the lungs, skin, and other internal organs) and kidney disease.

Exposure Levels
No data available

Interactive effects
Eye ailments. Skin disorders. Liver and kidney disorders. Individuals with respiratory disease, including but not limited to asthma and bronchitis, or subject to eye irritation, should not be exposed to quartz dust.

Data limitations
No data available

Substances	CAS Number	Skin corrosion/irritation
Ulexite	1319-33-1	Non-irritating to the skin (Rabbit) (similar substances)
Ethylene glycol	107-21-1	Non-irritating to the skin (Rabbit)
Crystalline silica, quartz	14808-60-7	Non-irritating to the skin

Substances	CAS Number	Serious eye damage/irritation
Ulexite	1319-33-1	Causes moderate eye irritation (Rabbit) (similar substances)
Ethylene glycol	107-21-1	Non-irritating to the eye (Rabbit)
Crystalline silica, quartz	14808-60-7	Mechanical irritation of the eyes is possible. No information available

Substances	CAS Number	Skin Sensitization
Ulexite	1319-33-1	Did not cause sensitization on laboratory animals (guinea pig) (similar substances)
Ethylene glycol	107-21-1	Did not cause sensitization on laboratory animals (guinea pig) Patch test on human volunteers did not demonstrate sensitization properties
Crystalline silica, quartz	14808-60-7	No information available.

Substances	CAS Number	Respiratory Sensitization
Ulexite	1319-33-1	No information available
Ethylene glycol	107-21-1	No information available
Crystalline silica, quartz	14808-60-7	No information available

Substances	CAS Number	Mutagenic Effects
Ulexite	1319-33-1	In vitro tests did not show mutagenic effects (similar substances)
Ethylene glycol	107-21-1	In vitro tests did not show mutagenic effects. In vivo tests did not show mutagenic effects.
Crystalline silica, quartz	14808-60-7	Not regarded as mutagenic.

Substances	CAS Number	Carcinogenic Effects
Ulexite	1319-33-1	Did not show carcinogenic effects in animal experiments (similar substances)
Ethylene glycol	107-21-1	Did not show carcinogenic effects in animal experiments
Crystalline silica, quartz	14808-60-7	Contains crystalline silica which may cause silicosis, a delayed and progressive lung disease. The IARC and NTP have determined there is sufficient evidence in humans of the carcinogenicity of crystalline silica with repeated respiratory exposure. Based on available scientific evidence, this

		substance is a threshold carcinogen with a mode of action involving indirect genotoxicity secondary to lung injury.

Substances	CAS Number	Reproductive toxicity
Ulexite	1319-33-1	Experiments have shown reproductive toxicity effects on laboratory animals (similar substances)
Ethylene glycol	107-21-1	Fetotoxic and teratogenic effects observed in experimental animals at concentrations that did not produce maternal toxicity.
Crystalline silica, quartz	14808-60-7	No information available

Substances	CAS Number	STOT - single exposure
Ulexite	1319-33-1	None under normal use conditions
Ethylene glycol	107-21-1	No significant toxicity observed in animal studies at concentration requiring classification.
Crystalline silica, quartz	14808-60-7	No significant toxicity observed in animal studies at concentration requiring classification.

Substances	CAS Number	STOT - repeated exposure
Ulexite	1319-33-1	None under normal use conditions
Ethylene glycol	107-21-1	Causes damage to organs through prolonged or repeated exposure: (Kidney)
Crystalline silica, quartz	14808-60-7	Causes damage to organs through prolonged or repeated exposure if inhaled: (Lungs)

Substances	CAS Number	Aspiration hazard
Ulexite	1319-33-1	Not applicable
Ethylene glycol	107-21-1	No information available
Crystalline silica, quartz	14808-60-7	Not applicable

12. Ecological Information

Ecotoxicity

Product Ecotoxicity Data

No data available

Substance Ecotoxicity Data

Substances	CAS Number	Toxicity to Algae	Toxicity to Fish	Toxicity to Microorganisms	Toxicity to Invertebrates
Ulexite	1319-33-1	EC50 (72h) 1398.64 mg/L (Skeletonema costatum)	LC50 (96h) > 320 mg/L (Scophthalmus maximus) LC50 (96h) > 1100 mg/L (Oncorhynchus mykiss) LC50 (96h) > 1021 mg/L (Lepomis macrochirus) LD50 (28d) 65 mg/L (Oncorhynchus mykiss)	No information available	EC50 (48h) 7341.67 mg/L (Acartia tonsa) EC50 (48h) 133 mg/L (Daphnia magna)
Ethylene glycol	107-21-1	EC50 6500 - 13000 mg/L (Pseudokirchneriella subcapitata) TGK (8d) > 10000 mg/L (Scenedesmus quadricauda)	LC50 41000 mg/L (Oncorhynchus mykiss) LC50 (96h) 72860 mg/L (Pimephales promelas) NOEC (7d) 15380 mg/L (mortality) (Pimephales promelas)	TTC (16h) > 10000 mg/L (Pseudomonas putida) EC20 (30 m) > 1995 mg/L (activated sludge, domestic) (similar substance)	EC50 46300 mg/L (Daphnia magna) EC50 (48h) >100 mg/L (Daphnia magna) NOEC (7d) 8590 mg/L (reproduction) (Ceriodaphnia dubia)
Crystalline silica, quartz	14808-60-7	EC50 (72 h) =440 mg/L (Selenastrum capricornutum)	LL0 (96 h) =10000 mg/L (Danio rerio)	No information available	LL50 (24 h) >10000 mg/L (Daphnia magna)

12.2. Persistence and degradability

Substances	CAS Number	Persistence and Degradability
Ulexite	1319-33-1	The methods for determining biodegradability are not applicable to inorganic substances.
Ethylene glycol	107-21-1	Readily biodegradable (100% @ 10d)
Crystalline silica, quartz	14808-60-7	The methods for determining biodegradability are not applicable to inorganic substances.

12.3. Bioaccumulative potential

Substances	CAS Number	Log Pow

Ulexite	1319-33-1	0.175
Ethylene glycol	107-21-1	-1.36
Crystalline silica, quartz	14808-60-7	No information available

12.4. Mobility in soil

Substances	CAS Number	Mobility
Ulexite	1319-33-1	No information available
Ethylene glycol	107-21-1	No information available
Crystalline silica, quartz	14808-60-7	No information available

12.6. Other adverse effects

Endocrine Disruptor Information

This product does not contain any known or suspected endocrine disruptors

13. Disposal Considerations

Safe handling and disposal methods

Disposal should be made in accordance with federal, state, and local regulations.

Disposal of any contaminated packaging

Follow all applicable national or local regulations.

Environmental regulations

Not applicable

14. Transport Information

Transportation Information

Australia ADG

UN Number	Not restricted
UN proper shipping name:	Not restricted
Transport Hazard Class(es):	Not applicable
Packing Group:	Not applicable
Environmental Hazards:	Not applicable

IMDG/IMO

UN Number	Not restricted
UN proper shipping name:	Not restricted
Transport Hazard Class(es):	Not applicable
Packing Group:	Not applicable
Environmental Hazards:	Not applicable

IATA/ICAO

UN Number	Not restricted
UN proper shipping name:	Not restricted
Transport Hazard Class(es):	Not applicable
Packing Group:	Not applicable
Environmental Hazards:	Not applicable

Special precautions during transport

None

HazChem Code

None Allocated

15. Regulatory Information

Safety, health and environmental regulations specific for the product

International Inventories

Australian AICS Inventory	All components are listed on the AICS or are subject to a relevant exemption, permit, or assessment certificate.
New Zealand Inventory of Chemicals	All components are listed on the NZIoC or are subject to a relevant exemption, permit, or assessment certificate.
EINECS (European Inventory of Existing Chemical Substances)	This product, and all its components, complies with EINECS
US TSCA Inventory	All components listed on inventory or are exempt.
Canadian Domestic Substances List (DSL)	All components listed on inventory or are exempt.

Poisons Schedule number

None Allocated

International Agreements

Montreal Protocol - Ozone Depleting Substances:	Does not apply
Stolkhom Convention - Persistent Organic Pollutants:	Does not apply
Rotterdam Convention - Prior Informed Consent:	Does not apply
Basel Convention - Hazardous Waste:	Does not apply

16. Other information

Date of preparation or review

Revision Date: 05-Jul-2016

Revision Note

SDS sections updated: 2

Full text of H-Statements referred to under sections 2 and 3

H302 - Harmful if swallowed
H319 - Causes serious eye irritation
H351 - Suspected of causing cancer if inhaled
H360 - May damage fertility or the unborn child
H372 - Causes damage to organs through prolonged or repeated exposure if swallowed
H372 - Causes damage to organs through prolonged or repeated exposure if inhaled

Additional information

For additional information on the use of this product, contact your local Halliburton representative.

For questions about the Safety Data Sheet for this or other Halliburton products, contact Chemical Stewardship at 1-580-251-4335.

Key abreviations or acronyms used

bw – body weight
CAS – Chemical Abstracts Service
EC50 – Effective Concentration 50%
LC50 – Lethal Concentration 50%
LD50 – Lethal Dose 50%
LL50 – Lethal Loading 50%
mg/kg – milligram/kilogram
mg/L – milligram/liter
NOEC – No Observed Effect Concentration
OEL – Occupational Exposure Limit
PBT – Persistent Bioaccumulative and Toxic
ppm – parts per million
STEL – Short Term Exposure Limit
TWA – Time-Weighted Average
vPvB – very Persistent and very Bioaccumulative
h - hour
mg/m^3 - milligram/cubic meter
mm - millimeter

mmHg - millimeter mercury
w/w - weight/weight
d - day

Key literature references and sources for data
www.ChemADVISOR.com/
OSHA
ECHA C&L

Disclaimer Statement
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End of Safety Data Sheet

HALLIBURTON

SAFETY DATA SHEET

DCA-21003

Revision Date: 30-Sep-2015 **Revision Number:** 9

1. Product Identifier & Identity for the Chemical

Statement of Hazardous Nature Non-Hazardous according to the criteria of the 3rd Revised Edition of the Globally Harmonised System of Classification and Labelling of Chemicals (GHS), Non-Dangerous Goods according to the criteria of ADG.

1.1. Product Identifier

Product Name DCA-21003

Other means of Identification

Synonyms: None

Product Code: HM007806

Recommended use of the chemical and restrictions on use

Recommended Use Fluid Loss Additive

Uses Advised Against No information available

Supplier's name, address and phone number

Manufacturer/Supplier

Halliburton/Baroid Australia Pty. Ltd.
15 Marriott Road
Jandakot
WA 6164
Australia

ACN Number: 009 000 775
Telephone Number: 61 (08) 9455 8300
Fax Number: 61 (08) 9455 5300

Product Emergency Telephone
Australia: + 61 1 800 686 951
Papua New Guinea: + 61 1 800 686 951
NewZealand: +64 800 451719

Fire, Police & Ambulance - Emergency Telephone
Australia: 000
Papua New Guinea: 000
New Zealand: 111

E-Mail address: fdunexchem@halliburton.com

Emergency phone number
+ 61 1 800 686 951

Australian Poisons Information Centre
24 Hour Service: - 13 11 26
Police or Fire Brigade: - 000 (exchange): - 1100

2. Hazard Identification

Statement of Hazardous Nature Non-Hazardous according to the criteria of the 3rd Revised Edition of the Globally Harmonised System of Classification and Labelling of Chemicals (GHS), Non-Dangerous

Goods according to the criteria of ADG.

Classification of the hazardous chemical

Not classified

Label elements, including precautionary statements

Hazard Pictograms

Signal Word	Not Hazardous
Hazard Statements	Not Classified
Precautionary Statements	
Prevention	None
Response	None
Storage	None
Disposal	None

Contains Substances	**CAS Number**
Contains no hazardous substances in concentrations above cut-off values according to the competent authority	NA

Other hazards which do not result in classification

None known

Australia Classification

For the full text of the H-phrases mentioned in this Section, see Section 16

Classification	Not Classified
Risk Phrases	None

3. Composition/information on Ingredients

Substances	CAS Number	PERCENT (w/w)	GHS Classification - Australia
Contains no hazardous substances in concentrations above cut-off values according to the competent authority	NA	60 - 100%	Not Applicable

4. First aid measures

Description of necessary first aid measures

Inhalation	If inhaled, remove from area to fresh air. Get medical attention if respiratory irritation develops or if breathing becomes difficult.
Eyes	Immediately flush eyes with large amounts of water for at least 15 minutes. Get immediate medical attention.
Skin	Wash with soap and water. Get medical attention if irritation persists.
Ingestion	If swallowed, induce vomiting immediately by giving two glasses of water and sticking fingers down throat; never give anything to an unconscious person. Get medical attention.

Symptoms caused by exposure

No significant hazards expected.

Medical Attention and Special Treatment
Notes to Physician Treat symptomatically

5. Fire Fighting Measures

Suitable extinguishing equipment
Suitable Extinguishing Media
Water fog, carbon dioxide, foam, dry chemical.
Extinguishing media which must not be used for safety reasons
None known.

Specific hazards arising from the chemical
Special Exposure Hazards
Decomposition in fire may produce harmful gases. Organic dust in the presence of an ignition source can be explosive in high concentrations. Good housekeeping practices are required to minimize this potential.

Special protective equipment and precautions for fire fighters
Special Protective Equipment for Fire-Fighters
Full protective clothing and approved self-contained breathing apparatus required for fire fighting personnel.

6. Accidental release measures

6.1. Personal precautions, protective equipment and emergency procedures
Use appropriate protective equipment. Spills of this product are very slippery.

6.2. Environmental precautions
Prevent from entering sewers, waterways, or low areas.

6.3. Methods and material for containment and cleaning up
Scoop up and remove.

7. Handling and storage

7.1. Precautions for Safe Handling
Handling Precautions
Avoid contact with eyes, skin, or clothing. Avoid creating or inhaling dust. Avoid dust accumulations.
Hygiene Measures
Handle in accordance with good industrial hygiene and safety practice.

7.2. Conditions for safe storage, including any incompatibilities
Storage Information
Use good housekeeping in storage and work areas to prevent accumulation of dust. Close container when not in use. Store between 40.5 F (4.7 C) and 120.5 F (49 C). Store away from oxidizers. Store in a cool, dry location. Product has a shelf life of 24 months.
Other Guidelines
No information available

8. Exposure Controls/Personal Protection

Control parameters - exposure standards, biological monitoring
Exposure Limits

Substances	CAS Number	Australia NOHSC	ACGIH TLV-TWA
Contains no hazardous substances in concentrations above cut-off values according to the competent authority	NA	Not applicable	Not applicable

Appropriate engineering controls

Engineering Controls	Use in a well ventilated area.

Personal protective equipment (PPE)

Respiratory Protection	If engineering controls and work practices cannot keep exposure below occupational exposure limits or if exposure is unknown, wear a NIOSH certified, European Standard EN 149, AS/NZS 1715:2009, or equivalent respirator when using this product. Selection of and instruction on using all personal protective equipment, including respirators, should be performed by an Industrial Hygienist or other qualified professional. Dust/mist respirator. (N95, P2/P3)
Hand Protection	Normal work gloves.
Skin Protection	Normal work coveralls.
Eye Protection	Wear safety glasses or goggles to protect against exposure.
Other Precautions	None known.
Environmental Exposure Controls	No information available

9. Physical and Chemical Properties

9.1. Information on basic physical and chemical properties

Physical State:	Powder	**Color:**	White to off white
Odor:	Sweet	**Odor Threshold:**	No information available

Property Remarks/ - Method	Values
pH:	No data available
Freezing Point/Range	No data available
Melting Point/Range	No data available
Boiling Point/Range	No data available
Flash Point	No data available
Evaporation rate	No data available
Vapor Pressure	No data available
Vapor Density	No data available
Specific Gravity	1.24
Water Solubility	Insoluble in water
Solubility in other solvents	No data available
Partition coefficient: n-octanol/water	No data available
Autoignition Temperature	388 °C / 730 °F
Decomposition Temperature	No data available
Viscosity	No data available
Explosive Properties	No information available
Oxidizing Properties	No information available

9.2. Other information

VOC Content (%)	No data available

10. Stability and Reactivity

10.1. Reactivity
Not expected to be reactive.
10.2. Chemical Stability
Stable
10.3. Possibility of Hazardous Reactions
Will Not Occur
10.4. Conditions to Avoid
Temperature over 440 F (240 C).
10.5. Incompatible Materials
Strong oxidizers. Strong alkalis.
10.6. Hazardous Decomposition Products
Toxic fumes. Aldehydes. Carbon monoxide and carbon dioxide.

11. Toxicological Information

Information on routes of exposure

Principle Route of Exposure Eye or skin contact, inhalation.

Sympotoms related to exposure

Most Important Symptoms/Effects

No significant hazards expected.

Numerical measures of toxicity

LD50 Oral: > 5000 mg/kg; (Rat)

LD50 Dermal: > 2000 mg/kg; (Rabbit)

Toxicology data for the components

Substances	CAS Number	LD50 Oral	LD50 Dermal	LC50 Inhalation
Contains no hazardous substances in concentrations above cut-off values according to the competent authority	NA	No data available	No data available	No data available

Immediate, delayed and chronic health effects from exposure

Inhalation May cause mild respiratory irritation.

Eye Contact May cause mild eye irritation.

Skin Contact Prolonged or repeated contact may cause slight skin irritation.

Ingestion Irritation of the mouth, throat, and stomach. Large doses may cause nausea, vomiting and diarrhea.

Chronic Effects/Carcinogenicity No data available to indicate product or components present at greater than 0.1% are chronic health hazards.

Exposure Levels

No data available

Interactive effects

None known.

Data limitations

No data available

12. Ecological Information

Ecotoxicity

Product Ecotoxicity Data

No data available

Substance Ecotoxicity Data

Substances	CAS Number	Toxicity to Algae	Toxicity to Fish	Toxicity to Microorganisms	Toxicity to Invertebrates
Contains no hazardous substances	NA	No information available	No information available	No information available	No information available

in concentrations above cut-off values according to the competent authority					

12.2. Persistence and degradability

Substances	CAS Number	Persistence and Degradability
Contains no hazardous substances in concentrations above cut-off values according to the competent authority	NA	No information available

12.3. Bioaccumulative potential

Does not bioaccumulate

Substances	CAS Number	Log Pow
Contains no hazardous substances in concentrations above cut-off values according to the competent authority	NA	No information available

12.4. Mobility in soil

Substances	CAS Number	Mobility
Contains no hazardous substances in concentrations above cut-off values according to the competent authority	NA	No information available

12.6. Other adverse effects

Endocrine Disruptor Information

This product does not contain any known or suspected endocrine disruptors

13. Disposal Considerations

Safe handling and disposal methods

Bury in a licensed landfill according to federal, state, and local regulations.

Disposal of any contaminated packaging

Follow all applicable national or local regulations.

Environmental regulations

Not applicable

14. Transport Information

Transportation Information

UN Number: Not restricted
UN Proper Shipping Name: Not restricted
Transport Hazard Class(es): Not applicable
Packing Group: Not applicable
Environmental Hazards: Not applicable

Special precautions during transport

None

HazChem Code

None Allocated

15. Regulatory Information

Safety, health and environmental regulations specific for the product

International Inventories

Australian AICS Inventory	All components listed on inventory or are exempt.
New Zealand Inventory of Chemicals	All components listed on inventory or are exempt.
EINECS Inventory	This product, and all its components, complies with EINECS
US TSCA Inventory	All components listed on inventory or are exempt.
Canadian DSL Inventory	All components listed on inventory or are exempt.

Poisons Schedule number
None Allocated

16. Other information

Date of preparation or review

Revision Date: 30-Sep-2015

Revision Note
SDS sections updated: 2

Full text of R-phrases referred to under Sections 2 and 3
None

Full text of H-Statements referred to under sections 2 and 3
None

Additional information For additional information on the use of this product, contact your local Halliburton representative.

For questions about the Safety Data Sheet for this or other Halliburton products, contact Chemical Stewardship at 1-580-251-4335.

Key abreviations or acronyms used
bw – body weight CAS – Chemical Abstracts Service EC50 – Effective Concentration 50% LC50 – Lethal Concentration 50% LD50 – Lethal Dose 50% LL50 – Lethal Loading 50% mg/kg – milligram/kilogram mg/L – milligram/liter NOEC – No Observed Effect Concentration OEL – Occupational Exposure Limit PBT – Persistent Bioaccumulative and Toxic ppm – parts per million STEL – Short Term Exposure Limit TWA – Time-Weighted Average vPvB – very Persistent and very Bioaccumulative h - hour mg/m^3 - milligram/cubic meter mm - millimeter mmHg - millimeter mercury w/w - weight/weight d - day

Key literature references and sources for data
www.ChemADVISOR.com/

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End of Safety Data Sheet

HALLIBURTON

SAFETY DATA SHEET

DCA-23001

Revision Date: 30-Sep-2015 **Revision Number:** 10

1. Product Identifier & Identity for the Chemical

Statement of Hazardous Nature Non-Hazardous according to the criteria of the 3rd Revised Edition of the Globally Harmonised System of Classification and Labelling of Chemicals (GHS), Non-Dangerous Goods according to the criteria of ADG.

1.1. Product Identifier

Product Name DCA-23001

Other means of Identification

Synonyms: None

Product Code: HM007701

Recommended use of the chemical and restrictions on use

Recommended Use Friction Reducer

Uses Advised Against No information available

Supplier's name, address and phone number

Manufacturer/Supplier

Halliburton Australia Pty. Ltd.
15 Marriott Road
Jandakot
WA 6164
Australia

ACN Number: 009 000 775
Telephone Number: + 61 1 800 686 951
Fax Number: 61 (08) 9455 5300

E-Mail address: fdunexchem@halliburton.com

Emergency phone number

+ 61 1 800 686 951

Australian Poisons Information Centre

24 Hour Service: - 13 11 26

Police or Fire Brigade: - 000 (exchange): - 1100

2. Hazard Identification

Statement of Hazardous Nature Non-Hazardous according to the criteria of the 3rd Revised Edition of the Globally Harmonised System of Classification and Labelling of Chemicals (GHS), Non-Dangerous Goods according to the criteria of ADG.

Classification of the hazardous chemical

Not classified

Label elements, including precautionary statements

Hazard Pictograms

Signal Word Not Hazardous

Hazard Statements Not Classified

Precautionary Statements

Prevention None

Response None

Storage None

Disposal None

Contains

Substances	**CAS Number**
Contains no hazardous substances in concentrations above cut-off values according to the competent authority	NA

Other hazards which do not result in classification

This mixture contains no substance considered to be persistent, bioaccumulating nor toxic (PBT).
This mixture contains no substance considered to be very persistent nor very bioaccumulating (vPvB).

Australia Classification

For the full text of the H-phrases mentioned in this Section, see Section 16

Classification Not Classified
Risk Phrases None

3. Composition/information on Ingredients

Substances	CAS Number	PERCENT (w/w)	GHS Classification - Australia
Contains no hazardous substances in concentrations above cut-off values according to the competent authority	NA	60 - 100%	Not Applicable

4. First aid measures

Description of necessary first aid measures

Inhalation If inhaled, remove from area to fresh air. Get medical attention if respiratory irritation develops or if breathing becomes difficult.

Eyes Immediately flush eyes with large amounts of water for at least 15 minutes. Get immediate medical attention.

Skin Wash with soap and water. Get medical attention if irritation persists.

Ingestion Do NOT induce vomiting. Give nothing by mouth. Obtain immediate medical attention.

Symptoms caused by exposure

No significant hazards expected.

Medical Attention and Special Treatment

Notes to Physician Treat symptomatically

5. Fire Fighting Measures

Suitable extinguishing equipment

Suitable Extinguishing Media

All standard fire fighting media

Extinguishing media which must not be used for safety reasons

None known.

Specific hazards arising from the chemical
Special Exposure Hazards
Not applicable.

Special protective equipment and precautions for fire fighters
Special Protective Equipment for Fire-Fighters
Full protective clothing and approved self-contained breathing apparatus required for fire fighting personnel.

6. Accidental release measures

6.1. Personal precautions, protective equipment and emergency procedures
Use appropriate protective equipment. Avoid creating and breathing dust. Avoid contact with skin, eyes and clothing. Ensure adequate ventilation.

6.2. Environmental precautions
Prevent from entering sewers, waterways, or low areas.

6.3. Methods and material for containment and cleaning up
Scoop up and remove.

7. Handling and storage

7.1. Precautions for Safe Handling
Handling Precautions
Avoid contact with eyes, skin, or clothing. Avoid creating or inhaling dust. Ensure adequate ventilation. Ground and bond containers when transferring from one container to another. Slippery when wet. Wash hands after use. Launder contaminated clothing before reuse. Use appropriate protective equipment.
Hygiene Measures
Handle in accordance with good industrial hygiene and safety practice.

7.2. Conditions for safe storage, including any incompatibilities
Storage Information
Store in a cool, dry location. Keep container closed when not in use. Keep from heat, sparks, and open flames. Product has a shelf life of 24 months.
Other Guidelines
No information available

8. Exposure Controls/Personal Protection

Control parameters - exposure standards, biological monitoring
Exposure Limits

Substances	CAS Number	Australia NOHSC	ACGIH TLV-TWA
Contains no hazardous substances in concentrations above cut-off values according to the competent authority	NA	Not applicable	Not applicable

Appropriate engineering controls
Engineering Controls Use in a well ventilated area.

Personal protective equipment (PPE)
Respiratory Protection If engineering controls and work practices cannot keep exposure below occupational exposure limits or if exposure is unknown, wear a NIOSH certified, European Standard EN 149, AS/NZS 1715:2009, or equivalent respirator when using this product. Selection of and instruction on using all personal protective equipment, including respirators, should be performed by an Industrial Hygienist or other qualified professional.

Hand Protection Normal work gloves.
Skin Protection Normal work coveralls.

Eye Protection	Wear safety glasses or goggles to protect against exposure.
Other Precautions	None known.
Environmental Exposure Controls	Do not allow material to contaminate ground water system

9. Physical and Chemical Properties

9.1. Information on basic physical and chemical properties

Physical State:	Powder	**Color:**	White
Odor:	Slight	**Odor Threshold:**	No information available

Property Remarks/ - Method	Values
pH:	9
Freezing Point/Range	No data available
Melting Point/Range	No data available
Boiling Point/Range	No data available
Flash Point	No data available
Evaporation rate	No data available
Vapor Pressure	No data available
Vapor Density	No data available
Specific Gravity	2
Water Solubility	Soluble in water
Solubility in other solvents	No data available
Partition coefficient: n-octanol/water	No data available
Autoignition Temperature	No data available
Decomposition Temperature	No data available
Viscosity	No data available
Explosive Properties	No information available
Oxidizing Properties	No information available

9.2. Other information

VOC Content (%)	No data available

10. Stability and Reactivity

10.1. Reactivity
Not expected to be reactive.
10.2. Chemical Stability
Stable
10.3. Possibility of Hazardous Reactions
Will Not Occur
10.4. Conditions to Avoid
None anticipated
10.5. Incompatible Materials
Strong oxidizers.
10.6. Hazardous Decomposition Products
Carbon monoxide and carbon dioxide. Ammonia.

11. Toxicological Information

Information on routes of exposure
Principle Route of Exposure Eye or skin contact, inhalation.

Sympotoms related to exposure
Most Important Symptoms/Effects
No significant hazards expected.

Numerical measures of toxicity

Toxicology data for the components

Substances	CAS Number	LD50 Oral	LD50 Dermal	LC50 Inhalation
Contains no hazardous substances in concentrations above cut-off values according to the competent authority	NA	No data available	No data available	No data available

Immediate, delayed and chronic health effects from exposure

Inhalation May cause mild respiratory irritation.
Eye Contact May cause mild eye irritation.
Skin Contact May cause mild skin irritation.
Ingestion Large doses may cause nausea, vomiting and diarrhea.

Chronic Effects/Carcinogenicity No data available to indicate product or components present at greater than 0.1% are chronic health hazards.

Exposure Levels
No data available

Interactive effects
Respiratory disorders. Skin disorders.

Data limitations
No data available

12. Ecological Information

Ecotoxicity
Product Ecotoxicity Data
No data available

Substance Ecotoxicity Data

Substances	CAS Number	Toxicity to Algae	Toxicity to Fish	Toxicity to Microorganisms	Toxicity to Invertebrates
Contains no hazardous substances in concentrations above cut-off values according to the competent authority	NA	No information available	No information available	No information available	No information available

12.2. Persistence and degradability

Substances	CAS Number	Persistence and Degradability
Contains no hazardous substances in concentrations above cut-off values according to the competent authority	NA	No information available

12.3. Bioaccumulative potential

Substances	CAS Number	Log Pow
Contains no hazardous substances in concentrations above cut-off values according to the competent authority	NA	No information available

12.4. Mobility in soil

Substances	CAS Number	Mobility
Contains no hazardous substances in concentrations above cut-off values according to the competent authority	NA	No information available

12.6. Other adverse effects

Endocrine Disruptor Information

This product does not contain any known or suspected endocrine disruptors

13. Disposal Considerations

Safe handling and disposal methods

Bury in a licensed landfill according to federal, state, and local regulations.

Disposal of any contaminated packaging

Follow all applicable national or local regulations.

Environmental regulations

Not applicable

14. Transport Information

Transportation Information

UN Number: Not restricted
UN Proper Shipping Name: Not restricted
Transport Hazard Class(es): Not applicable
Packing Group: Not applicable
Environmental Hazards: Not applicable

Special precautions during transport

None

HazChem Code

None Allocated

15. Regulatory Information

Safety, health and environmental regulations specific for the product

International Inventories

Australian AICS Inventory All components listed on inventory or are exempt.
New Zealand Inventory of Chemicals All components listed on inventory or are exempt.
EINECS Inventory This product, and all its components, complies with EINECS
US TSCA Inventory All components listed on inventory or are exempt.
Canadian DSL Inventory All components listed on inventory or are exempt.

Poisons Schedule number

None Allocated

16. Other information

Date of preparation or review

Revision Date: 30-Sep-2015

Revision Note
SDS sections updated: 2

Full text of R-phrases referred to under Sections 2 and 3
None

Full text of H-Statements referred to under sections 2 and 3
None

Additional information For additional information on the use of this product, contact your local Halliburton representative.

For questions about the Safety Data Sheet for this or other Halliburton products, contact Chemical Stewardship at 1-580-251-4335.

Key abreviations or acronyms used
bw – body weight CAS – Chemical Abstracts Service EC50 – Effective Concentration 50% LC50 – Lethal Concentration 50% LD50 – Lethal Dose 50% LL50 – Lethal Loading 50% mg/kg – milligram/kilogram mg/L – milligram/liter NOEC – No Observed Effect Concentration OEL – Occupational Exposure Limit PBT – Persistent Bioaccumulative and Toxic ppm – parts per million STEL – Short Term Exposure Limit TWA – Time-Weighted Average vPvB – very Persistent and very Bioaccumulative h - hour mg/m^3 - milligram/cubic meter mm - millimeter mmHg - millimeter mercury w/w - weight/weight d - day

Key literature references and sources for data
www.ChemADVISOR.com/

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End of Safety Data Sheet

HALLIBURTON

SAFETY DATA SHEET

DCA-24001

Revision Date: 11-Jan-2017 **Revision Number:** 15

1. Product Identifier & Identity for the Chemical

Statement of Hazardous Nature Non-Hazardous according to the criteria of the 3rd Revised Edition of the Globally Harmonised System of Classification and Labelling of Chemicals (GHS), Non-Dangerous Goods according to the criteria of ADG.

1.1. Product Identifier

Product Name DCA-24001

Other means of Identification

Synonyms None

Hazardous Material Number: HM007732

Recommended use of the chemical and restrictions on use

Recommended Use Stabilizer

Uses advised against No information available

Supplier's name, address and phone number

Manufacturer/Supplier Halliburton Australia Pty. Ltd.
15 Marriott Road, Jandakot, WA 6164
Australia
ACN Number: 009 000 775
Telephone Number: + 61 1 800 686 951
Fax Number: 61 (08) 9455 5300

E-mail Address fdunexchem@halliburton.com

Emergency phone number

+ 61 1 800 686 951
Global Incident Response Access Code: 334305
Contract Number: 14012

Australian Poisons Information Centre
24 Hour Service: - 13 11 26
Police or Fire Brigade: - 000 (exchange): - 1100

2. Hazard Identification

Statement of Hazardous Nature Non-Hazardous according to the criteria of the 3rd Revised Edition of the Globally Harmonised System of Classification and Labelling of Chemicals (GHS), Non-Dangerous Goods according to the criteria of ADG.

Classification of the hazardous chemical

Not classified

Label elements, including precautionary statements

Hazard Pictograms

Signal Word Not Hazardous

Hazard Statements: Not Classified

Precautionary Statements

Prevention None
Response None
Storage None
Disposal None

Contains

Substances	**CAS Number**
Contains no hazardous substances in concentrations above cut-off values according to the competent authority	NA

Other hazards which do not result in classification
None known

For the full text of the H-phrases mentioned in this Section, see Section 16

3. Composition/information on Ingredients

Substances	CAS Number	PERCENT (w/w)	GHS Classification - Australia
Contains no hazardous substances in concentrations above cut-off values according to the competent authority	NA	60 - 100%	Not Applicable

4. First aid measures

Description of necessary first aid measures

Inhalation If inhaled, remove from area to fresh air. Get medical attention if respiratory irritation develops or if breathing becomes difficult.

Eyes In case of contact, immediately flush eyes with plenty of water for at least 15 minutes and get medical attention if irritation persists.

Skin Wash with soap and water. Get medical attention if irritation persists.

Ingestion Under normal conditions, first aid procedures are not required.

Symptoms caused by exposure
No significant hazards expected.

Medical Attention and Special Treatment
Notes to Physician Treat symptomatically

5. Fire Fighting Measures

Suitable extinguishing equipment
Suitable Extinguishing Media
Water fog, carbon dioxide, foam, dry chemical.
Extinguishing media which must not be used for safety reasons
None known.

Specific hazards arising from the chemical
Special exposure hazards in a fire
Decomposition in fire may produce harmful gases.

Special protective equipment and precautions for fire fighters
Special protective equipment for firefighters
Full protective clothing and approved self-contained breathing apparatus required for fire fighting personnel.

6. Accidental release measures

6.1. Personal precautions, protective equipment and emergency procedures
Use appropriate protective equipment.

6.2. Environmental precautions
Prevent from entering sewers, waterways, or low areas.

6.3. Methods and material for containment and cleaning up
Isolate spill and stop leak where safe. Contain spill with sand or other inert materials. Scoop up and remove.

7. Handling and storage

7.1. Precautions for safe handling
Handling Precautions
Avoid contact with eyes, skin, or clothing. Avoid breathing vapors.
Hygiene Measures
Handle in accordance with good industrial hygiene and safety practice.

7.2. Conditions for safe storage, including any incompatibilities
Storage Information
Store in a cool well ventilated area. Keep container closed when not in use. Product has a shelf life of 24 months.
Other Guidelines
No information available

8. Exposure Controls/Personal Protection

Control parameters - exposure standards, biological monitoring
Exposure Limits

Substances	CAS Number	Australia NOHSC	ACGIH TLV-TWA
Contains no hazardous substances in concentrations above cut-off values according to the competent authority	NA	Not applicable	Not applicable

Appropriate engineering controls
Engineering Controls Use in a well ventilated area.

Personal protective equipment (PPE)
Personal Protective Equipment If engineering controls and work practices cannot prevent excessive exposures, the selection and proper use of personal protective equipment should be determined by an industrial hygienist or other qualified professional based on the specific application of this product.
Respiratory Protection If engineering controls and work practices cannot keep exposure below occupational exposure limits or if exposure is unknown, wear a NIOSH certified, European Standard EN 149, AS/NZS 1715:2009, or equivalent respirator when using this product. Selection of and instruction on using all personal protective equipment, including respirators, should be performed by an Industrial Hygienist or other qualified professional.
Dust/mist respirator. (N95, P2/P3)
Hand Protection Normal work gloves.
Skin Protection Normal work coveralls.
Eye Protection Wear safety glasses or goggles to protect against exposure.
Other Precautions None known.
Environmental Exposure Controls No information available

9. Physical and Chemical Properties

9.1. Information on basic physical and chemical properties

Physical State:	Liquid	**Color**	Clear to hazy
Odor:	Mild sulfur	**Odor Threshold:**	No information available

Property Remarks/ - Method	Values
pH:	8
Freezing Point / Range	No data available
Melting Point / Range	No data available
Boiling Point / Range	106 °C / 224 °F
Flash Point	No data available
Evaporation rate	No data available
Vapor Pressure	No data available
Vapor Density	No data available
Specific Gravity	1.29
Water Solubility	Miscible with water
Solubility in other solvents	No data available
Partition coefficient: n-octanol/water	No data available
Autoignition Temperature	No data available
Decomposition Temperature	No data available
Viscosity	No data available
Explosive Properties	No information available
Oxidizing Properties	No information available

9.2. Other information
VOC Content (%) No data available

10. Stability and Reactivity

10.1. Reactivity
Not expected to be reactive.
10.2. Chemical stability
Stable
10.3. Possibility of hazardous reactions
Will Not Occur
10.4. Conditions to avoid
None anticipated
10.5. Incompatible materials
Strong oxidizers. Hydrochloric acid
10.6. Hazardous decomposition products
Oxides of sulfur.

11. Toxicological Information

Information on routes of exposure
Principle Route of Exposure Eye or skin contact, inhalation.

Symptoms related to exposure
Most Important Symptoms/Effects
No significant hazards expected.

Numerical measures of toxicity

Toxicology data for the components

Substances	CAS Number	LD50 Oral	LD50 Dermal	LC50 Inhalation
Contains no hazardous substances in concentrations above cut-off values according to the competent authority	NA	No data available	No data available	No data available

Immediate, delayed and chronic health effects from exposure

Inhalation	None known.
Eye Contact	May cause mild eye irritation.
Skin Contact	Not irritating to skin in rabbits.
Ingestion	Large doses may cause nausea, vomiting and diarrhea.

Chronic Effects/Carcinogenicity No data available to indicate product or components present at greater than 0.1% are chronic health hazards.

Exposure Levels
No data available

Interactive effects
None known.

Data limitations
No data available

12. Ecological Information

Ecotoxicity

Substance Ecotoxicity Data

Substances	CAS Number	Toxicity to Algae	Toxicity to Fish	Toxicity to Microorganisms	Toxicity to Invertebrates
Contains no hazardous substances in concentrations above cut-off values according to the competent authority	NA	No information available	No information available	No information available	No information available

12.2. Persistence and degradability

Substances	CAS Number	Persistence and Degradability
Contains no hazardous substances in concentrations above cut-off values according to the competent authority	NA	No information available

12.3. Bioaccumulative potential
Does not bioaccumulate.

Substances	CAS Number	Log Pow
Contains no hazardous substances in concentrations above cut-off values according to the competent authority	NA	No information available

12.4. Mobility in soil

Substances	CAS Number	Mobility
Contains no hazardous substances in concentrations above cut-off values according to the competent authority	NA	No information available

12.6. Other adverse effects

Endocrine Disruptor Information

This product does not contain any known or suspected endocrine disruptors

13. Disposal Considerations

Safe handling and disposal methods

Disposal should be made in accordance with federal, state, and local regulations.

Disposal of any contaminated packaging

Follow all applicable national or local regulations. Contaminated packaging may be disposed of by: rendering packaging incapable of containing any substance, or treating packaging to remove residual contents, or treating packaging to make sure the residual contents are no longer hazardous, or by disposing of packaging into commercial waste collection.

Environmental regulations

Not applicable

14. Transport Information

Transportation Information

Australia ADG

UN Number	Not restricted
UN proper shipping name:	Not restricted
Transport Hazard Class(es):	Not applicable
Packing Group:	Not applicable
Environmental Hazards:	Not applicable

IMDG/IMO

UN Number	Not restricted
UN proper shipping name:	Not restricted
Transport Hazard Class(es):	Not applicable
Packing Group:	Not applicable
Environmental Hazards:	Not applicable

IATA/ICAO

UN Number	Not restricted
UN proper shipping name:	Not restricted
Transport Hazard Class(es):	Not applicable
Packing Group:	Not applicable
Environmental Hazards:	Not applicable

Special precautions during transport

None

HazChem Code

None Allocated

15. Regulatory Information

Safety, health and environmental regulations specific for the product

International Inventories

Australian AICS Inventory	All components are listed on the AICS or are subject to a relevant exemption, permit, or assessment certificate.
New Zealand Inventory of Chemicals	All components are listed on the NZIoC or are subject to a relevant exemption, permit, or assessment certificate.
EINECS (European Inventory of Existing Chemical Substances)	This product, and all its components, complies with EINECS
US TSCA Inventory	All components listed on inventory or are exempt.
Canadian Domestic Substances List	All components listed on inventory or are exempt.

(DSL)

Poisons Schedule number
None Allocated

International Agreements

Montreal Protocol - Ozone Depleting Substances:	Does not apply
Stockholm Convention - Persistent Organic Pollutants:	Does not apply
Rotterdam Convention - Prior Informed Consent:	Does not apply
Basel Convention - Hazardous Waste:	Does not apply

16. Other information

Date of preparation or review

Revision Date: 11-Jan-2017

Revision Note
SDS sections updated: 2

Full text of H-Statements referred to under sections 2 and 3
None

Additional information

For additional information on the use of this product, contact your local Halliburton representative.

For questions about the Safety Data Sheet for this or other Halliburton products, contact Chemical Stewardship at 1-580-251-4335.

Key abreviations or acronyms used
bw – body weight
CAS – Chemical Abstracts Service
EC50 – Effective Concentration 50%
LC50 – Lethal Concentration 50%
LD50 – Lethal Dose 50%
LL50 – Lethal Loading 50%
mg/kg – milligram/kilogram
mg/L – milligram/liter
NOEC – No Observed Effect Concentration
OEL – Occupational Exposure Limit
PBT – Persistent Bioaccumulative and Toxic
ppm – parts per million
STEL – Short Term Exposure Limit
TWA – Time-Weighted Average
vPvB – very Persistent and very Bioaccumulative
h - hour
mg/m^3 - milligram/cubic meter
mm - millimeter
mmHg - millimeter mercury
w/w - weight/weight
d - day

Key literature references and sources for data
www.ChemADVISOR.com/
NZ CCID

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End of Safety Data Sheet

HALLIBURTON

SAFETY DATA SHEET

DCA-25003

Revision Date: 30-Sep-2015 **Revision Number:** 13

1. Product Identifier & Identity for the Chemical

Statement of Hazardous Nature Non-Hazardous according to the criteria of the 3rd Revised Edition of the Globally Harmonised System of Classification and Labelling of Chemicals (GHS), Non-Dangerous Goods according to the criteria of ADG.

1.1. Product Identifier

Product Name DCA-25003

Other means of Identification

Synonyms: None

Product Code: HM007670

Recommended use of the chemical and restrictions on use

Recommended Use Gelling Agent

Uses Advised Against No information available

Supplier's name, address and phone number

Manufacturer/Supplier Halliburton Australia Pty. Ltd.
15 Marriott Road
Jandakot
WA 6164
Australia

ACN Number: 009 000 775
Telephone Number: + 61 1 800 686 951
Fax Number: 61 (08) 9455 5300

E-Mail address: fdunexchem@halliburton.com

Emergency phone number

+ 61 1 800 686 951

Australian Poisons Information Centre

24 Hour Service: - 13 11 26

Police or Fire Brigade: - 000 (exchange): - 1100

2. Hazard Identification

Statement of Hazardous Nature Non-Hazardous according to the criteria of the 3rd Revised Edition of the Globally Harmonised System of Classification and Labelling of Chemicals (GHS), Non-Dangerous Goods according to the criteria of ADG.

Classification of the hazardous chemical

Not classified

Label elements, including precautionary statements

Hazard Pictograms

Signal Word Not Hazardous

Hazard Statements Not Classified

Precautionary Statements

Prevention None

Response None

Storage None

Disposal None

Contains Substances	**CAS Number**
Contains no hazardous substances in concentrations above cut-off values according to the competent authority	NA

Other hazards which do not result in classification
Dust can form an explosive mixture in air
This mixture contains no substance considered to be persistent, bioaccumulating nor toxic (PBT).
This mixture contains no substance considered to be very persistent nor very bioaccumulating (vPvB).

Australia Classification
For the full text of the H-phrases mentioned in this Section, see Section 16

Classification Not Classified
Risk Phrases None

3. Composition/information on Ingredients

Substances	CAS Number	PERCENT (w/w)	GHS Classification - Australia
Contains no hazardous substances in concentrations above cut-off values according to the competent authority	NA	60 - 100%	Not Applicable

4. First aid measures

Description of necessary first aid measures
Inhalation If inhaled, remove from area to fresh air. Get medical attention if respiratory irritation develops or if breathing becomes difficult.
Eyes In case of contact, immediately flush eyes with plenty of water for at least 15 minutes and get medical attention if irritation persists.
Skin Wash with soap and water.
Ingestion Under normal conditions, first aid procedures are not required.

Symptoms caused by exposure
No significant hazards expected.

Medical Attention and Special Treatment
Notes to Physician Treat symptomatically

5. Fire Fighting Measures

Suitable extinguishing equipment
Suitable Extinguishing Media
Water fog, carbon dioxide, foam, dry chemical.
Extinguishing media which must not be used for safety reasons

None known.

Specific hazards arising from the chemical

Special Exposure Hazards

Organic dust in the presence of an ignition source can be explosive in high concentrations. Good housekeeping practices are required to minimize this potential.

Special protective equipment and precautions for fire fighters

Special Protective Equipment for Fire-Fighters

Full protective clothing and approved self-contained breathing apparatus required for fire fighting personnel.

6. Accidental release measures

6.1. Personal precautions, protective equipment and emergency procedures

Use appropriate protective equipment. Avoid creating and breathing dust. Ensure adequate ventilation. Avoid contact with skin, eyes and clothing.

6.2. Environmental precautions

Prevent from entering sewers, waterways, or low areas.

6.3. Methods and material for containment and cleaning up

Scoop up and remove.

7. Handling and storage

7.1. Precautions for Safe Handling

Handling Precautions

Avoid creating or inhaling dust. Avoid contact with eyes, skin, or clothing. Ensure adequate ventilation. Wash hands after use. Launder contaminated clothing before reuse. Use appropriate protective equipment.

Hygiene Measures

Handle in accordance with good industrial hygiene and safety practice.

7.2. Conditions for safe storage, including any incompatibilities

Storage Information

Store away from oxidizers. Store in a cool, dry location. Product has a shelf life of 24 months.

Other Guidelines

No information available

8. Exposure Controls/Personal Protection

Control parameters - exposure standards, biological monitoring

Exposure Limits

Substances	CAS Number	Australia NOHSC	ACGIH TLV-TWA
Contains no hazardous substances in concentrations above cut-off values according to the competent authority	NA	Not applicable	Not applicable

Appropriate engineering controls

Engineering Controls Use in a well ventilated area.

Personal protective equipment (PPE)

Respiratory Protection If engineering controls and work practices cannot keep exposure below occupational exposure limits or if exposure is unknown, wear a NIOSH certified, European Standard EN 149, AS/NZS 1715:2009, or equivalent respirator when using this product. Selection of and instruction on using all personal protective equipment, including respirators, should be performed by an Industrial Hygienist or other qualified professional.
Dust/mist respirator. (N95, P2/P3)

Hand Protection Normal work gloves.

Skin Protection Normal work coveralls.

Eye Protection Wear safety glasses or goggles to protect against exposure.

Other Precautions None known.
Environmental Exposure Controls Do not allow material to contaminate ground water system

9. Physical and Chemical Properties

9.1. Information on basic physical and chemical properties

Physical State: Solid
Color: White to light straw
Odor: Bean
Odor Threshold: No information available

Property Remarks/ - Method	Values
pH:	10.1
Freezing Point/Range	No data available
Melting Point/Range	No data available
Boiling Point/Range	No data available
Flash Point	No data available
Evaporation rate	No data available
Vapor Pressure	No data available
Vapor Density	No data available
Specific Gravity	1.3
Water Solubility	Hydrolyzes
Solubility in other solvents	No data available
Partition coefficient: n-octanol/water	No data available
Autoignition Temperature	510 °C / 950 °F
Decomposition Temperature	No data available
Viscosity	No data available
Explosive Properties	No information available
Oxidizing Properties	No information available

9.2. Other information

VOC Content (%) No data available

10. Stability and Reactivity

10.1. Reactivity
Not expected to be reactive.
10.2. Chemical Stability
Stable
10.3. Possibility of Hazardous Reactions
Will Not Occur
10.4. Conditions to Avoid
None anticipated
10.5. Incompatible Materials
Strong oxidizers.
10.6. Hazardous Decomposition Products
Carbon monoxide and carbon dioxide.

11. Toxicological Information

Information on routes of exposure
Principle Route of Exposure Eye or skin contact, inhalation.

Sympotoms related to exposure
Most Important Symptoms/Effects
No significant hazards expected.

Numerical measures of toxicity

Toxicology data for the components

Substances	CAS Number	LD50 Oral	LD50 Dermal	LC50 Inhalation
Contains no hazardous substances in concentrations above cut-off values according to the competent authority	NA	No data available	No data available	No data available

Immediate, delayed and chronic health effects from exposure

Inhalation May cause mild respiratory irritation.
Eye Contact May cause mild eye irritation.
Skin Contact May cause mild skin irritation.
Ingestion None known.

Chronic Effects/Carcinogenicity No data available to indicate product or components present at greater than 0.1% are chronic health hazards.

Exposure Levels
No data available

Interactive effects
None known.

Data limitations
No data available

12. Ecological Information

Ecotoxicity
Product Ecotoxicity Data
No data available

Substance Ecotoxicity Data

Substances	CAS Number	Toxicity to Algae	Toxicity to Fish	Toxicity to Microorganisms	Toxicity to Invertebrates
Contains no hazardous substances in concentrations above cut-off values according to the competent authority	NA	No information available	No information available	No information available	No information available

12.2. Persistence and degradability

Substances	CAS Number	Persistence and Degradability
Contains no hazardous substances in concentrations above cut-off values according to the competent authority	NA	No information available

12.3. Bioaccumulative potential

Substances	CAS Number	Log Pow
Contains no hazardous substances in concentrations above cut-off values according to the competent authority	NA	No information available

12.4. Mobility in soil

Substances	CAS Number	Mobility
Contains no hazardous substances in concentrations above cut-off values according to the competent authority	NA	No information available

12.6. Other adverse effects

Endocrine Disruptor Information

This product does not contain any known or suspected endocrine disruptors

13. Disposal Considerations

Safe handling and disposal methods

Follow all applicable community, national or regional regulations regarding waste management methods.

Disposal of any contaminated packaging

Follow all applicable national or local regulations.

Environmental regulations

Not applicable

14. Transport Information

Transportation Information

UN Number:	Not restricted
UN Proper Shipping Name:	Not restricted
Transport Hazard Class(es):	Not applicable
Packing Group:	Not applicable
Environmental Hazards:	Not applicable

Special precautions during transport

None

HazChem Code

None Allocated

15. Regulatory Information

Safety, health and environmental regulations specific for the product

International Inventories

Australian AICS Inventory	All components listed on inventory or are exempt.
New Zealand Inventory of Chemicals	All components listed on inventory or are exempt.
EINECS Inventory	This product, and all its components, complies with EINECS
US TSCA Inventory	All components listed on inventory or are exempt.
Canadian DSL Inventory	All components listed on inventory or are exempt.

Poisons Schedule number

None Allocated

16. Other information

Date of preparation or review

Revision Date: 30-Sep-2015

Revision Note
SDS sections updated: 2

Full text of R-phrases referred to under Sections 2 and 3
None

Full text of H-Statements referred to under sections 2 and 3
None

Additional information

For additional information on the use of this product, contact your local Halliburton representative.

For questions about the Safety Data Sheet for this or other Halliburton products, contact Chemical Stewardship at 1-580-251-4335.

Key abreviations or acronyms used
bw – body weight CAS – Chemical Abstracts Service EC50 – Effective Concentration 50% LC50 – Lethal Concentration 50% LD50 – Lethal Dose 50% LL50 – Lethal Loading 50% mg/kg – milligram/kilogram mg/L – milligram/liter NOEC – No Observed Effect Concentration OEL – Occupational Exposure Limit PBT – Persistent Bioaccumulative and Toxic ppm – parts per million STEL – Short Term Exposure Limit TWA – Time-Weighted Average vPvB – very Persistent and very Bioaccumulative h - hour mg/m^3 - milligram/cubic meter mm - millimeter mmHg - millimeter mercury w/w - weight/weight d - day

Key literature references and sources for data
www.ChemADVISOR.com/

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End of Safety Data Sheet

HALLIBURTON

SAFETY DATA SHEET

DCA-25005

Revision Date: 30-Sep-2015 **Revision Number:** 10

1. Product Identifier & Identity for the Chemical

Statement of Hazardous Nature Non-Hazardous according to the criteria of the 3rd Revised Edition of the Globally Harmonised System of Classification and Labelling of Chemicals (GHS), Non-Dangerous Goods according to the criteria of ADG.

1.1. Product Identifier

Product Name DCA-25005

Other means of Identification

Synonyms: None

Product Code: HM007672

Recommended use of the chemical and restrictions on use

Recommended Use Gelling Agent

Uses Advised Against No information available

Supplier's name, address and phone number

Manufacturer/Supplier

Halliburton Australia Pty. Ltd.
15 Marriott Road
Jandakot
WA 6164
Australia

ACN Number: 009 000 775
Telephone Number: + 61 1 800 686 951
Fax Number: 61 (08) 9455 5300

E-Mail address: fdunexchem@halliburton.com

Emergency phone number

+ 61 1 800 686 951

Australian Poisons Information Centre

24 Hour Service: - 13 11 26

Police or Fire Brigade: - 000 (exchange): - 1100

2. Hazard Identification

Statement of Hazardous Nature Non-Hazardous according to the criteria of the 3rd Revised Edition of the Globally Harmonised System of Classification and Labelling of Chemicals (GHS), Non-Dangerous Goods according to the criteria of ADG.

Classification of the hazardous chemical

Not classified

Label elements, including precautionary statements

Hazard Pictograms

Signal Word Not Hazardous

Hazard Statements Not Classified

Precautionary Statements

Prevention None

Response None

Storage None

Disposal None

Contains

Substances	**CAS Number**
Contains no hazardous substances in concentrations above cut-off values according to the competent authority	NA

Other hazards which do not result in classification
This substance is not considered to be persistent, bioaccumulating nor toxic (PBT).
This substance is not considered to be very persistent nor very bioaccumulating (vPvB).

Australia Classification
For the full text of the H-phrases mentioned in this Section, see Section 16

Classification Not Classified
Risk Phrases None

3. Composition/information on Ingredients

Substances	CAS Number	PERCENT (w/w)	GHS Classification - Australia
Contains no hazardous substances in concentrations above cut-off values according to the competent authority	NA	60 - 100%	Not Applicable

4. First aid measures

Description of necessary first aid measures

Inhalation If inhaled, remove from area to fresh air. Get medical attention if respiratory irritation develops or if breathing becomes difficult.

Eyes In case of contact, immediately flush eyes with plenty of water for at least 15 minutes and get medical attention if irritation persists.

Skin Wash with soap and water. Get medical attention if irritation persists.

Ingestion Under normal conditions, first aid procedures are not required.

Symptoms caused by exposure
No significant hazards expected.

Medical Attention and Special Treatment
Notes to Physician Treat symptomatically

5. Fire Fighting Measures

Suitable extinguishing equipment
Suitable Extinguishing Media
Water fog, carbon dioxide, foam, dry chemical.
Extinguishing media which must not be used for safety reasons
None known.

Specific hazards arising from the chemical

Special Exposure Hazards

Decomposition in fire may produce harmful gases. Organic dust in the presence of an ignition source can be explosive in high concentrations. Good housekeeping practices are required to minimize this potential.

Special protective equipment and precautions for fire fighters

Special Protective Equipment for Fire-Fighters

Full protective clothing and approved self-contained breathing apparatus required for fire fighting personnel.

6. Accidental release measures

6.1. Personal precautions, protective equipment and emergency procedures

Use appropriate protective equipment. Avoid creating and breathing dust. Avoid contact with skin, eyes and clothing. Ensure adequate ventilation.

6.2. Environmental precautions

Prevent from entering sewers, waterways, or low areas.

6.3. Methods and material for containment and cleaning up

Scoop up and remove.

7. Handling and storage

7.1. Precautions for Safe Handling

Handling Precautions

Avoid contact with eyes, skin, or clothing. Avoid creating or inhaling dust. Ensure adequate ventilation. Wash hands after use. Launder contaminated clothing before reuse. Use appropriate protective equipment.

Hygiene Measures

Handle in accordance with good industrial hygiene and safety practice.

7.2. Conditions for safe storage, including any incompatibilities

Storage Information

Store away from oxidizers. Store in a cool, dry location. Product has a shelf life of 24 months.

Other Guidelines

No information available

8. Exposure Controls/Personal Protection

Control parameters - exposure standards, biological monitoring

Exposure Limits

Substances	CAS Number	Australia NOHSC	ACGIH TLV-TWA
Contains no hazardous substances in concentrations above cut-off values according to the competent authority	NA	Not applicable	Not applicable

Appropriate engineering controls

Engineering Controls Use in a well ventilated area.

Personal protective equipment (PPE)

Respiratory Protection Not normally needed. But if significant exposures are possible then the following respirator is recommended:
Dust/mist respirator. (N95, P2/P3)

Hand Protection Normal work gloves.

Skin Protection Normal work coveralls.

Eye Protection Wear safety glasses or goggles to protect against exposure.

Other Precautions None known.

Environmental Exposure Controls Do not allow material to contaminate ground water system

9. Physical and Chemical Properties

9.1. Information on basic physical and chemical properties

Physical State: Solid
Color: Off white
Odor: Bean
Odor Threshold: No information available

Property Remarks/ - Method	Values
pH:	6.5-7.5
Freezing Point/Range	No data available
Melting Point/Range	No data available
Boiling Point/Range	No data available
Flash Point	> 93 °C / > 200 °F Cleveland Open Cup (COC)
Evaporation rate	No data available
Vapor Pressure	No data available
Vapor Density	No data available
Specific Gravity	1.42 - 1.47
Water Solubility	Soluble in water
Solubility in other solvents	No data available
Partition coefficient: n-octanol/water	No data available
Autoignition Temperature	No data available
Decomposition Temperature	No data available
Viscosity	No data available
Explosive Properties	No information available
Oxidizing Properties	No information available

9.2. Other information

VOC Content (%) No data available

10. Stability and Reactivity

10.1. Reactivity
Not expected to be reactive.
10.2. Chemical Stability
Stable
10.3. Possibility of Hazardous Reactions
Will Not Occur
10.4. Conditions to Avoid
None anticipated
10.5. Incompatible Materials
Strong oxidizers.
10.6. Hazardous Decomposition Products
Carbon monoxide and carbon dioxide.

11. Toxicological Information

Information on routes of exposure
Principle Route of Exposure Eye or skin contact, inhalation.

Sympotoms related to exposure
Most Important Symptoms/Effects
No significant hazards expected.

Numerical measures of toxicity

Toxicology data for the components

Substances	CAS Number	LD50 Oral	LD50 Dermal	LC50 Inhalation
Contains no hazardous substances in concentrations above	NA	No data available	No data available	No data available

cut-off values according to the competent authority				

Immediate, delayed and chronic health effects from exposure

Inhalation May cause mild respiratory irritation.
Eye Contact May cause mild eye irritation.
Skin Contact None known.
Ingestion None known.

Chronic Effects/Carcinogenicity No data available to indicate product or components present at greater than 0.1% are chronic health hazards.

Exposure Levels
No data available

Interactive effects
None known.

Data limitations
No data available

12. Ecological Information

Ecotoxicity
Product Ecotoxicity Data
No data available

Substance Ecotoxicity Data

Substances	CAS Number	Toxicity to Algae	Toxicity to Fish	Toxicity to Microorganisms	Toxicity to Invertebrates
Contains no hazardous substances in concentrations above cut-off values according to the competent authority	NA	No information available	No information available	No information available	No information available

12.2. Persistence and degradability

Substances	CAS Number	Persistence and Degradability
Contains no hazardous substances in concentrations above cut-off values according to the competent authority	NA	No information available

12.3. Bioaccumulative potential

Substances	CAS Number	Log Pow
Contains no hazardous substances in concentrations above cut-off values according to the competent authority	NA	No information available

12.4. Mobility in soil

Substances	CAS Number	Mobility
Contains no hazardous substances in concentrations above cut-off values according to the competent authority	NA	No information available

12.6. Other adverse effects

Endocrine Disruptor Information

This product does not contain any known or suspected endocrine disruptors

13. Disposal Considerations

Safe handling and disposal methods

Bury in a licensed landfill according to federal, state, and local regulations.

Disposal of any contaminated packaging

Follow all applicable national or local regulations.

Environmental regulations

Not applicable

14. Transport Information

Transportation Information

UN Number: Not restricted
UN Proper Shipping Name: Not restricted
Transport Hazard Class(es): Not applicable
Packing Group: Not applicable
Environmental Hazards: Not applicable

Special precautions during transport

None

HazChem Code

None Allocated

15. Regulatory Information

Safety, health and environmental regulations specific for the product

International Inventories

Australian AICS Inventory All components listed on inventory or are exempt.
New Zealand Inventory of Chemicals All components listed on inventory or are exempt.
EINECS Inventory This product, and all its components, complies with EINECS
US TSCA Inventory All components listed on inventory or are exempt.
Canadian DSL Inventory All components listed on inventory or are exempt.

Poisons Schedule number

None Allocated

16. Other information

Date of preparation or review

Revision Date: 30-Sep-2015

Revision Note

SDS sections updated: 2

Full text of R-phrases referred to under Sections 2 and 3
None

Full text of H-Statements referred to under sections 2 and 3
None

Additional information

For additional information on the use of this product, contact your local Halliburton representative.

For questions about the Safety Data Sheet for this or other Halliburton products, contact Chemical Stewardship at 1-580-251-4335.

Key abreviations or acronyms used

bw – body weight CAS – Chemical Abstracts Service EC50 – Effective Concentration 50% LC50 – Lethal Concentration 50% LD50 – Lethal Dose 50% LL50 – Lethal Loading 50% mg/kg – milligram/kilogram mg/L – milligram/liter NOEC – No Observed Effect Concentration OEL – Occupational Exposure Limit PBT – Persistent Bioaccumulative and Toxic ppm – parts per million STEL – Short Term Exposure Limit TWA – Time-Weighted Average vPvB – very Persistent and very Bioaccumulative h - hour mg/m^3 - milligram/cubic meter mm - millimeter mmHg - millimeter mercury w/w - weight/weight d - day

Key literature references and sources for data
www.ChemADVISOR.com/

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End of Safety Data Sheet

HALLIBURTON

SAFETY DATA SHEET

DCA-30001

Revision Date: 05-Jul-2016 **Revision Number:** 11

1. Product Identifier & Identity for the Chemical

Statement of Hazardous Nature Non-Hazardous according to the criteria of the 3rd Revised Edition of the Globally Harmonised System of Classification and Labelling of Chemicals (GHS), Non-Dangerous Goods according to the criteria of ADG.

1.1. Product Identifier

Product Name DCA-30001

Other means of Identification

Synonyms None

Hazardous Material Number: HM007676

Recommended use of the chemical and restrictions on use

Recommended Use Scale Inhibitor

Uses advised against No information available

Supplier's name, address and phone number

Manufacturer/Supplier

Halliburton/Baroid Australia Pty. Ltd.
15 Marriott Road
Jandakot
WA 6164
Australia

ACN Number: 009 000 775
Telephone Number: 61 (08) 9455 8300
Fax Number: 61 (08) 9455 5300

Product Emergency Telephone
Australia: + 61 1 800 686 951
Papua New Guinea: + 61 1 800 686 951
NewZealand: +64 800 451719

Fire, Police & Ambulance - Emergency Telephone
Australia: 000
Papua New Guinea: 000
New Zealand: 111

E-mail Address fdunexchem@halliburton.com

Emergency phone number

+ 61 1 800 686 951

Australian Poisons Information Centre
24 Hour Service: - 13 11 26
Police or Fire Brigade: - 000 (exchange): - 1100

2. Hazard Identification

Statement of Hazardous Nature Non-Hazardous according to the criteria of the 3rd Revised Edition of the Globally Harmonised System of Classification and Labelling of Chemicals (GHS), Non-Dangerous Goods according to the criteria of ADG.

Classification of the hazardous chemical

Not classified

Label elements, including precautionary statements

Hazard pictograms

Signal Word Not Hazardous

Hazard Statements: Not Classified

Precautionary Statements

Prevention None
Response None
Storage None
Disposal None

Contains

Substances	**CAS Number**
Contains no hazardous substances in concentrations above cut-off values according to the competent authority	NA

Other hazards which do not result in classification

This mixture contains no substance considered to be persistent, bioaccumulating nor toxic (PBT).
This mixture contains no substance considered to be very persistent nor very bioaccumulating (vPvB).

For the full text of the H-phrases mentioned in this Section, see Section 16

3. Composition/information on Ingredients

Substances	CAS Number	PERCENT (w/w)	GHS Classification - Australia
Contains no hazardous substances in concentrations above cut-off values according to the competent authority	NA	60 - 100%	Not Applicable

4. First aid measures

Description of necessary first aid measures

Inhalation If inhaled, remove from area to fresh air. Get medical attention if respiratory irritation develops or if breathing becomes difficult.

Eyes In case of contact, immediately flush eyes with plenty of water for at least 15 minutes and get medical attention if irritation persists.

Skin Wash with soap and water. Get medical attention if irritation persists.

Ingestion Do NOT induce vomiting. Give nothing by mouth. Obtain immediate medical attention.

Symptoms caused by exposure

No significant hazards expected.

Medical Attention and Special Treatment

Notes to Physician Treat symptomatically

5. Fire Fighting Measures

Suitable extinguishing equipment

Suitable Extinguishing Media

All standard fire fighting media

Extinguishing media which must not be used for safety reasons

None known.

Specific hazards arising from the chemical

Special exposure hazards in a fire

Not applicable

Special protective equipment and precautions for fire fighters

Special protective equipment for firefighters

Full protective clothing and approved self-contained breathing apparatus required for fire fighting personnel.

6. Accidental release measures

6.1. Personal precautions, protective equipment and emergency procedures

Use appropriate protective equipment. Avoid contact with skin, eyes and clothing. Avoid breathing vapors. Ensure adequate ventilation.

6.2. Environmental precautions

Prevent from entering sewers, waterways, or low areas.

6.3. Methods and material for containment and cleaning up

Isolate spill and stop leak where safe. Contain spill with sand or other inert materials. Scoop up and remove.

7. Handling and storage

7.1. Precautions for safe handling

Handling Precautions

Avoid contact with eyes, skin, or clothing. Avoid breathing mist. Avoid breathing vapors. Ensure adequate ventilation. Wash hands after use. Launder contaminated clothing before reuse. Use appropriate protective equipment.

Hygiene Measures

Handle in accordance with good industrial hygiene and safety practice.

7.2. Conditions for safe storage, including any incompatibilities

Storage Information

Store away from oxidizers. Product has a shelf life of 12 months.

Other Guidelines

No information available

8. Exposure Controls/Personal Protection

Control parameters - exposure standards, biological monitoring

Exposure Limits

Substances	CAS Number	Australia NOHSC	ACGIH TLV-TWA
Contains no hazardous substances in concentrations above cut-off values according to the competent authority	NA	Not applicable	Not applicable

Appropriate engineering controls

Engineering Controls Use in a well ventilated area.

Personal protective equipment (PPE)

Personal Protective Equipment If engineering controls and work practices cannot prevent excessive exposures, the selection and proper use of personal protective equipment should be determined by an industrial hygienist or other qualified professional based on the specific application of this product.

Respiratory Protection If engineering controls and work practices cannot keep exposure below occupational exposure limits or if exposure is unknown, wear a NIOSH certified, European Standard EN

149, AS/NZS 1715:2009, or equivalent respirator when using this product. Selection of and instruction on using all personal protective equipment, including respirators, should be performed by an Industrial Hygienist or other qualified professional.

Hand Protection	Butyl rubber gloves.
Skin Protection	Normal work coveralls.
Eye Protection	Chemical goggles; also wear a face shield if splashing hazard exists.
Other Precautions	None known.
Environmental Exposure Controls	Do not allow material to contaminate ground water system

9. Physical and Chemical Properties

9.1. Information on basic physical and chemical properties

Physical State:	Liquid	**Color**	Clear to slightly hazy amber
Odor:	Mild	**Odor Threshold:**	No information available

Property Remarks/ - Method	Values
pH:	6.49 - 7.49
Freezing Point / Range	-1.1 °C
Melting Point / Range	No data available
Boiling Point / Range	100 °C
Flash Point	> 95 °C / PMCC
Evaporation rate	< 1
Vapor Pressure	18 mmHg
Vapor Density	> 1
Specific Gravity	1.24
Water Solubility	Soluble in water
Solubility in other solvents	No data available
Partition coefficient: n-octanol/water	1.2
Autoignition Temperature	No data available
Decomposition Temperature	No data available
Viscosity	No data available
Explosive Properties	No information available
Oxidizing Properties	No information available

9.2. Other information

VOC Content (%)	No data available

10. Stability and Reactivity

10.1. Reactivity
Not expected to be reactive.
10.2. Chemical stability
Stable
10.3. Possibility of hazardous reactions
Will Not Occur
10.4. Conditions to avoid
None anticipated
10.5. Incompatible materials
Strong oxidizers.
10.6. Hazardous decomposition products
Carbon monoxide and carbon dioxide. Toxic monomer fumes.

11. Toxicological Information

Information on routes of exposure
Principle Route of Exposure Eye and skin contact.

Symptoms related to exposure
Most Important Symptoms/Effects

No significant hazards expected.

Numerical measures of toxicity

Toxicology data for the components

Substances	CAS Number	LD50 Oral	LD50 Dermal	LC50 Inhalation
Contains no hazardous substances in concentrations above cut-off values according to the competent authority	NA	No data available	No data available	No data available

Immediate, delayed and chronic health effects from exposure

Inhalation May cause mild respiratory irritation.
Eye Contact May cause mild eye irritation.
Skin Contact Prolonged or repeated contact may cause slight skin irritation.
Ingestion In large amounts: Irritation of the mouth, throat, and stomach.

Chronic Effects/Carcinogenicity No data available to indicate product or components present at greater than 0.1% are chronic health hazards.

Exposure Levels
No data available

Interactive effects
Skin disorders. Eye ailments. Respiratory disorders.

Data limitations
No data available

12. Ecological Information

Ecotoxicity
Product Ecotoxicity Data
No data available

Substance Ecotoxicity Data

Substances	CAS Number	Toxicity to Algae	Toxicity to Fish	Toxicity to Microorganisms	Toxicity to Invertebrates
Contains no hazardous substances in concentrations above cut-off values according to the competent authority	NA	No information available	No information available	No information available	No information available

12.2. Persistence and degradability
Biodegradable.

Substances	CAS Number	Persistence and Degradability

Contains no hazardous substances in concentrations above cut-off values according to the competent authority	NA	No information available

12.3. Bioaccumulative potential

Does not bioaccumulate.

Substances	CAS Number	Log Pow
Contains no hazardous substances in concentrations above cut-off values according to the competent authority	NA	No information available

12.4. Mobility in soil

Substances	CAS Number	Mobility
Contains no hazardous substances in concentrations above cut-off values according to the competent authority	NA	No information available

12.6. Other adverse effects

Endocrine Disruptor Information

This product does not contain any known or suspected endocrine disruptors

13. Disposal Considerations

Safe handling and disposal methods

Disposal should be made in accordance with federal, state, and local regulations.

Disposal of any contaminated packaging

Follow all applicable national or local regulations.

Environmental regulations

Not applicable

14. Transport Information

Transportation Information

Australia ADG

UN Number	Not restricted
UN proper shipping name:	Not restricted
Transport Hazard Class(es):	Not applicable
Packing Group:	Not applicable
Environmental Hazards:	Not applicable

IMDG/IMO

UN Number	Not restricted
UN proper shipping name:	Not restricted
Transport Hazard Class(es):	Not applicable
Packing Group:	Not applicable
Environmental Hazards:	Not applicable

IATA/ICAO

UN Number	Not restricted
UN proper shipping name:	Not restricted
Transport Hazard Class(es):	Not applicable
Packing Group:	Not applicable
Environmental Hazards:	Not applicable

Special precautions during transport

None

HazChem Code

None Allocated

15. Regulatory Information

Safety, health and environmental regulations specific for the product

International Inventories

Australian AICS Inventory	All components are listed on the AICS or are subject to a relevant exemption, permit, or assessment certificate.
New Zealand Inventory of Chemicals	All components are listed on the NZIoC or are subject to a relevant exemption, permit, or assessment certificate.
EINECS (European Inventory of Existing Chemical Substances)	This product, and all its components, complies with EINECS
US TSCA Inventory	All components listed on inventory or are exempt.
Canadian Domestic Substances List (DSL)	All components listed on inventory or are exempt.

Poisons Schedule number
None Allocated

International Agreements

Montreal Protocol - Ozone Depleting Substances:	Does not apply
Stolkhom Convention - Persistent Organic Pollutants:	Does not apply
Rotterdam Convention - Prior Informed Consent:	Does not apply
Basel Convention - Hazardous Waste:	Does not apply

16. Other information

Date of preparation or review

Revision Date: 05-Jul-2016

Revision Note
SDS sections updated: 2

Full text of H-Statements referred to under sections 2 and 3
None

Additional information For additional information on the use of this product, contact your local Halliburton representative.

For questions about the Safety Data Sheet for this or other Halliburton products, contact Chemical Stewardship at 1-580-251-4335.

Key abreviations or acronyms used
bw – body weight
CAS – Chemical Abstracts Service
EC50 – Effective Concentration 50%
LC50 – Lethal Concentration 50%
LD50 – Lethal Dose 50%
LL50 – Lethal Loading 50%
mg/kg – milligram/kilogram
mg/L – milligram/liter
NOEC – No Observed Effect Concentration
OEL – Occupational Exposure Limit
PBT – Persistent Bioaccumulative and Toxic
ppm – parts per million
STEL – Short Term Exposure Limit
TWA – Time-Weighted Average
vPvB – very Persistent and very Bioaccumulative
h - hour

mg/m^3 - milligram/cubic meter
mm - millimeter
mmHg - millimeter mercury
w/w - weight/weight
d - day

Key literature references and sources for data
www.ChemADVISOR.com/

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End of Safety Data Sheet

HALLIBURTON

SAFETY DATA SHEET

DCA-32002

Revision Date: 07-Feb-2018 **Revision Number:** 19

1. Product Identifier & Identity for the Chemical

Statement of Hazardous Nature Hazardous according to the criteria of the 3rd Revised Edition of the Globally Harmonised System of Classification and Labelling of Chemicals (GHS), Non-Dangerous Goods according to the criteria of ADG.

1.1. Product Identifier

Product Name DCA-32002

Other means of Identification

Synonyms None

Hazardous Material Number: HM007683

Recommended use of the chemical and restrictions on use

Recommended Use Surfactant

Uses advised against No information available

Supplier's name, address and phone number

Manufacturer/Supplier Halliburton Australia Pty. Ltd.
15 Marriott Road, Jandakot, WA 6164
Australia
ACN Number: 009 000 775
Telephone Number: + 61 1 800 686 951
Fax Number: 61 (08) 9455 5300

E-mail Address fdunexchem@halliburton.com

Emergency phone number

+ 61 1 800 686 951
Global Incident Response Access Code: 334305
Contract Number: 14012

Australian Poisons Information Centre
24 Hour Service: - 13 11 26
Police or Fire Brigade: - 000 (exchange): - 1100

2. Hazard Identification

Statement of Hazardous Nature Hazardous according to the criteria of the 3rd Revised Edition of the Globally Harmonised System of Classification and Labelling of Chemicals (GHS), Non-Dangerous Goods according to the criteria of ADG.

Classification of the hazardous chemical

Acute Oral Toxicity	Category 4 - H302
Skin Corrosion/Irritation	Category 2 - H315
Serious Eye Damage/Irritation	Category 1 - H318
Acute Aquatic Toxicity	Category 2 - H401

Label elements, including precautionary statements

Hazard Pictograms

Signal Word DANGER

Hazard Statements:
H302 - Harmful if swallowed
H315 - Causes skin irritation
H318 - Causes serious eye damage
H401 - Toxic to aquatic life

Precautionary Statements

Prevention
P264 - Wash face, hands and any exposed skin thoroughly after handling
P270 - Do not eat, drink or smoke when using this product
P273 - Avoid release to the environment
P280 - Wear protective gloves/eye protection/face protection

Response
P301 + P312 - IF SWALLOWED: Call a POISON CENTER or doctor/physician if you feel unwell
P330 - Rinse mouth
P302 + P352 - IF ON SKIN: Wash with plenty of water.
P332 + P313 - If skin irritation occurs: Get medical advice/attention
P362 + P364 - Take off contaminated clothing and wash before reuse
P305 + P351 + P338 - IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing
P310 - Immediately call a POISON CENTER or doctor/physician

Storage None

Disposal P501 - Dispose of contents/container in accordance with local/regional/national/international regulations

Contains

Substances	**CAS Number**
Alcohols, C6-C12, ethoxylated propoxylated	68937-66-6
Alcohols, C10-C16, ethoxylated propoxylated	69227-22-1

Other hazards which do not result in classification
This mixture contains no substance considered to be persistent, bioaccumulating nor toxic (PBT).
This mixture contains no substance considered to be very persistent nor very bioaccumulating (vPvB).

For the full text of the H-phrases mentioned in this Section, see Section 16

3. Composition/information on Ingredients

Substances	CAS Number	PERCENT (w/w)	GHS Classification - Australia
Alcohols, C6-C12, ethoxylated propoxylated	68937-66-6	60 - 100%	Acute Tox. 4 (H302) Skin Irrit. 2 (H315) Eye Corr. 1 (H318) Aquatic Acute 2 (H401)
Alcohols, C10-C16, ethoxylated propoxylated	69227-22-1	10 - 30%	Acute Tox. 4 (H302) Skin Irrit. 2 (H315) Eye Corr. 1 (H318) Aquatic Acute 2 (H401)

4. First aid measures

Description of necessary first aid measures

Inhalation	Under normal conditions, first aid procedures are not required.
Eyes	Immediately flush eyes with large amounts of water for at least 15 minutes. Get immediate medical attention.
Skin	Wash with soap and water. Get medical attention if irritation persists.
Ingestion	Do NOT induce vomiting. Give nothing by mouth. Obtain immediate medical attention.

Symptoms caused by exposure

Causes severe eye irritation which may damage tissue. Causes skin irritation. Harmful if swallowed.

Medical Attention and Special Treatment

Notes to Physician Treat symptomatically

5. Fire Fighting Measures

Suitable extinguishing equipment

Suitable Extinguishing Media

Water fog, carbon dioxide, foam, dry chemical.

Extinguishing media which must not be used for safety reasons

None known.

Specific hazards arising from the chemical

Special exposure hazards in a fire

Decomposition in fire may produce harmful gases.

Special protective equipment and precautions for fire fighters

Special protective equipment for firefighters

Full protective clothing and approved self-contained breathing apparatus required for fire fighting personnel.

6. Accidental release measures

6.1. Personal precautions, protective equipment and emergency procedures

Use appropriate protective equipment. Avoid contact with skin, eyes and clothing. Avoid breathing vapors. Ensure adequate ventilation.

6.2. Environmental precautions

Prevent from entering sewers, waterways, or low areas.

6.3. Methods and material for containment and cleaning up

Isolate spill and stop leak where safe. Contain spill with sand or other inert materials. Scoop up and remove.

7. Handling and storage

7.1. Precautions for safe handling

Handling Precautions

Avoid contact with eyes, skin, or clothing. Wash hands after use. Avoid breathing vapors. Ensure adequate ventilation. Slippery when wet. Launder contaminated clothing before reuse. Use appropriate protective equipment.

Hygiene Measures

Handle in accordance with good industrial hygiene and safety practice.

7.2. Conditions for safe storage, including any incompatibilities

Storage Information

Store away from oxidizers. Keep container closed when not in use. Keep from heat, sparks, and open flames. Product has a shelf life of 24 months.

Other Guidelines

No information available

8. Exposure Controls/Personal Protection

Control parameters - exposure standards, biological monitoring

Exposure Limits

Substances	CAS Number	Australia NOHSC	ACGIH TLV-TWA
Alcohols, C6-C12, ethoxylated propoxylated	68937-66-6	Not applicable	Not applicable
Alcohols, C10-C16, ethoxylated propoxylated	69227-22-1	Not applicable	Not applicable

Appropriate engineering controls

Engineering Controls None known.

Personal protective equipment (PPE)

Personal Protective Equipment If engineering controls and work practices cannot prevent excessive exposures, the selection and proper use of personal protective equipment should be determined by an industrial hygienist or other qualified professional based on the specific application of this product.

Respiratory Protection If engineering controls and work practices cannot keep exposure below occupational exposure limits or if exposure is unknown, wear a NIOSH certified, European Standard EN 149, AS/NZS 1715:2009, or equivalent respirator when using this product. Selection of and instruction on using all personal protective equipment, including respirators, should be performed by an Industrial Hygienist or other qualified professional.

Hand Protection Impervious rubber gloves. Polyvinylchloride gloves.
Skin Protection Normal work coveralls.
Eye Protection Wear safety glasses or goggles to protect against exposure.
Other Precautions None known.
Environmental Exposure Controls Do not allow material to contaminate ground water system

9. Physical and Chemical Properties

9.1. Information on basic physical and chemical properties

Physical State: Liquid
Odor: Mild
Color Yellow
Odor Threshold: No information available

Property Remarks/ - Method	Values
pH:	6.5 (1%)
Freezing Point / Range	-3 °C
Melting Point / Range	No data available
Boiling Point / Range	No data available
Flash Point	240 °C / 464 °F PMCC
Evaporation rate	No data available
Vapor Pressure	No data available
Vapor Density	> 10
Specific Gravity	0.98
Water Solubility	Soluble in water
Solubility in other solvents	No data available
Partition coefficient: n-octanol/water	No data available
Autoignition Temperature	No data available
Decomposition Temperature	No data available
Viscosity	No data available
Explosive Properties	No information available
Oxidizing Properties	No information available

9.2. Other information

VOC Content (%) No data available

10. Stability and Reactivity

10.1. Reactivity

Not expected to be reactive.

10.2. Chemical stability

Stable

10.3. Possibility of hazardous reactions

Will Not Occur

10.4. Conditions to avoid

None anticipated

10.5. Incompatible materials

Strong oxidizers. Strong acids. Strong alkalis.

10.6. Hazardous decomposition products

Carbon monoxide and carbon dioxide.

11. Toxicological Information

Information on routes of exposure

Principle Route of Exposure Eye or skin contact, inhalation.

Symptoms related to exposure

Most Important Symptoms/Effects

Causes severe eye irritation which may damage tissue. Causes skin irritation. Harmful if swallowed.

Toxicology data for the components

Substances	CAS Number	LD50 Oral	LD50 Dermal	LC50 Inhalation
Alcohols, C6-C12, ethoxylated propoxylated	68937-66-6	600 mg/kg (Rat) (similar substance)	> 5200 mg/kg (Rabbit) (similar substance)	> 0.22 mg/L (saturated concentration) (Rat) (similar substance)
Alcohols, C10-C16, ethoxylated propoxylated	69227-22-1	600 mg/kg (Rat) (similar substance)	> 5200 mg/kg (Rabbit) (similar substance)	>0.22 mg/L (saturated concentration) (Rat) (similar substance)

Immediate, delayed and chronic health effects from exposure

Inhalation May cause mild respiratory irritation.

Eye Contact Causes severe eye irritation which may damage tissue.

Skin Contact Causes skin irritation.

Ingestion Harmful if swallowed. Irritation of the mouth, throat, and stomach.

Chronic Effects/Carcinogenicity No data available to indicate product or components present at greater than 0.1% are chronic health hazards.

Exposure Levels

No data available

Interactive effects

Skin disorders.

Data limitations

No data available

Substances	CAS Number	Skin corrosion/irritation
Alcohols, C6-C12, ethoxylated propoxylated	68937-66-6	Causes skin irritation. (Rabbit) (similar substances)
Alcohols, C10-C16, ethoxylated propoxylated	69227-22-1	Causes skin irritation. (Rabbit) (similar substances)

Substances	CAS Number	Serious eye damage/irritation
Alcohols, C6-C12, ethoxylated propoxylated	68937-66-6	Causes severe eye irritation (Rabbit) (similar substances)
Alcohols, C10-C16, ethoxylated propoxylated	69227-22-1	Causes severe eye irritation (Rabbit) (similar substances)

Substances	CAS Number	Skin Sensitization

Alcohols, C6-C12, ethoxylated propoxylated	68937-66-6	Did not cause sensitization on laboratory animals (guinea pig) (similar substances)
Alcohols, C10-C16, ethoxylated propoxylated	69227-22-1	Did not cause sensitization on laboratory animals (guinea pig) (similar substances)

Substances	CAS Number	Respiratory Sensitization
Alcohols, C6-C12, ethoxylated propoxylated	68937-66-6	No information available
Alcohols, C10-C16, ethoxylated propoxylated	69227-22-1	No information available

Substances	CAS Number	Mutagenic Effects
Alcohols, C6-C12, ethoxylated propoxylated	68937-66-6	In vitro tests did not show mutagenic effects. In vivo tests did not show mutagenic effects. (similar substances)
Alcohols, C10-C16, ethoxylated propoxylated	69227-22-1	In vitro tests did not show mutagenic effects. In vivo tests did not show mutagenic effects. (similar substances)

Substances	CAS Number	Carcinogenic Effects
Alcohols, C6-C12, ethoxylated propoxylated	68937-66-6	Did not show carcinogenic effects in animal experiments (similar substances)
Alcohols, C10-C16, ethoxylated propoxylated	69227-22-1	Did not show carcinogenic or teratogenic effects in animal experiments (similar substances)

Substances	CAS Number	Reproductive toxicity
Alcohols, C6-C12, ethoxylated propoxylated	68937-66-6	Animal testing did not show any effects on fertility.
Alcohols, C10-C16, ethoxylated propoxylated	69227-22-1	Animal testing did not show any effects on fertility.

Substances	CAS Number	STOT - single exposure
Alcohols, C6-C12, ethoxylated propoxylated	68937-66-6	No significant toxicity observed in animal studies at concentration requiring classification. (similar substances)
Alcohols, C10-C16, ethoxylated propoxylated	69227-22-1	No significant toxicity observed in animal studies at concentration requiring classification. (similar substances)

Substances	CAS Number	STOT - repeated exposure
Alcohols, C6-C12, ethoxylated propoxylated	68937-66-6	No significant toxicity observed in animal studies at concentration requiring classification. (similar substances)
Alcohols, C10-C16, ethoxylated propoxylated	69227-22-1	No significant toxicity observed in animal studies at concentration requiring classification. (similar substances)

Substances	CAS Number	Aspiration hazard
Alcohols, C6-C12, ethoxylated propoxylated	68937-66-6	No adverse health effects are expected from swallowing.
Alcohols, C10-C16, ethoxylated propoxylated	69227-22-1	No adverse health effects are expected from swallowing.

12. Ecological Information

Ecotoxicity

Algae Toxicity ErC50 (72h): 2.58 - 3.44 mg/L (Desmodesmus subspicatus)

Acute Crustaceans Toxicity: EC50(48h): 1.45 - 1.79 mg/L (Daphnia magna)

Substance Ecotoxicity Data

Substances	CAS Number	Toxicity to Algae	Toxicity to Fish	Toxicity to Microorganisms	Toxicity to Invertebrates
Alcohols, C6-C12, ethoxylated propoxylated	68937-66-6	EC50 (72h) 0.75 mg/L (Pseudokirchnerella subcapitata) (similar substance) EC50 (96h) 0.7 mg/L (Pseudokirchneriella subapitata) (similar substance) CD10 8 mg/L	LC50 (96h) 0.59 mg/L (Pleuronectes platessa) (similar substance) LC50 (96) 1.4 mg/L (Pimephales promelas) (similar substance) NOEC 4.4 mg/L (Pimephales promelas, juvenile)	ErC50 (16.9h) > 10 g/L (growth inhibition) (Pseudomonas putida) (similar substance)	EC50 (48h) 0.14 mg/L (Daphnia magna) (similar substance) EC50 (48h) 0.39 mg/L (Cerodaphnia dubia) (similar substance)

		(Pseudokirchneriella subapitata) EC10 2 mg/L (Brachionus calyciflorus)			
Alcohols, C10-C16, ethoxylated propoxylated	69227-22-1	EC50 (72h) 0.75 mg/L (Pseudokirchnerella subcapitata) (similar substance) ErC50 (48h) 0.7 mg/L (Skeletonema costatum) EC10 9.79 mg/L (Selenastrum capricornutum) (similar substance) ErC50 1.1 mg/L (Scenedesmus subspicatus) (similar substance)	LC50 (96h) 0.59 mg/L (Pleuronectes platessa) (similar substance) LC50 (96h) 1.6 mg/L (Pimephales promelas) (similar substace) LC50 (96h) 3 mg/L (Brachydanio rerio) (similar substance)	ErC50 (16.9h) > 10 g/L (Pseudomonas putida) (similar substance)	EC50 (48h) 0.14 mg/L (Daphnia magna) (similar substance) EC50 (48h) 02 mg/L (Daphnia magna) (similar substance)

12.2. Persistence and degradability

Readily biodegradable

Substances	CAS Number	Persistence and Degradability
Alcohols, C6-C12, ethoxylated propoxylated	68937-66-6	Readily biodegradable (60% @ 28d) (similar substances)
Alcohols, C10-C16, ethoxylated propoxylated	69227-22-1	Readily biodegradable (84% @ 28d) (similar substances)

12.3. Bioaccumulative potential

Substances	CAS Number	Log Pow
Alcohols, C6-C12, ethoxylated propoxylated	68937-66-6	Log Pow: 4.3 - 5.36 (estimated) BCF: 1.1 - 1.8 (fish, estimated)
Alcohols, C10-C16, ethoxylated propoxylated	69227-22-1	Log Pow: 4.3 - 5.36 (estimated) BCF: 1.1 - 1.8 (fish, estimated)

12.4. Mobility in soil

Substances	CAS Number	Mobility
Alcohols, C6-C12, ethoxylated propoxylated	68937-66-6	KOC = >4
Alcohols, C10-C16, ethoxylated propoxylated	69227-22-1	KOC = >4

12.6. Other adverse effects

Endocrine Disruptor Information

This product does not contain any known or suspected endocrine disruptors

13. Disposal Considerations

Safe handling and disposal methods

Disposal should be made in accordance with federal, state, and local regulations.

Disposal of any contaminated packaging

Follow all applicable national or local regulations. Contaminated packaging may be disposed of by: rendering packaging incapable of containing any substance, or treating packaging to remove residual contents, or treating packaging to make sure the residual contents are no longer hazardous, or by disposing of packaging into commercial waste collection.

Environmental regulations

Not applicable

14. Transport Information

Transportation Information

Australia ADG

UN Number Not restricted

UN proper shipping name:	Not restricted
Transport Hazard Class(es):	Not applicable
Packing Group:	Not applicable
Environmental Hazards:	Not applicable

IMDG/IMO

UN Number	Not restricted
UN proper shipping name:	Not restricted
Transport Hazard Class(es):	Not applicable
Packing Group:	Not applicable
Environmental Hazards:	Not applicable

IATA/ICAO

UN Number	Not restricted
UN proper shipping name:	Not restricted
Transport Hazard Class(es):	Not applicable
Packing Group:	Not applicable
Environmental Hazards:	Not applicable

Special precautions during transport
None

HazChem Code
•3Z

15. Regulatory Information

Safety, health and environmental regulations specific for the product

International Inventories

Australian AICS Inventory	All components are listed on the AICS or are subject to a relevant exemption, permit, or assessment certificate.
New Zealand Inventory of Chemicals	All components are listed on the NZIoC or are subject to a relevant exemption, permit, or assessment certificate.
EINECS (European Inventory of Existing Chemical Substances)	This product, and all its components, complies with EINECS
US TSCA Inventory	All components listed on inventory or are exempt.
Canadian Domestic Substances List (DSL)	All components listed on inventory or are exempt.

Poisons Schedule number
None Allocated

International Agreements

Montreal Protocol - Ozone Depleting Substances:	Does not apply
Stockholm Convention - Persistent Organic Pollutants:	Does not apply
Rotterdam Convention - Prior Informed Consent:	Does not apply
Basel Convention - Hazardous Waste:	Does not apply

16. Other information

Date of preparation or review

Revision Date: 07-Feb-2018

Revision Note
SDS sections updated:
2

Full text of H-Statements referred to under sections 2 and 3
H302 - Harmful if swallowed

H315 - Causes skin irritation
H318 - Causes serious eye damage

Additional information

For additional information on the use of this product, contact your local Halliburton representative.

For questions about the Safety Data Sheet for this or other Halliburton products, contact Chemical Stewardship at 1-580-251-4335.

Key abreviations or acronyms used

bw – body weight
CAS – Chemical Abstracts Service
EC50 – Effective Concentration 50%
LC50 – Lethal Concentration 50%
LD50 – Lethal Dose 50%
LL50 – Lethal Loading 50%
mg/kg – milligram/kilogram
mg/L – milligram/liter
NOEC – No Observed Effect Concentration
OEL – Occupational Exposure Limit
PBT – Persistent Bioaccumulative and Toxic
ppm – parts per million
STEL – Short Term Exposure Limit
TWA – Time-Weighted Average
vPvB – very Persistent and very Bioaccumulative
h - hour
mg/m^3 - milligram/cubic meter
mm - millimeter
mmHg - millimeter mercury
w/w - weight/weight
d - day

Key literature references and sources for data

www.ChemADVISOR.com/
NZ CCID

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End of Safety Data Sheet

HALLIBURTON

SAFETY DATA SHEET

DCA-32009

Revision Date: 20-Nov-2015 **Revision Number:** 7

1. Product Identifier & Identity for the Chemical

Statement of Hazardous Nature Hazardous according to the criteria of the 3rd Revised Edition of the Globally Harmonised System of Classification and Labelling of Chemicals (GHS), Non-Dangerous Goods according to the criteria of ADG.

1.1. Product Identifier

Product Name DCA-32009

Other means of Identification

Synonyms: None

Product Code: HM007719

Recommended use of the chemical and restrictions on use

Recommended Use Cleaner

Uses Advised Against No information available

Supplier's name, address and phone number

Manufacturer/Supplier

Halliburton Australia Pty. Ltd.
15 Marriott Road
Jandakot
WA 6164
Australia

ACN Number: 009 000 775
Telephone Number: + 61 1 800 686 951
Fax Number: 61 (08) 9455 5300

E-Mail address: fdunexchem@halliburton.com

Emergency phone number

+ 61 1 800 686 951

Australian Poisons Information Centre

24 Hour Service: - 13 11 26

Police or Fire Brigade: - 000 (exchange): - 1100

2. Hazard Identification

Statement of Hazardous Nature Hazardous according to the criteria of the 3rd Revised Edition of the Globally Harmonised System of Classification and Labelling of Chemicals (GHS), Non-Dangerous Goods according to the criteria of ADG.

Classification of the hazardous chemical

Acute Inhalation Toxicity - Dusts and Mists	Category 4 - H332
Skin Corrosion / irritation	Category 2 - H315
Serious Eye Damage / Eye Irritation	Category 2 - H319
Flammable Liquids.	Category 4 - H227

Label elements, including precautionary statements

Hazard Pictograms

Signal Word Warning

Hazard Statements
H227 - Combustible liquid
H315 - Causes skin irritation
H319 - Causes serious eye irritation
H332 - Harmful if inhaled

Precautionary Statements

Prevention
P210 - Keep away from heat/sparks/open flames/hot surfaces. - No smoking
P261 - Avoid breathing dust/fume/gas/mist/vapors/spray
P264 - Wash face, hands and any exposed skin thoroughly after handling
P280 - Wear protective gloves/eye protection/face protection

Response
P302 + P352 - IF ON SKIN: Wash with plenty of soap and water
P332 + P313 - If skin irritation occurs: Get medical advice/attention
P362 - Take off contaminated clothing and wash before reuse
P304 + P340 - IF INHALED: Remove to fresh air and keep at rest in a position comfortable for breathing
P312 - Call a POISON CENTER or doctor/physician if you feel unwell
P305 + P351 + P338 - IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing
P337 + P313 - If eye irritation persists: Get medical advice/attention
P370 + P378 - In case of fire: Use water spray for extinction

Storage P403 + P235 - Store in a well-ventilated place. Keep cool

Disposal P501 - Dispose of contents/container in accordance with local/regional/national/international regulations

Contains

Substances	**CAS Number**
Ethylene glycol monobutyl ether	111-76-2
Oxylated alkylphenols	Proprietary
Alkyl hexanol	Proprietary
Isopropanol	67-63-0

Other hazards which do not result in classification
None known

Australia Classification
For the full text of the H-phrases mentioned in this Section, see Section 16

Classification Xn - Harmful.

Risk Phrases
R20 Harmful by inhalation.
R36/38 Irritating to eyes and skin.

3. Composition/information on Ingredients

Substances	CAS Number	PERCENT (w/w)	GHS Classification - Australia
Ethylene glycol monobutyl ether	111-76-2	30 - 60%	Acute Tox. 4 (H302) Acute Tox. 4 (H312) Acute Tox. 4 (H332) Skin Irrit. 2 (H315) Eye Irrit. 2 (H319) Flam. Liq. 4 (H227)
Oxylated alkylphenols	Proprietary	10 - 30%	Skin Irrit. 2 (H315) Eye Irrit. 2A (H319)
Alkyl hexanol	Proprietary	10 - 30%	Acute Tox. 4 (H332) Skin Irrit. 2 (H315) Eye Irrit. 2A (H319) STOT SE 3 (H335) Aquatic Acute 3 (H402) Flam. Liq. 4 (H227)
Isopropanol	67-63-0	10 - 30%	Eye Irrit. 2 (H319) STOT SE 3 (H336) Flam. Liq. 2 (H225)

4. First aid measures

Description of necessary first aid measures

Inhalation If inhaled, move victim to fresh air and seek medical attention.

Eyes In case of contact, or suspected contact, immediately flush eyes with plenty of water for at least 15 minutes and get medical attention immediately after flushing.

Skin In case of contact, immediately flush skin with plenty of soap and water for at least 15 minutes. Get medical attention. Remove contaminated clothing and launder before reuse. Destroy or properly dispose of contaminated shoes.

Ingestion Do NOT induce vomiting. Give nothing by mouth. Obtain immediate medical attention.

Symptoms caused by exposure

Causes eye irritation Causes skin irritation. May be harmful if inhaled.

Medical Attention and Special Treatment

Notes to Physician Treat symptomatically

5. Fire Fighting Measures

Suitable extinguishing equipment

Suitable Extinguishing Media

Water fog, carbon dioxide, foam, dry chemical.

Extinguishing media which must not be used for safety reasons

None known.

Specific hazards arising from the chemical

Special Exposure Hazards

Use water spray to cool fire exposed surfaces. Closed containers may explode in fire. Decomposition in fire may produce harmful gases.

Special protective equipment and precautions for fire fighters

Special Protective Equipment for Fire-Fighters

Full protective clothing and approved self-contained breathing apparatus required for fire fighting personnel.

6. Accidental release measures

6.1. Personal precautions, protective equipment and emergency procedures

Use appropriate protective equipment.

6.2. Environmental precautions

Prevent from entering sewers, waterways, or low areas.

6.3. Methods and material for containment and cleaning up

Isolate spill and stop leak where safe. Contain spill with sand or other inert materials. Scoop up and remove.

7. Handling and storage

7.1. Precautions for Safe Handling

Handling Precautions

Avoid contact with eyes, skin, or clothing. Avoid breathing vapors.

Hygiene Measures

Handle in accordance with good industrial hygiene and safety practice.

7.2. Conditions for safe storage, including any incompatibilities

Storage Information

Keep from heat, sparks, and open flames. Store in a cool well ventilated area. Keep container closed when not in use. Store locked up. Product has a shelf life of 24 months.

Other Guidelines

No information available

8. Exposure Controls/Personal Protection

Control parameters - exposure standards, biological monitoring

Exposure Limits

Substances	CAS Number	Australia NOHSC	ACGIH TLV-TWA
Ethylene glycol monobutyl ether	111-76-2	TWA: 20 ppm TWA: 96.9 mg/m³ STEL: 50 ppm STEL: 242 mg/m³	TWA: 20 ppm Skin
Oxylated alkylphenols	Proprietary	Not applicable	Not applicable
Alkyl hexanol	Proprietary	TWA: 50 ppm TWA: 266 mg/m³	TWA: 50 ppm
Isopropanol	67-63-0	TWA: 400 ppm TWA: 983 mg/m³ STEL: 500 ppm STEL: 1230 mg/m³	TWA: 200 ppm STEL: 400 ppm

Appropriate engineering controls

Engineering Controls Use in a well ventilated area. Local exhaust ventilation should be used in areas without good cross ventilation.

Personal protective equipment (PPE)

Respiratory Protection Organic vapor respirator. In high concentrations, supplied air respirator or a self-contained breathing apparatus.

Hand Protection Impervious rubber gloves.

Skin Protection Rubber apron.

Eye Protection Chemical goggles; also wear a face shield if splashing hazard exists.

Other Precautions None known.

Environmental Exposure Controls No information available

9. Physical and Chemical Properties

9.1. Information on basic physical and chemical properties

Physical State: Liquid **Color:** Clear light amber

Odor: Sweet **Odor Threshold:** No information available

Property	Values	Remarks/ - Method
pH:	8	

Freezing Point/Range	No data available
Melting Point/Range	No data available
Boiling Point/Range	136 °C / 278 °F
Flash Point	79 °C / 175 °F PMCC
upper flammability limit	10.6%
lower flammability limit	1.5%
Evaporation rate	No data available
Vapor Pressure	0.8 mmHg
Vapor Density	No data available
Specific Gravity	0.92
Water Solubility	Soluble in water
Solubility in other solvents	No data available
Partition coefficient: n-octanol/water	No data available
Autoignition Temperature	No data available
Decomposition Temperature	No data available
Viscosity	No data available
Explosive Properties	No information available
Oxidizing Properties	No information available

9.2. Other information

VOC Content (%) No data available

10. Stability and Reactivity

10.1. Reactivity

Not expected to be reactive.

10.2. Chemical Stability

Stable

10.3. Possibility of Hazardous Reactions

Will Not Occur

10.4. Conditions to Avoid

Keep away from heat, sparks and flame.

10.5. Incompatible Materials

Strong oxidizers. Strong alkalis. Amphoteric metals such as aluminum, magnesium, lead, tin, or zinc.

10.6. Hazardous Decomposition Products

Toxic fumes. Carbon monoxide and carbon dioxide.

11. Toxicological Information

Information on routes of exposure

Principle Route of Exposure Eye or skin contact, inhalation.

Symptoms related to exposure

Most Important Symptoms/Effects

Causes eye irritation Causes skin irritation. May be harmful if inhaled.

Numerical measures of toxicity

Toxicology data for the components

Substances	CAS Number	LD50 Oral	LD50 Dermal	LC50 Inhalation
Ethylene glycol monobutyl ether	111-76-2	470 mg/kg (Rat) 1414 mg/kg (Guinea pig) 1746 mg/kg (Rat) 320 mg/kg (Rabbit) 530 mg/kg (Rat) 560 mg/kg (Rat) 3000 mg/kg (Rat) 2400 mg/kg (Rat)	220 mg/kg (Rabbit) 2270 mg/kg (Rat) 200 mg/kg (Guinea pig) >2000 mg/kg (Rabbit) 841 mg/kg (Rabbit) 435 mg/kg (Rabbit) >2000 mg/kg (Guinea pig) >2000 mg/kg (Rat) 100 mg/kg (Rabbit) 207 mg/kg (Guinea pig) 400-500 mg/kg (Rabbit)	450 mg/L (Rat) 4h 2.174 mg/L (Rat) 4h 2.21 mg/L (Rat) 4h 450-486 mg/L (Rat) 4h 925 mg/L (Rat) 4h >633 mg/L (Guinea pig) 1h
Oxylated alkylphenols	Proprietary	No data available	No data available	No data available

Alkyl hexanol	Proprietary	> 2000 mg/kg	1980 mg/kg	1.45 mg/L (Rat) 4h
Isopropanol	67-63-0	4396 mg/kg (Rat) 5840 mg/kg (Rat) 3600 mg/kg (Mouse)	12,800 mg/kg (Rat) 12,870 mg/kg (Rabbit) 6280 mg/kg (Rabbit)	72.6 mg/L (Rat) 4h > 10,000 mg/L (Rat) 6h

Immediate, delayed and chronic health effects from exposure

Product Information Under certain conditions of use, some of the product ingredients may cause the following:

Inhalation Harmful if inhaled. May cause mild respiratory irritation. May cause central nervous system depression including headache, dizziness, drowsiness, incoordination, slowed reaction time, slurred speech, giddiness and unconsciousness.

Eye Contact Causes moderate eye irritation.

Skin Contact Causes moderate skin irritation.

Ingestion May cause abdominal pain, vomiting, nausea, and diarrhea.

Chronic Effects/Carcinogenicity No data available to indicate product or components present at greater than 0.1% are chronic health hazards.

Exposure Levels

No data available

Interactive effects

Skin disorders. Eye ailments.

Data limitations

No data available

Substances	CAS Number	Skin corrosion/irritation
Ethylene glycol monobutyl ether	111-76-2	Causes moderate skin irritation. (Rabbit)
Oxylated alkylphenols		Irritating to skin. (Rabbit)
Alkyl hexanol		Causes moderate skin irritation. (Rabbit)
Isopropanol	67-63-0	Non-irritating to the skin (Rabbit)

Substances	CAS Number	Eye damage/irritation
Ethylene glycol monobutyl ether	111-76-2	Causes moderate eye irritation. (Rabbit)
Oxylated alkylphenols		Irritating to eyes. (Rabbit)
Alkyl hexanol		Causes moderate eye irritation. (Rabbit)
Isopropanol	67-63-0	Causes moderate eye irritation. (Rabbit)

Substances	CAS Number	Skin Sensitization
Ethylene glycol monobutyl ether	111-76-2	Did not cause sensitization on laboratory animals (guinea pig)
Oxylated alkylphenols		No information available
Alkyl hexanol		Did not cause sensitization on laboratory animals (guinea pig)
Isopropanol	67-63-0	Did not cause sensitization on laboratory animals (guinea pig)

Substances	CAS Number	Respiratory Sensitization
Ethylene glycol monobutyl ether	111-76-2	No information available
Oxylated alkylphenols		No information available
Alkyl hexanol		Not regarded as a sensitizer.
Isopropanol	67-63-0	No information available

Substances	CAS Number	Mutagenic Effects
Ethylene glycol monobutyl ether	111-76-2	In vivo tests did not show mutagenic effects. In vitro tests did not show mutagenic effects
Oxylated alkylphenols		Not regarded as mutagenic.
Alkyl hexanol		In vitro tests did not show mutagenic effects.
Isopropanol	67-63-0	In vitro tests did not show mutagenic effects. In vivo tests did not show mutagenic effects.

Substances	CAS Number	Carcinogenic Effects

Ethylene glycol monobutyl ether	111-76-2	Not regarded as carcinogenic.
Oxylated alkylphenols		No information available.
Alkyl hexanol		Did not show carcinogenic effects in animal experiments
Isopropanol	67-63-0	Did not show carcinogenic effects in animal experiments

Substances	CAS Number	Reproductive toxicity
Ethylene glycol monobutyl ether	111-76-2	Animal testing did not show any effects on fertility. Did not show teratogenic effects in animal experiments.
Oxylated alkylphenols		No information available
Alkyl hexanol		Animal testing did not show any effects on fertility. Did not show teratogenic effects in animal experiments.
Isopropanol	67-63-0	No significant toxicity observed in animal studies at concentration requiring classification.

Substances	CAS Number	STOT - single exposure
Ethylene glycol monobutyl ether	111-76-2	No data of sufficient quality are available.
Oxylated alkylphenols		No significant toxicity observed in animal studies at concentration requiring classification.
Alkyl hexanol		May cause respiratory irritation.
Isopropanol	67-63-0	May cause headache, dizziness, and other central nervous system effects.

Substances	CAS Number	STOT - repeated exposure
Ethylene glycol monobutyl ether	111-76-2	No data of sufficient quality are available.
Oxylated alkylphenols		No significant toxicity observed in animal studies at concentration requiring classification.
Alkyl hexanol		No significant toxicity observed in animal studies at concentration requiring classification.
Isopropanol	67-63-0	No significant toxicity observed in animal studies at concentration requiring classification. (similar substances)

Substances	CAS Number	Aspiration hazard
Ethylene glycol monobutyl ether	111-76-2	No adverse health effects are expected from swallowing.
Oxylated alkylphenols		Not applicable
Alkyl hexanol		Not applicable
Isopropanol	67-63-0	Not applicable

12. Ecological Information

Ecotoxicity

Product Ecotoxicity Data

No data available

Substance Ecotoxicity Data

Substances	CAS Number	Toxicity to Algae	Toxicity to Fish	Toxicity to Microorganisms	Toxicity to Invertebrates
Ethylene glycol monobutyl ether	111-76-2	EC50 839.56 mg/L (Skeletonema costatum) EbC50 (72h) 911 mg/L EC50 > 500 mg/L (Scenedesmus subspicatus) NOEC (72h) 88 mg/L (biomass)(Pseudokirchnerella subcapitata)	LC50 > 1000 mg/L (Scophthalmus maximus, juvenile) LC50 (96h) 1474 mg/L (Oncorhynchus mykiss) NOEC (21d) > 100mg/L (Danio rerio)	TT/EC3 (48h) 463 mg/L (Uronema parduzci) TT/EC3 (72h) 73 mg/L (Entosiphon sulcatum) TT/EC3 (16h) 700 mg/L (Pseudomonas putida)	No information available
Oxylated alkylphenols	Proprietary	No information available	EC50 (96h) 1.2 - 9.3 mg/L (Pimephales promelas)	No information available	EC50 (48h) 1.6 - 10 mg/L (Daphnia magna)
Alkyl hexanol	Proprietary	No information available	LC50 (96h) 17.1 mg/L (Leuciscus idus melanotus)	No information available	No information available
Isopropanol	67-63-0	EC50 (72h) > 1000 mg/L (Desmodesmus subspicatus) EC50 (7d) 1800 mg/L (Scenedesmus quadricauda)	LC50 (96h) 9640 mg/L (Pimephales promelas) LC50 (7d) 7060 mg/L (Poecilia reticulata)	TT (16h) 1050 mg/L (Pseudomonas putida)	EC50 (48h) 13,299 mg/L (Daphnia magna) EC50 (24h) > 10,000 mg/L (Daphnia magna)

12.2. Persistence and degradability

Substances	CAS Number	Persistence and Degradability
Ethylene glycol monobutyl ether	111-76-2	Readily biodegradable (75-88% @ 28d)
Oxylated alkylphenols	Proprietary	No information available
Alkyl hexanol	Proprietary	Readily biodegradable (100 @ 14d)
Isopropanol	67-63-0	Readily biodegradable (53% @ 5d)

12.3. Bioaccumulative potential

Substances	CAS Number	Log Pow
Ethylene glycol monobutyl ether	111-76-2	0.81
Oxylated alkylphenols	Proprietary	No information available
Alkyl hexanol	Proprietary	2.73 BCF = 25.33
Isopropanol	67-63-0	0.05

12.4. Mobility in soil

Substances	CAS Number	Mobility
Ethylene glycol monobutyl ether	111-76-2	No information available
Oxylated alkylphenols	Proprietary	No information available
Alkyl hexanol	Proprietary	KOC = 26
Isopropanol	67-63-0	KOC = 1.5

12.6. Other adverse effects

Endocrine Disruptor Information

This product does not contain any known or suspected endocrine disruptors

13. Disposal Considerations

Safe handling and disposal methods

Disposal should be made in accordance with federal, state, and local regulations. Substance should NOT be deposited into a sewage facility.

Disposal of any contaminated packaging

Follow all applicable national or local regulations.

Environmental regulations

Not applicable

14. Transport Information

Transportation Information

UN Number: Not restricted
UN Proper Shipping Name: Not restricted
Transport Hazard Class(es): Not applicable
Packing Group: Not applicable
Environmental Hazards: Not applicable

Special precautions during transport

None

HazChem Code

None Allocated

15. Regulatory Information

Safety, health and environmental regulations specific for the product

International Inventories

Australian AICS Inventory	All components are listed on the AICS or are subject to a relevant exemption, permit, or assessment certificate.
New Zealand Inventory of Chemicals	All components are listed on the AICS or are subject to a relevant exemption, permit, or assessment certificate.
EINECS Inventory	This product does not comply with EINECS
US TSCA Inventory	All components listed on inventory or are exempt.
Canadian DSL Inventory	All components listed on inventory or are exempt.

Poisons Schedule number

None Allocated

International Agreements

Montreal Protocol - Ozone Depleting Substances:	Does not apply
Stolkhom Convention - Persistent Organic Pollutants:	Does not apply
Rotterdam Convention - Prior Informed Consent:	Does not apply
Basel Convention - Hazardous Waste:	Does not apply

16. Other information

Date of preparation or review

Revision Date: 20-Nov-2015

Revision Note

SDS sections updated: 2

Full text of R-phrases referred to under Sections 2 and 3

R20 Harmful by inhalation.
R36/38 Irritating to eyes and skin.

Full text of H-Statements referred to under sections 2 and 3

H225 - Highly flammable liquid and vapor
H227 - Combustible liquid
H302 - Harmful if swallowed
H312 - Harmful in contact with skin
H315 - Causes skin irritation
H319 - Causes serious eye irritation
H332 - Harmful if inhaled
H335 - May cause respiratory irritation
H336 - May cause drowsiness or dizziness
H402 - Harmful to aquatic life

Additional information

For additional information on the use of this product, contact your local Halliburton representative.

For questions about the Safety Data Sheet for this or other Halliburton products, contact Chemical Stewardship at 1-580-251-4335.

Key abreviations or acronyms used

bw – body weight
CAS – Chemical Abstracts Service
EC50 – Effective Concentration 50%
LC50 – Lethal Concentration 50%
LD50 – Lethal Dose 50%
LL50 – Lethal Loading 50%
mg/kg – milligram/kilogram
mg/L – milligram/liter
NOEC – No Observed Effect Concentration

OEL – Occupational Exposure Limit
PBT – Persistent Bioaccumulative and Toxic
ppm – parts per million
STEL – Short Term Exposure Limit
TWA – Time-Weighted Average
vPvB – very Persistent and very Bioaccumulative
h - hour
mg/m^3 - milligram/cubic meter
mm - millimeter
mmHg - millimeter mercury
w/w - weight/weight
d - day

Key literature references and sources for data
www.ChemADVISOR.com/
NZ CCID
Bioaquatics Testing, 1990

Disclaimer Statement
This information is furnished without warranty, expressed or implied, as to accuracy or completeness. The information is obtained from various sources including the manufacturer and other third party sources. The information may not be valid under all conditions nor if this material is used in combination with other materials or in any process. Final determination of suitability of any material is the sole responsibility of the user.

End of Safety Data Sheet

HALLIBURTON

SAFETY DATA SHEET

DCA-32014

Revision Date: 31-Aug-2017 **Revision Number:** 3

1. Product Identifier & Identity for the Chemical

Statement of Hazardous Nature Hazardous according to the criteria of the 3rd Revised Edition of the Globally Harmonised System of Classification and Labelling of Chemicals (GHS), Dangerous Goods according to the criteria of ADG.

1.1. Product Identifier

Product Name DCA-32014

Other means of Identification

Synonyms None

Hazardous Material Number: HM008547

Recommended use of the chemical and restrictions on use

Recommended Use Surfactant

Uses advised against Consumer use

Supplier's name, address and phone number

Manufacturer/Supplier Halliburton Australia Pty. Ltd.
15 Marriott Road, Jandakot, WA 6164
Australia
ACN Number: 009 000 775
Telephone Number: + 61 1 800 686 951
Fax Number: 61 (08) 9455 5300

E-mail Address fdunexchem@halliburton.com

Emergency phone number

+ 61 1 800 686 951
Global Incident Response Access Code: 334305
Contract Number: 14012

Australian Poisons Information Centre
24 Hour Service: - 13 11 26
Police or Fire Brigade: - 000 (exchange): - 1100

2. Hazard Identification

Statement of Hazardous Nature Hazardous according to the criteria of the 3rd Revised Edition of the Globally Harmonised System of Classification and Labelling of Chemicals (GHS), Dangerous Goods according to the criteria of ADG.

Classification of the hazardous chemical

Aspiration Toxicity	Category 1 - H304
Skin Corrosion/Irritation	Category 2 - H315
Serious Eye Damage/Irritation	Category 1 - H318
Reproductive Toxicity	Category 1B - H360
Acute Aquatic Toxicity	Category 2 - H401
Flammable liquids.	Category 3 - H226

Label elements, including precautionary statements

Hazard Pictograms

Signal Word DANGER

Hazard Statements:
H226 - Flammable liquid and vapor
H304 - May be fatal if swallowed and enters airways
H315 - Causes skin irritation
H318 - Causes serious eye damage
H360 - May damage fertility or the unborn child
H401 - Toxic to aquatic life

Precautionary Statements

Prevention
P201 - Obtain special instructions before use
P202 - Do not handle until all safety precautions have been read and understood
P210 - Keep away from heat, hot surfaces, sparks, open flames and other ignition sources. No smoking.
P233 - Keep container tightly closed
P240 - Ground and bond container and receiving equipment.
P241 - Use explosion-proof electrical/ventilating/lighting/equipment
P242 - Use only non-sparking tools
P243 - Take action to prevent static discharges.
P264 - Wash face, hands and any exposed skin thoroughly after handling
P273 - Avoid release to the environment
P280 - Wear protective gloves/protective clothing/eye protection/face protection
P281 - Use personal protective equipment as required

Response
P301 + P310 - IF SWALLOWED: Immediately call a POISON CENTER or doctor/physician
P331 - Do NOT induce vomiting
P302 + P352 - IF ON SKIN: Wash with plenty of water.
P332 + P313 - If skin irritation occurs: Get medical advice/attention
P362 + P364 - Take off contaminated clothing and wash before reuse
P305 + P351 + P338 - IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing
P310 - Immediately call a POISON CENTER or doctor/physician
P308 + P313 - IF exposed or concerned: Get medical advice/attention
P370 + P378 - In case of fire: Use water spray for extinction

Storage
P403 + P235 - Store in a well-ventilated place. Keep cool
P405 - Store locked up

Disposal
P501 - Dispose of contents/container in accordance with local/regional/national/international regulations

Contains

Substances	CAS Number
Hydrotreated light petroleum distillate	64742-47-8
Ethanol	64-17-5
Fatty acids, tall-oil, ethoxylated	61791-00-2
C12-C15 Ethoxylated alcohols	68131-39-5
Amides, tall-oil fatty, N,N-bis(hydroxyethyl)	68155-20-4
Butyl alcohol	71-36-3

Methanol 67-56-1

Other hazards which do not result in classification
None known

For the full text of the H-phrases mentioned in this Section, see Section 16

3. Composition/information on Ingredients

Substances	CAS Number	PERCENT (w/w)	GHS Classification - Australia
Hydrotreated light petroleum distillate	64742-47-8	10 - 30%	Asp. Tox. 1 (H304)
Ethanol	64-17-5	10 - 30%	Eye Irrit. 2A (H319) Flam. Liq. 2 (H225)
Fatty acids, tall-oil, ethoxylated	61791-00-2	10 - 30%	Skin Irrit. 2 (H315) Eye Irrit. 2A (H319)
C12-C15 Ethoxylated alcohols	68131-39-5	10 - 30%	Acute Tox. 4 (H302) Skin Irrit. 2 (H315) Eye Corr. 1 (H318) Aquatic Acute 1 (H400) Aquatic Chronic 3 (H412)
Amides, tall-oil fatty, N,N-bis(hydroxyethyl)	68155-20-4	10 - 30%	Skin Irrit. 2 (H315) Eye Corr. 1 (H318) Aquatic Acute 2 (H401) Aquatic Chronic 3 (H412)
Butyl alcohol	71-36-3	5 - 10%	Acute Tox. 4 (H302) Skin Irrit. 2 (H315) Eye Corr. 1 (H318) STOT SE 3 (H335) Flam. Liq. 3 (H226)
Methanol	67-56-1	0.1 - 1%	Acute Tox. 3 (H301) Acute Tox. 3 (H311) Acute Tox. 3 (H331) Repr. 1B (H360) STOT SE 1 (H370) Flam. Liq. 2 (H225)

4. First aid measures

Description of necessary first aid measures

Inhalation If inhaled, remove from area to fresh air. Get medical attention if respiratory irritation develops or if breathing becomes difficult.

Eyes In case of contact, immediately flush eyes with plenty of water for at least 30 minutes. Remove contact lenses after the first 5 minutes and continue washing. Seek immediate medical attention/advice. Suitable emergency eye wash facility should be immediately available

Skin In case of contact, immediately flush skin with plenty of soap and water for at least 15 minutes. Get medical attention.

Ingestion Get medical attention! If vomiting occurs, keep head lower than hips to prevent aspiration. Rinse mouth. Never give anything by mouth to an unconscious person. Following ingestion, onset of symptoms may be delayed by 12 to 24 hours. Admission to hospital should be the first priority even if symptoms are absent.

Symptoms caused by exposure

Causes severe eye irritation which may damage tissue. Causes skin irritation. Aspiration into the lungs may cause chemical pneumonitis including coughing, difficulty breathing, wheezing, coughing up blood and pneumonia, which can be fatal. Potential reproductive hazard. May cause birth defects.

Medical Attention and Special Treatment

Notes to Physician Treat symptomatically

5. Fire Fighting Measures

Suitable extinguishing equipment

Suitable Extinguishing Media

Water fog, carbon dioxide, foam, dry chemical.

Extinguishing media which must not be used for safety reasons

Do NOT spray pool fires directly with water. A solid stream of water directed into hot burning liquid can cause splattering.

Specific hazards arising from the chemical

Special exposure hazards in a fire

Decomposition in fire may produce harmful gases.

Special protective equipment and precautions for fire fighters

Special protective equipment for firefighters

Full protective clothing and approved self-contained breathing apparatus required for fire fighting personnel.

6. Accidental release measures

6.1. Personal precautions, protective equipment and emergency procedures

Ensure adequate ventilation. Use appropriate protective equipment. Remove sources of ignition. Take precautionary measures against static discharges All equipment used when handling the product must be grounded Avoid contact with skin, eyes and clothing.

6.2. Environmental precautions

Prevent from entering sewers, waterways, or low areas.

6.3. Methods and material for containment and cleaning up

Dike far ahead of liquid spill for later disposal. Soak up with inert absorbent material. Pick up and transfer to properly labeled containers. Remove ignition sources and work with non-sparking tools.

7. Handling and storage

7.1. Precautions for safe handling

Handling Precautions

Ensure adequate ventilation. Use appropriate protective equipment. Remove sources of ignition. Ground and bond containers when transferring from one container to another. Avoid contact with eyes, skin, or clothing.

Hygiene Measures

Handle in accordance with good industrial hygiene and safety practice.

7.2. Conditions for safe storage, including any incompatibilities

Storage Information

Store in a cool well ventilated area. Keep from heat, sparks, and open flames.

Other Guidelines

No information available

8. Exposure Controls/Personal Protection

Control parameters - exposure standards, biological monitoring

Exposure Limits

Substances	CAS Number	Australia NOHSC	ACGIH TLV-TWA
Hydrotreated light petroleum distillate	64742-47-8	Not applicable	Not applicable
Ethanol	64-17-5	TWA: 1000 ppm TWA: 1880 mg/m^3	STEL: 1000 ppm
Fatty acids, tall-oil, ethoxylated	61791-00-2	Not applicable	Not applicable
C12-C15 Ethoxylated alcohols	68131-39-5	Not applicable	Not applicable
Amides, tall-oil fatty, N,N-bis(hydroxyethyl)	68155-20-4	Not applicable	Not applicable
Butyl alcohol	71-36-3	50 ppm	TWA: 20 ppm

Methanol	67-56-1	TWA: 200 ppm TWA: 262 mg/m^3 STEL: 250 ppm STEL: 328 mg/m^3	TWA: 200 ppm STEL: 250 ppm

Appropriate engineering controls

Engineering Controls Ensure adequate ventilation, especially in confined areas

Personal protective equipment (PPE)

Personal Protective Equipment If engineering controls and work practices cannot prevent excessive exposures, the selection and proper use of personal protective equipment should be determined by an industrial hygienist or other qualified professional based on the specific application of this product.

Respiratory Protection If engineering controls and work practices cannot keep exposure below occupational exposure limits or if exposure is unknown, wear a NIOSH certified, European Standard EN 149, AS/NZS 1715:2009, or equivalent respirator when using this product. Selection of and instruction on using all personal protective equipment, including respirators, should be performed by an Industrial Hygienist or other qualified professional.
Organic vapor respirator.

Hand Protection Use gloves which are suitable for the chemicals present in this product as well as other environmental factors in the workplace.

Skin Protection Wear impervious protective clothing, including boots, gloves, lab coat, apron, rain jacket, pants or coverall, as appropriate, to prevent skin contact.

Eye Protection Chemical goggles; also wear a face shield if splashing hazard exists.

Other Precautions Eyewash fountains and safety showers must be easily accessible.

Environmental Exposure Controls No information available

9. Physical and Chemical Properties

9.1. Information on basic physical and chemical properties

Physical State: Liquid
Color Colorless to Light Amber
Odor: Mild hydrocarbon
Odor Threshold: No information available

Property Remarks/ - Method	Values
pH:	No data available
Freezing Point / Range	-44.2 °C
Melting Point / Range	No data available
Boiling Point / Range	No data available
Flash Point	34 °C / 93.2 °F
Evaporation rate	No data available
Vapor Pressure	No data available
Vapor Density	No data available
Specific Gravity	0.918
Water Solubility	No data available
Solubility in other solvents	No data available
Partition coefficient: n-octanol/water	No data available
Autoignition Temperature	No data available
Decomposition Temperature	No data available
Viscosity	No data available
Explosive Properties	No information available
Oxidizing Properties	No information available

9.2. Other information

VOC Content (%) No data available

10. Stability and Reactivity

10.1. Reactivity

Not expected to be reactive.

10.2. Chemical stability
Stable
10.3. Possibility of hazardous reactions
Will Not Occur
10.4. Conditions to avoid
Keep away from heat, sparks and flame.
10.5. Incompatible materials
Strong oxidizers. Strong acids. Strong alkalis.
10.6. Hazardous decomposition products
Carbon oxides. Oxides of nitrogen.

11. Toxicological Information

Information on routes of exposure
Principle Route of Exposure Skin contact. Eye contact. Inhalation.

Symptoms related to exposure
Most Important Symptoms/Effects
Causes severe eye irritation which may damage tissue. Causes skin irritation. Aspiration into the lungs may cause chemical pneumonitis including coughing, difficulty breathing, wheezing, coughing up blood and pneumonia, which can be fatal. Potential reproductive hazard. May cause birth defects.

Toxicology data for the components

Substances	CAS Number	LD50 Oral	LD50 Dermal	LC50 Inhalation
Hydrotreated light petroleum distillate	64742-47-8	>5000 mg/kg-bw (rat) (similar substance)	>2000 mg/kg-bw (rabbit) (similar substance)	>5.2 mg/L (rat, 4 h, vapor) (similar substance)
Ethanol	64-17-5	7060 mg/kg (Rat) 10,470 mg/kg (Rat)	> 15,800 mg/kg (Rabbit) 17,100 mg/kg (Rabbit)	124.7 mg/L (Rat) 4h
Fatty acids, tall-oil, ethoxylated	61791-00-2	> 6400 mg/kg (Rat)	No data available	No data available
C12-C15 Ethoxylated alcohols	68131-39-5	2 g/kg (Rat) 1600 mg/kg (Rat) > 5000 mg/kg (Rat)	> 2000 mg/kg (Rat) 2500 mg/kg (Rabbit)	No data available
Amides, tall-oil fatty, N,N-bis(hydroxyethyl)	68155-20-4	3500 mg/kg (Rat) > 5000 mg/kg (Rat)	> 2000 mg/kg (Rabbit)	> 0.219 mg/L (Mouse) 4h (similar substance)
Butyl alcohol	71-36-3	790 mg/kg (Rat)	3400 mg/kg (Rabbit)	> 17.6 mg/L (Rat) 4h
Methanol	67-56-1	300 mg/kg-bw (human) < 790 to 13,000 mg/kg (rat)	1000 mg/kg-bw (human) 17,100 mg/kg (rabbit)	10 mg/L (human, 4h, vapor)

Immediate, delayed and chronic health effects from exposure
Inhalation May cause central nervous system depression including headache, dizziness, drowsiness, incoordination, slowed reaction time, slurred speech, giddiness and unconsciousness.
Eye Contact Causes severe eye irritation which may damage tissue.
Skin Contact Causes skin irritation.
Ingestion Aspiration into the lungs may cause chemical pneumonitis including coughing, difficulty breathing, wheezing, coughing up blood and pneumonia, which can be fatal. Ingestion of this product may cause blindness due to the presence of methanol.

Chronic Effects/Carcinogenicity Prolonged or repeated exposure may cause reproductive system damage. May cause birth defects.

Exposure Levels
No data available

Interactive effects
No data available

Data limitations
No data available

Substances	CAS Number	Skin corrosion/irritation
Hydrotreated light petroleum distillate	64742-47-8	Non-irritating to the skin (similar substances)
Ethanol	64-17-5	Not irritating to skin in rabbits.
Fatty acids, tall-oil, ethoxylated	61791-00-2	Irritating to skin.
C12-C15 Ethoxylated alcohols	68131-39-5	May cause moderate skin irritation. (Rabbit)
Amides, tall-oil fatty, N,N-bis(hydroxyethyl)	68155-20-4	Skin, rabbit: Causes moderate skin irritation. (similar substances)
Butyl alcohol	71-36-3	Causes moderate skin irritation.
Methanol	67-56-1	Non-irritating to the skin (Rabbit)

Substances	CAS Number	Serious eye damage/irritation
Hydrotreated light petroleum distillate	64742-47-8	Non-irritating to rabbit's eye (similar substances)
Ethanol	64-17-5	Causes moderate eye irritation (Rabbit)
Fatty acids, tall-oil, ethoxylated	61791-00-2	Irritating to eyes
C12-C15 Ethoxylated alcohols	68131-39-5	Risk of serious damage to eyes (Rabbit) (similar substances)
Amides, tall-oil fatty, N,N-bis(hydroxyethyl)	68155-20-4	Causes severe eye irritation (similar substances)
Butyl alcohol	71-36-3	Causes severe eye irritation
Methanol	67-56-1	Non-irritating to the eye (Rabbit)

Substances	CAS Number	Skin Sensitization
Hydrotreated light petroleum distillate	64742-47-8	Did not cause sensitization on laboratory animals (guinea pig) (similar substances)
Ethanol	64-17-5	Did not cause sensitization on laboratory animals
Fatty acids, tall-oil, ethoxylated	61791-00-2	No information available
C12-C15 Ethoxylated alcohols	68131-39-5	Did not cause sensitization on laboratory animals (guinea pig)
Amides, tall-oil fatty, N,N-bis(hydroxyethyl)	68155-20-4	Did not cause sensitization on laboratory animals (similar substances)
Butyl alcohol	71-36-3	Not confirmed to cause skin or respiratory sensitization.
Methanol	67-56-1	Did not cause sensitization on laboratory animals (guinea pig)

Substances	CAS Number	Respiratory Sensitization
Hydrotreated light petroleum distillate	64742-47-8	No information available
Ethanol	64-17-5	Did not cause sensitization on laboratory animals
Fatty acids, tall-oil, ethoxylated	61791-00-2	No information available
C12-C15 Ethoxylated alcohols	68131-39-5	No information available
Amides, tall-oil fatty, N,N-bis(hydroxyethyl)	68155-20-4	No information available
Butyl alcohol	71-36-3	No information available
Methanol	67-56-1	No information available

Substances	CAS Number	Mutagenic Effects
Hydrotreated light petroleum distillate	64742-47-8	In vitro tests did not show mutagenic effects. In vivo tests did not show mutagenic effects. (similar substances)
Ethanol	64-17-5	Not regarded as mutagenic.
Fatty acids, tall-oil, ethoxylated	61791-00-2	No information available
C12-C15 Ethoxylated alcohols	68131-39-5	In vivo tests did not show mutagenic effects. In vitro tests did not show mutagenic effects.
Amides, tall-oil fatty, N,N-bis(hydroxyethyl)	68155-20-4	In vitro tests did not show mutagenic effects. In vivo tests did not show mutagenic effects. (similar substances)
Butyl alcohol	71-36-3	In vitro tests did not show mutagenic effects.
Methanol	67-56-1	The weight of evidence from available in vitro and in vivo studies indicates that this substance is not expected to be mutagenic.

Substances	CAS Number	Carcinogenic Effects

Hydrotreated light petroleum distillate	64742-47-8	Did not show carcinogenic effects in animal experiments (similar substances)
Ethanol	64-17-5	Did not show carcinogenic effects in animal experiments
Fatty acids, tall-oil, ethoxylated	61791-00-2	No information available
C12-C15 Ethoxylated alcohols	68131-39-5	Did not show carcinogenic effects in animal experiments
Amides, tall-oil fatty, N,N-bis(hydroxyethyl)	68155-20-4	Not regarded as carcinogenic.
Butyl alcohol	71-36-3	No information available
Methanol	67-56-1	No data of sufficient quality are available.

Substances	**CAS Number**	**Reproductive toxicity**
Hydrotreated light petroleum distillate	64742-47-8	Animal testing did not show any effects on fertility. Did not show teratogenic effects in animal experiments. (similar substances)
Ethanol	64-17-5	Animal testing did not show any effects on fertility.
Fatty acids, tall-oil, ethoxylated	61791-00-2	No information available
C12-C15 Ethoxylated alcohols	68131-39-5	No significant toxicity observed in animal studies at concentration requiring classification.
Amides, tall-oil fatty, N,N-bis(hydroxyethyl)	68155-20-4	Not a confirmed teratogen or embryotoxin.
Butyl alcohol	71-36-3	Animal testing did not show any effects on fertility. Did not show teratogenic effects in animal experiments.
Methanol	67-56-1	Experiments have shown reproductive toxicity effects on laboratory animals

Substances	**CAS Number**	**STOT - single exposure**
Hydrotreated light petroleum distillate	64742-47-8	No significant toxicity observed in animal studies at concentration requiring classification.
Ethanol	64-17-5	No significant toxicity observed in animal studies at concentration requiring classification.
Fatty acids, tall-oil, ethoxylated	61791-00-2	No information available
C12-C15 Ethoxylated alcohols	68131-39-5	No significant toxicity observed in animal studies at concentration requiring classification. (similar substances)
Amides, tall-oil fatty, N,N-bis(hydroxyethyl)	68155-20-4	No significant toxicity observed in animal studies at concentration requiring classification.
Butyl alcohol	71-36-3	May cause respiratory irritation.
Methanol	67-56-1	May cause disorder and damage to the Central Nervous System (CNS)

Substances	**CAS Number**	**STOT - repeated exposure**
Hydrotreated light petroleum distillate	64742-47-8	No significant toxicity observed in animal studies at concentration requiring classification. (similar substances)
Ethanol	64-17-5	No significant toxicity observed in animal studies at concentration requiring classification.
Fatty acids, tall-oil, ethoxylated	61791-00-2	No information available
C12-C15 Ethoxylated alcohols	68131-39-5	No significant toxicity observed in animal studies at concentration requiring classification. (similar substances)
Amides, tall-oil fatty, N,N-bis(hydroxyethyl)	68155-20-4	No significant toxicity observed in animal studies at concentration requiring classification.
Butyl alcohol	71-36-3	No significant toxicity observed in animal studies at concentration requiring classification.
Methanol	67-56-1	No data of sufficient quality are available.

Substances	**CAS Number**	**Aspiration hazard**
Hydrotreated light petroleum distillate	64742-47-8	Aspiration into the lungs may cause chemical pneumonitis including coughing, difficulty breathing, wheezing, coughing up blood and pneumonia, which can be fatal.
Ethanol	64-17-5	Not applicable
Fatty acids, tall-oil, ethoxylated	61791-00-2	Not applicable
C12-C15 Ethoxylated alcohols	68131-39-5	No adverse health effects are expected from swallowing.
Amides, tall-oil fatty, N,N-bis(hydroxyethyl)	68155-20-4	No information available
Butyl alcohol	71-36-3	Aspiration into the lungs may cause chemical pneumonitis including coughing, difficulty breathing, wheezing, coughing up blood and pneumonia, which can be fatal.
Methanol	67-56-1	Not applicable

12. Ecological Information

Ecotoxicity

Product Ecotoxicity Data

Product is not classified as hazardous to the environment.

Substance Ecotoxicity Data

Substances	CAS Number	Toxicity to Algae	Toxicity to Fish	Toxicity to Microorganisms	Toxicity to Invertebrates
Hydrotreated light petroleum distillate	64742-47-8	ErL50(72 h)>10000 mg/L (Skeletonema costatum)	LC50(96 h)>10000 mg/L (Scophthalmus maximus) NOELC(28 d)>1000 mg/L (fish)	No information available	LC50(48 h)>10000 mg/L (Acartia tonsa) NOEC(21 d)=1000 mg/L (Daphnia magna)
Ethanol	64-17-5	No information available	LC50 > 100 mg/L (Pimephales promelas)	No information available	LC50 9268 - 14,221 mg/L (Daphnia magna) LC50 5012 mg/L (Ceridaphnia dubia) NOEC 9.6 mg/L (Daphnia magna)
Fatty acids, tall-oil, ethoxylated	61791-00-2	EC50 (72h) > 44 mg/L EC50 (72h) 2.5 mg/L (Skeletonema costatum)	LC50 (95h) 7.8 mg/L (Brachydanio rerio) LC50 (96h) 45 mg/L (Cyprinodon variegatus)	EC20 (180m) >1000 mg/L	EC50 (48h) 16 mg/L (Daphnia magna) EC50 (48h) 26.8 mg/L (Acartia tonsa)
C12-C15 Ethoxylated alcohols	68131-39-5	No information available	EC50 (48h) 0.39 mg/L (Ceriodaphnia dubia) NOEC (30d) 0.28 mg/L (Pimephales promelas) NOEC (16d) 0.16 mg/L(Lepomis macrochirus)	No information available	No information available
Amides, tall-oil fatty, N,N-bis(hydroxyethyl)	68155-20-4	EC50 (72h) 2.2 mg/L (Scendesmus subspicatus) (similar substance)	LC50 (96h) 6.7 mg/L (Danio rerio) (similar substance)	No information available	LC50 (21d) = 0.1 mg/L (Daphnia magna) LC50 (48h) = 2.15 mg/L
Butyl alcohol	71-36-3	EC50 (96h) 225 mg/L (Pseudokirchnerella subcapitata)	LC50 (96h) 1376 mg/L (Pimephales promelas)	No information available	EC50 (48h) 1328 mg/L (Daphnia magna) NOEC (21d) 4.1 mg/L (Daphnia magna) EC50 (21d) 18 mg/L (Daphnia magna)
Methanol	67-56-1	EC50 (96 h) =22000 mg/L (Pseudokirchnerella subcapitata) NOEC (8 d) =8000 mg/L (Scenedesmus quadricauda)	LC50 (96 h) =15400 mg/L (Lepomis macrochirus) EC50 (200 h) =14536 mg/L (Oryzias latipes)	IC50 (3h) > 1000 mg/L (activated sludge)	EC50 (96 h) =18260 mg/L (Dapnia magna) NOEC (21 d) =208 mg/L (Dapnia magna)

12.2. Persistence and degradability

Substances	CAS Number	Persistence and Degradability
Hydrotreated light petroleum distillate	64742-47-8	Readily biodegradable (68.1% @ 28d)
Ethanol	64-17-5	No information available
Fatty acids, tall-oil, ethoxylated	61791-00-2	Readily biodegradable (74% @ 28d)
C12-C15 Ethoxylated alcohols	68131-39-5	Readily biodegradable
Amides, tall-oil fatty, N,N-bis(hydroxyethyl)	68155-20-4	Readily biodegradable (77% @ 28d)
Butyl alcohol	71-36-3	Biodegradable. (92% @ 20d)
Methanol	67-56-1	Readily biodegradable (95% @ 20d)

12.3. Bioaccumulative potential

Substances	CAS Number	Log Pow
Hydrotreated light petroleum distillate	64742-47-8	No information available
Ethanol	64-17-5	-0.32
Fatty acids, tall-oil, ethoxylated	61791-00-2	MW > 700
C12-C15 Ethoxylated alcohols	68131-39-5	3
Amides, tall-oil fatty, N,N-bis(hydroxyethyl)	68155-20-4	3.2 (estimated)

Butyl alcohol	71-36-3	1
Methanol	67-56-1	Not Bioaccumulative; BCF=1

12.4. Mobility in soil

Substances	CAS Number	Mobility
Hydrotreated light petroleum distillate	64742-47-8	No information available
Ethanol	64-17-5	No information available
Fatty acids, tall-oil, ethoxylated	61791-00-2	No information available
C12-C15 Ethoxylated alcohols	68131-39-5	No information available
Amides, tall-oil fatty, N,N-bis(hydroxyethyl)	68155-20-4	No information available
Butyl alcohol	71-36-3	KOC = 72
Methanol	67-56-1	No information available

12.6. Other adverse effects

Endocrine Disruptor Information

This product does not contain any known or suspected endocrine disruptors

13. Disposal Considerations

Safe handling and disposal methods

Disposal should be made in accordance with federal, state, and local regulations.

Disposal of any contaminated packaging

Follow all applicable national or local regulations.

Environmental regulations

Not applicable

14. Transport Information

Transportation Information

Australia ADG

UN Number UN1993
UN proper shipping name: Flammable Liquid, N.O.S. (Contains Ethanol, Butanol)
Transport Hazard Class(es): 3
Packing Group: III
Environmental Hazards: Not applicable

IMDG/IMO

UN Number UN1993
UN proper shipping name: Flammable Liquid, N.O.S. (Contains Ethanol, Butanol)
Transport Hazard Class(es): 3
Packing Group: III
Environmental Hazards: Not applicable

IATA/ICAO

UN Number UN1993
UN proper shipping name: Flammable Liquid, N.O.S. (Contains Ethanol, Butanol)
Transport Hazard Class(es): 3
Packing Group: III
Environmental Hazards: Not applicable

Special precautions during transport

None

HazChem Code

•3Y

15. Regulatory Information

Safety, health and environmental regulations specific for the product

International Inventories

Australian AICS Inventory	All components are listed on the AICS or are subject to a relevant exemption, permit, or assessment certificate.
New Zealand Inventory of Chemicals	All components are listed on the NZIoC or are subject to a relevant exemption, permit, or assessment certificate.
EINECS (European Inventory of Existing Chemical Substances)	This product does not comply with EINECS
US TSCA Inventory	All components listed on inventory or are exempt.
Canadian Domestic Substances List (DSL)	All components listed on inventory or are exempt.

Poisons Schedule number

None Allocated

International Agreements

Montreal Protocol - Ozone Depleting Substances:	Does not apply
Stockholm Convention - Persistent Organic Pollutants:	Does not apply
Rotterdam Convention - Prior Informed Consent:	Does not apply
Basel Convention - Hazardous Waste:	Does not apply

16. Other information

Date of preparation or review

Revision Date: 31-Aug-2017

Revision Note

SDS sections updated:
2

Full text of H-Statements referred to under sections 2 and 3

H225 - Highly flammable liquid and vapor
H226 - Flammable liquid and vapor
H301 - Toxic if swallowed
H302 - Harmful if swallowed
H304 - May be fatal if swallowed and enters airways
H311 - Toxic in contact with skin
H315 - Causes skin irritation
H318 - Causes serious eye damage
H319 - Causes serious eye irritation
H331 - Toxic if inhaled
H335 - May cause respiratory irritation
H360 - May damage fertility or the unborn child
H370 - Causes damage to organs
H400 - Very toxic to aquatic life
H401 - Toxic to aquatic life
H412 - Harmful to aquatic life with long lasting effects

Additional information

For additional information on the use of this product, contact your local Halliburton representative.

For questions about the Safety Data Sheet for this or other Halliburton products, contact Chemical Stewardship at 1-580-251-4335.

Key abreviations or acronyms used

bw – body weight
CAS – Chemical Abstracts Service
EC50 – Effective Concentration 50%
LC50 – Lethal Concentration 50%

LD50 – Lethal Dose 50%
LL50 – Lethal Loading 50%
mg/kg – milligram/kilogram
mg/L – milligram/liter
NOEC – No Observed Effect Concentration
OEL – Occupational Exposure Limit
PBT – Persistent Bioaccumulative and Toxic
ppm – parts per million
STEL – Short Term Exposure Limit
TWA – Time-Weighted Average
vPvB – very Persistent and very Bioaccumulative
h - hour
mg/m^3 - milligram/cubic meter
mm - millimeter
mmHg - millimeter mercury
w/w - weight/weight
d - day

Key literature references and sources for data
www.ChemADVISOR.com/

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End of Safety Data Sheet

HALLIBURTON

SAFETY DATA SHEET

DCA-2120875

Revision Date: 25-Jun-2015 **Revision Number:** 3

1. Product Identifier & Identity for the Chemical

Statement of Hazardous Nature Non-Hazardous according to the criteria of the 3rd Revised Edition of the Globally Harmonised System of Classification and Labelling of Chemicals (GHS), Non-Dangerous Goods according to the criteria of ADG.

1.1. Product Identifier

Product Name DCA-2120875

Other means of Identification

Synonyms: None

Product Code: HM008041

Recommended use of the chemical and restrictions on use

Recommended Use Diverter

Uses Advised Against No information available

Supplier's name, address and phone number

Manufacturer/Supplier

Halliburton/Baroid Australia Pty. Ltd.
15 Marriott Road
Jandakot
WA 6164
Australia

ACN Number: 009 000 775
Telephone Number: 61 (08) 9455 8300
Fax Number: 61 (08) 9455 5300

Product Emergency Telephone
Australia: + 61 1 800 686 951
Papua New Guinea: + 61 1 800 686 951
NewZealand: +64 800 451719

Fire, Police & Ambulance - Emergency Telephone
Australia: 000
Papua New Guinea: 000
New Zealand: 111

E-Mail address: fdunexchem@halliburton.com

Emergency phone number

+ 61 1 800 686 951

Australian Poisons Information Centre
24 Hour Service: - 13 11 26
Police or Fire Brigade: - 000 (exchange): - 1100

2. Hazard Identification

Statement of Hazardous Nature Non-Hazardous according to the criteria of the 3rd Revised Edition of the Globally Harmonised System of Classification and Labelling of Chemicals (GHS), Non-Dangerous Goods according to the criteria of ADG.

Classification of the hazardous chemical

Not classified

Label elements, including precautionary statements

Hazard Pictograms

Signal Word	Not Hazardous
Hazard Statements	Not Classified
Precautionary Statements	
Prevention	None
Response	None
Storage	None
Disposal	None

Contains Substances	**CAS Number**
Contains no hazardous substances in concentrations above cut-off values according to the competent authority	NA

Other hazards which do not result in classification

None known

Australia Classification

For the full text of the H-phrases mentioned in this Section, see Section 16

Classification	Not Classified
Risk Phrases	None

3. Composition/information on Ingredients

Substances	CAS Number	PERCENT (w/w)	GHS Classification - Australia
Contains no hazardous substances in concentrations above cut-off values according to the competent authority	NA	60 - 100%	Not Applicable

4. First aid measures

Description of necessary first aid measures

Inhalation	If inhaled, remove from area to fresh air. Get medical attention if respiratory irritation develops or if breathing becomes difficult.
Eyes	In case of contact, immediately flush eyes with plenty of water for at least 15 minutes and get medical attention if irritation persists.
Skin	Wash with soap and water. Get medical attention if irritation persists.
Ingestion	Do NOT induce vomiting. Give nothing by mouth. Obtain immediate medical attention.

Symptoms caused by exposure

No significant hazards expected.

Medical Attention and Special Treatment

Notes to Physician	Treat symptomatically

5. Fire Fighting Measures

Suitable extinguishing equipment

Suitable Extinguishing Media

Water fog, carbon dioxide, foam, dry chemical.

Extinguishing media which must not be used for safety reasons

None known.

Specific hazards arising from the chemical

Special Exposure Hazards

Decomposition in fire may produce harmful gases.

Special protective equipment and precautions for fire fighters

Special Protective Equipment for Fire-Fighters

Full protective clothing and approved self-contained breathing apparatus required for fire fighting personnel.

6. Accidental release measures

6.1. Personal precautions, protective equipment and emergency procedures

Use appropriate protective equipment. Slippery when wet.

6.2. Environmental precautions

Prevent from entering sewers, waterways, or low areas.

6.3. Methods and material for containment and cleaning up

Scoop up and remove.

7. Handling and storage

7.1. Precautions for Safe Handling

Handling Precautions

Avoid contact with eyes, skin, or clothing. Avoid creating or inhaling dust. Avoid dust accumulations.

Hygiene Measures

Handle in accordance with good industrial hygiene and safety practice.

7.2. Conditions for safe storage, including any incompatibilities

Storage Information

Use good housekeeping in storage and work areas to prevent accumulation of dust. Close container when not in use. Store between 40.5 F (4.7 C) and 120.5 F (49 C). Store away from oxidizers. Store in a cool, dry location. Product has a shelf life of 12 months.

Other Guidelines

No information available

8. Exposure Controls/Personal Protection

Control parameters - exposure standards, biological monitoring

Exposure Limits

Substances	CAS Number	Australia NOHSC	ACGIH TLV-TWA
Contains no hazardous substances in concentrations above cut-off values according to the competent authority	NA	Not applicable	Not applicable

Appropriate engineering controls

Engineering Controls Use in a well ventilated area.

Personal protective equipment (PPE)

Respiratory Protection Not normally needed. But if significant exposures are possible then the following respirator

	is recommended:
	Dust/mist respirator. (N95, P2/P3)
Hand Protection	Normal work gloves.
Skin Protection	Normal work coveralls.
Eye Protection	Wear safety glasses or goggles to protect against exposure.
Other Precautions	None known.
Environmental Exposure Controls	No information available

9. Physical and Chemical Properties

9.1. Information on basic physical and chemical properties

Physical State:	Beads	**Color:**	Green
Odor:	Odorless - Acidic	**Odor Threshold:**	No information available

Property Remarks/ - Method	Values
pH:	6-8
Freezing Point/Range	150-230 °C
Melting Point/Range	No data available
Boiling Point/Range	No data available
Flash Point	No data available
Evaporation rate	No data available
Vapor Pressure	No data available
Vapor Density	No data available
Specific Gravity	1.16 - 1.20
Water Solubility	Insoluble in water
Solubility in other solvents	No data available
Partition coefficient: n-octanol/water	No data available
Autoignition Temperature	300 °C / 572 °F
Decomposition Temperature	No data available
Viscosity	No data available
Explosive Properties	No information available
Oxidizing Properties	No information available

9.2. Other information

VOC Content (%)	No data available

10. Stability and Reactivity

10.1. Reactivity
Not expected to be reactive.
10.2. Chemical Stability
Stable
10.3. Possibility of Hazardous Reactions
Will Not Occur
10.4. Conditions to Avoid
Temperature over 440 F (240 C).
10.5. Incompatible Materials
Strong oxidizers. Strong alkalis.
10.6. Hazardous Decomposition Products
Toxic fumes. Aldehydes. Carbon monoxide and carbon dioxide.

11. Toxicological Information

Information on routes of exposure
Principle Route of Exposure Eye or skin contact, inhalation.

Sympotoms related to exposure
Most Important Symptoms/Effects
No significant hazards expected.

Numerical measures of toxicity

LD50 Oral: No information available.
LD50 Dermal: No information available.

Toxicology data for the components

Substances	CAS Number	LD50 Oral	LD50 Dermal	LC50 Inhalation
Contains no hazardous substances in concentrations above cut-off values according to the competent authority	NA	No data available	No data available	No data available

Immediate, delayed and chronic health effects from exposure

Inhalation None known.
Eye Contact None known.
Skin Contact None known.
Ingestion May cause abdominal pain, vomiting, nausea, and diarrhea.

Chronic Effects/Carcinogenicity No data available to indicate product or components present at greater than 0.1% are chronic health hazards.

Exposure Levels

No data available

Interactive effects

None known.

Data limitations

No data available

12. Ecological Information

Ecotoxicity

Product Ecotoxicity Data
No data available

Substance Ecotoxicity Data

Substances	CAS Number	Toxicity to Algae	Toxicity to Fish	Toxicity to Microorganisms	Toxicity to Invertebrates
Contains no hazardous substances in concentrations above cut-off values according to the competent authority	NA	No information available	No information available	No information available	No information available

12.2. Persistence and degradability

Expected to be biodegradable

Substances	CAS Number	Persistence and Degradability

Contains no hazardous substances in concentrations above cut-off values according to the competent authority	NA	No information available

12.3. Bioaccumulative potential

Does not bioaccumulate

Substances	CAS Number	Log Pow
Contains no hazardous substances in concentrations above cut-off values according to the competent authority	NA	No information available

12.4. Mobility in soil

Substances	CAS Number	Mobility
Contains no hazardous substances in concentrations above cut-off values according to the competent authority	NA	No information available

12.6. Other adverse effects

Endocrine Disruptor Information

This product does not contain any known or suspected endocrine disruptors

13. Disposal Considerations

Safe handling and disposal methods

Bury in a licensed landfill according to federal, state, and local regulations.

Disposal of any contaminated packaging

Follow all applicable national or local regulations.

Environmental regulations

Not applicable

14. Transport Information

Transportation Information

UN Number: Not restricted
UN Proper Shipping Name: Not restricted
Transport Hazard Class(es): Not applicable
Packing Group: Not applicable
Environmental Hazards: Not applicable

Special precautions during transport

None

HazChem Code

None Allocated

15. Regulatory Information

Safety, health and environmental regulations specific for the product

International Inventories

Australian AICS Inventory All components listed on inventory or are exempt.
New Zealand Inventory of Chemicals All components listed on inventory or are exempt.
EINECS Inventory This product, and all its components, complies with EINECS
US TSCA Inventory All components listed on inventory or are exempt.
Canadian DSL Inventory All components listed on inventory or are exempt.

Poisons Schedule number

None Allocated

16. Other information

Date of preparation or review

Revision Date: 25-Jun-2015

Revision Note
SDS sections updated: 2

Full text of R-phrases referred to under Sections 2 and 3
None

Full text of H-Statements referred to under sections 2 and 3
None

Additional information

For additional information on the use of this product, contact your local Halliburton representative.

For questions about the Safety Data Sheet for this or other Halliburton products, contact Chemical Stewardship at 1-580-251-4335.

Key abreviations or acronyms used
bw – body weight
CAS – Chemical Abstracts Service
EC50 – Effective Concentration 50%
LC50 – Lethal Concentration 50%
LD50 – Lethal Dose 50%
LL50 – Lethal Loading 50%
mg/kg – milligram/kilogram
mg/L – milligram/liter
NOEC – No Observed Effect Concentration
OEL – Occupational Exposure Limit
PBT – Persistent Bioaccumulative and Toxic
ppm – parts per million
STEL – Short Term Exposure Limit
TWA – Time-Weighted Average
vPvB – very Persistent and very Bioaccumulative
h - hour
mg/m^3 - milligram/cubic meter
mm - millimeter
mmHg - millimeter mercury
w/w - weight/weight
d - day

Key literature references and sources for data
www.ChemADVISOR.com/

Disclaimer Statement
This information is furnished without warranty, expressed or implied, as to accuracy or completeness. The information is obtained from various sources including the manufacturer and other third party sources. The information may not be valid under all conditions nor if this material is used in combination with other materials or in any process. Final determination of suitability of any material is the sole responsibility of the user.

End of Safety Data Sheet

NALCO Champion
An Ecolab Company

SAFETY DATA SHEET

EC9374A ACID CORROSION INHIBITOR

Section: 1. PRODUCT AND COMPANY IDENTIFICATION

Product name	:	EC9374A ACID CORROSION INHIBITOR
Other means of identification	:	Not applicable.
Recommended use	:	ACID CORROSION INHIBITOR
Restrictions on use	:	Refer to available product literature or ask your local Sales Representative for restrictions on use and dose limits.
Company	:	ECOLAB PTY LTD 2 Drake Avenue Macquarie Park NSW 2113 Australia A.B.N. 59 000 449 990 TEL: 1300 654 224 FAX: +61 2 8870 8680
Emergency telephone number	:	1800 205 506 International: +64 7 958 2372
Issuing date	:	10.06.2016

Section: 2. HAZARDS IDENTIFICATION

GHS Classification

Flammable liquids	:	Category 2
Skin corrosion/irritation	:	Category 1B
Serious eye damage/eye irritation	:	Category 1
Skin sensitization	:	Category 1

GHS Label element

Hazard pictograms :

Signal Word : Danger

Hazard Statements : Highly flammable liquid and vapour.
Causes severe skin burns and eye damage.
May cause an allergic skin reaction.

Precautionary Statements : **Prevention:**
Keep away from heat/sparks/open flames/hot surfaces. - No smoking. Ground/bond container and receiving equipment. Use explosion-proof electrical/ ventilating/ lighting/ equipment. Take precautionary measures against static discharge. Avoid breathing dust/ fume/ gas/ mist/ vapours/ spray. Wear protective gloves/ protective clothing/ eye protection/ face protection. Use only non-sparking tools.
Response:
IF SWALLOWED: Rinse mouth. Do NOT induce vomiting.IF ON SKIN (or hair): Remove/ Take off immediately all contaminated clothing. Rinse skin with water/ shower.IF INHALED: Remove victim to fresh air and keep at rest in a position comfortable for breathing. Immediately call a POISON CENTER or doctor/ physician.IF IN EYES: Rinse cautiously with water for several minutes. Remove

contact lenses, if present and easy to do. Continue rinsing. Immediately call a POISON CENTER or doctor/ physician.
Specific treatment (see supplemental first aid instructions on this label).
Storage:
Store locked up. Store in a well-ventilated place. Keep cool.
Disposal:
Dispose of contents/container to an approved facility in accordance with local, regional, national and international regulations.

Other hazards : None known.

Section: 3. COMPOSITION/INFORMATION ON INGREDIENTS

Pure substance/mixture : Mixture

Chemical Name	CAS-No.	Concentration: (%)
Formic Acid	64-18-6	30 - 60
Aromatic aldehyde	Proprietary	10 - 30
Isopropanol	67-63-0	5 - 10
2-Mercaptoethanol	60-24-2	1 - 5
Methanol	67-56-1	1 - 5

Section: 4. FIRST AID MEASURES

In case of eye contact : Rinse immediately with plenty of water, also under the eyelids, for at least 15 minutes. Remove contact lenses, if present and easy to do. Continue rinsing. Get medical attention immediately.

In case of skin contact : Wash off immediately with plenty of water for at least 15 minutes. Use a mild soap if available. Wash clothing before reuse. Thoroughly clean shoes before reuse. Get medical attention immediately.

If swallowed : Contact the Poison's Information Centre (eg Australia 13 1126; New Zealand 0800 764 766).

Rinse mouth with water. Do NOT induce vomiting. Never give anything by mouth to an unconscious person. Get medical attention immediately.

If inhaled : Remove to fresh air. Treat symptomatically. Get medical attention if symptoms occur.

Protection of first-aiders : In event of emergency assess the danger before taking action. Do not put yourself at risk of injury. If in doubt, contact emergency responders. Use personal protective equipment as required.

Notes to physician : Treat symptomatically.

Most important symptoms and effects, both acute and delayed : See Section 11 for more detailed information on health effects and symptoms.

Section: 5. FIREFIGHTING MEASURES

Suitable extinguishing media : Foam
Carbon dioxide
Dry powder
Other extinguishing agent suitable for Class B fires
For large fires, use water spray or fog, thoroughly drenching the burning material.

Unsuitable extinguishing media	:	None known.
Specific hazards during firefighting	:	Fire Hazard Keep away from heat and sources of ignition. Flash back possible over considerable distance. Beware of vapours accumulating to form explosive concentrations. Vapours can accumulate in low areas.
Hazardous combustion products	:	Decomposition products may include the following materials: Carbon oxides
Special protective equipment for firefighters	:	Use personal protective equipment.
Specific extinguishing methods	:	Use water spray to cool unopened containers. Collect contaminated fire extinguishing water separately. This must not be discharged into drains. Fire residues and contaminated fire extinguishing water must be disposed of in accordance with local regulations.
Hazchem Code	:	●3WE

Section: 6. ACCIDENTAL RELEASE MEASURES

Initial Emergency Response Guide No	:	18
Personal precautions, protective equipment and emergency procedures	:	Ensure adequate ventilation. Remove all sources of ignition. Keep people away from and upwind of spill/leak. Avoid inhalation, ingestion and contact with skin and eyes. When workers are facing concentrations above the exposure limit they must use appropriate certified respirators. Ensure clean-up is conducted by trained personnel only. Refer to protective measures listed in sections 7 and 8.
Environmental precautions	:	Do not allow contact with soil, surface or ground water.
Methods and materials for containment and cleaning up	:	Eliminate all ignition sources if safe to do so. Stop leak if safe to do so. Contain spillage, and then collect with non-combustible absorbent material, (e.g. sand, earth, diatomaceous earth, vermiculite) and place in container for disposal according to local / national regulations (see section 13). Flush away traces with water. For large spills, dike spilled material or otherwise contain material to ensure runoff does not reach a waterway.

Section: 7. HANDLING AND STORAGE

Advice on safe handling	:	Open drum carefully as content may be under pressure. Take necessary action to avoid static electricity discharge (which might cause ignition of organic vapours). Do not ingest. Keep away from fire, sparks and heated surfaces. Do not breathe dust/fume/gas/mist/vapours/spray. Do not get in eyes, on skin, or on clothing. Wash hands thoroughly after handling. Use only with adequate ventilation.
Conditions for safe storage	:	Keep away from heat and sources of ignition. Keep in a cool, well-ventilated place. Keep away from oxidizing agents. Keep out of reach of children. Keep container tightly closed. Store in suitable labeled containers.

Suitable material : The following compatibility data is suggested based on similar product data and/or industry experience: HDPE (high density polyethylene), Stainless Steel 304, Stainless Steel 316L, Hastelloy C-276, PTFE, Perfluoroelastomer

Unsuitable material : The following compatibility data is suggested based on similar product data and/or industry experience: Copper, Ethylene propylene, Mild steel, Polypropylene, Polyethylene, Plexiglass, EPDM, Brass, PVC, Buna-N, Polyurethane, Neoprene, Aluminum, Chlorosulfonated polyethylene rubber, Polytetrafluoroethylene/polypropylene copolymer, Fluoroelastomer

Section: 8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Components with workplace control parameters

Exposure guidelines have not been established for this product. Available exposure limits for the substance(s) are shown below.

Components	CAS-No.	Form of exposure	Permissible concentration	Basis
Formic Acid	64-18-6	TWA	5 ppm 9.4 mg/m3	AU OEL
		VLE	10 ppm 19 mg/m3	AU OEL
Formic Acid	64-18-6	WES-STEL	10 ppm 19 mg/m3	NZ OEL
		WES-TWA	5 ppm 9.4 mg/m3	NZ OEL
Formic Acid	64-18-6	TWA	5 ppm	ACGIH
		STEL	10 ppm	ACGIH
		TWA	5 ppm 9 mg/m3	NIOSH REL
		TWA	5 ppm 9 mg/m3	OSHA Z1
Isopropanol	67-63-0	TWA	400 ppm 983 mg/m3	AU OEL
		VLE	500 ppm 1,230 mg/m3	AU OEL
Isopropanol	67-63-0	WES-TWA	400 ppm 983 mg/m3	NZ OEL
		WES-STEL	500 ppm 1,230 mg/m3	NZ OEL
Isopropanol	67-63-0	TWA	200 ppm	ACGIH
		STEL	400 ppm	ACGIH
		TWA	400 ppm 980 mg/m3	NIOSH REL
		STEL	500 ppm 1,225 mg/m3	NIOSH REL
		TWA	400 ppm 980 mg/m3	OSHA Z1
Heavy Aromatic Naphtha	64742-94-5	TWA	500 ppm 2,000 mg/m3	OSHA Z1
		TWA	200 mg/m3 (as total hydrocarbon vapor)	ACGIH
Methanol	67-56-1	TWA	200 ppm 262 mg/m3	AU OEL
		VLE	250 ppm 328 mg/m3	AU OEL

Methanol	67-56-1	WES-TWA	200 ppm 262 mg/m3	NZ OEL
		WES-STEL	250 ppm 328 mg/m3	NZ OEL
Methanol	67-56-1	TWA	200 ppm	ACGIH
		STEL	250 ppm	ACGIH
		TWA	200 ppm 260 mg/m3	NIOSH REL
		STEL	250 ppm 325 mg/m3	NIOSH REL
		TWA	200 ppm 260 mg/m3	OSHA Z1

Engineering measures : Effective exhaust ventilation system. Maintain air concentrations below occupational exposure standards.

Personal protective equipment

Eye protection : Safety goggles
Face-shield

Hand protection : Wear the following personal protective equipment:
Standard glove type.
Laminate film
Nitrile
Unsupported neoprene
PVC
Natural rubber
Neoprene/natural rubber blend
Gloves should be discarded and replaced if there is any indication of degradation or chemical breakthrough.

Skin protection : Personal protective equipment comprising: suitable protective gloves, safety goggles and protective clothing

Respiratory protection : When workers are facing concentrations above the exposure limit they must use appropriate certified respirators.

Hygiene measures : Handle in accordance with good industrial hygiene and safety practice. Remove and wash contaminated clothing before re-use. Wash face, hands and any exposed skin thoroughly after handling. Provide suitable facilities for quick drenching or flushing of the eyes and body in case of contact or splash hazard.

Section: 9. PHYSICAL AND CHEMICAL PROPERTIES

Appearance : Liquid

Colour : dark brown

Odour : Sharp

Flash point : 13 °C, Method: ASTM D 93, Pensky-Martens closed cup

pH : 3.1, 5 %

Odour Threshold : no data available

Melting point/freezing point : no data available

Initial boiling point and boiling range : 64.4 °C

Evaporation rate	:	no data available
Flammability (solid, gas)	:	no data available
Upper explosion limit	:	no data available
Lower explosion limit	:	no data available
Vapour pressure	:	92.5 mm Hg, (15.6 °C), 118.4 mm Hg, (37.7 °C),
Relative vapour density	:	1.11
Relative density	:	1.11, (15.6 °C),
Density	:	9.26 lb/gal
Water solubility	:	dispersible
Solubility in other solvents	:	no data available
Partition coefficient: n-octanol/water	:	no data available
Auto-ignition temperature	:	no data available
Thermal decomposition temperature	:	no data available
Viscosity, dynamic	:	no data available
Viscosity, kinematic	:	12 mm2/s (40 °C)
Molecular weight	:	no data available
VOC	:	no data available

Section: 10. STABILITY AND REACTIVITY

Chemical stability	:	Stable under normal conditions.
Possibility of hazardous reactions	:	No dangerous reaction known under conditions of normal use.
Conditions to avoid	:	Heat, flames and sparks.
Incompatible materials	:	Strong oxidizing agents
Hazardous decomposition products	:	Decomposition products may include the following materials: Carbon oxides

Section: 11. TOXICOLOGICAL INFORMATION

Information on likely routes of exposure	:	Inhalation, Eye contact, Skin contact

Potential Health Effects

Eyes	:	Causes serious eye damage.
Skin	:	Causes severe skin burns. May cause allergic skin reaction.
Ingestion	:	Causes digestive tract burns.
Inhalation	:	May cause nose, throat, and lung irritation.

Chronic Exposure	:	Health injuries are not known or expected under normal use.

Experience with human exposure

Eye contact	:	Redness, Pain, Corrosion
Skin contact	:	Redness, Pain, Irritation, Corrosion, Allergic reactions
Ingestion	:	Corrosion, Abdominal pain
Inhalation	:	Respiratory irritation, Cough

Toxicity

Product

Acute oral toxicity	:	Acute toxicity estimate: > 2,000 mg/kg
Acute inhalation toxicity	:	Acute toxicity estimate: > 20 mg/l Exposure time: 4 h
Acute dermal toxicity	:	Acute toxicity estimate: > 2,000 mg/kg
Skin corrosion/irritation	:	no data available
Serious eye damage/eye irritation	:	no data available
Respiratory or skin sensitization	:	no data available
Carcinogenicity	:	No component of this product present at levels greater than or equal to 0.1% is identified as probable, possible or confirmed human carcinogen by IARC.
Reproductive effects	:	No toxicity to reproduction
Germ cell mutagenicity	:	Contains no ingredient listed as a mutagen
Teratogenicity	:	no data available
STOT - single exposure	:	no data available
STOT - repeated exposure	:	no data available
Aspiration toxicity	:	No aspiration toxicity classification

Human Hazard Characterization

Based on our hazard characterization, the potential human hazard is: High

Section: 12. ECOLOGICAL INFORMATION

Ecotoxicity

Environmental Effects	:	This product has no known ecotoxicological effects.

Product

Toxicity to fish	:	no data available
Toxicity to daphnia and other aquatic invertebrates	:	no data available
Toxicity to algae	:	no data available

Components

Toxicity to fish : Formic Acid
LC50 : > 100 mg/l
Exposure time: 96 h

Aromatic aldehyde
LC50 : 103.085 mg/l
Exposure time: 96 h

Isopropanol
LC50 Pimephales promelas (fathead minnow): 9,640 mg/l
Exposure time: 96 h

Methanol
LC50 : 15,400 mg/l
Exposure time: 96 h

Components

Toxicity to daphnia and other aquatic invertebrates : Aromatic aldehyde
EC50 Daphnia magna (Water flea): 119.56 mg/l
Exposure time: 48 h

Isopropanol
LC50 Daphnia magna (Water flea): > 10,000 mg/l

2-Mercaptoethanol
EC50 : 0.89 mg/l
Exposure time: 48 h

Methanol
EC50 : > 10,000 mg/l
Exposure time: 48 h

Components

Toxicity to algae : Aromatic aldehyde
NOEC : 37.2314 mg/l
Exposure time: 72 h

Methanol
EC50 : 22,000 mg/l
Exposure time: 72 h

Components

Toxicity to bacteria : Aromatic aldehyde
8.612 mg/l

Isopropanol
1,050 mg/l

Methanol
> 1,000 mg/l

Components

Toxicity to fish (Chronic toxicity) : Methanol
NOEC: 7,900 mg/l
Exposure time: 8.3 d

Persistence and degradability

The organic portion of this preparation is expected to be inherently biodegradable.

Mobility

The environmental fate was estimated using a level III fugacity model embedded in the EPI (estimation program interface) Suite TM, provided by the US EPA. The model assumes a steady state condition between the total input and output. The level III model does not require equilibrium between the defined media. The information provided is intended to give the user a general estimate of the environmental fate of this product under the defined conditions of the models.
If released into the environment this material is expected to distribute to the air, water and soil/sediment in the approximate respective percentages;

Air	:	<5%
Water	:	10 - 30%
Soil	:	50 - 70%

The portion in water is expected to float on the surface.

Bioaccumulative potential

Component substances have a low potential to bioconcentrate.

Other information

no data available

ENVIRONMENTAL HAZARD AND EXPOSURE CHARACTERIZATION
Based on our hazard characterization, the potential environmental hazard is: Low

Section: 13. DISPOSAL CONSIDERATIONS

Disposal methods	:	The product should not be allowed to enter drains, water courses or the soil. Where possible recycling is preferred to disposal or incineration. If recycling is not practicable, dispose of in compliance with local regulations. Dispose of wastes in an approved waste disposal facility.
Disposal considerations	:	Dispose of as unused product. Empty containers should be taken to an approved waste handling site for recycling or disposal. Do not re-use empty containers.

Section: 14. TRANSPORT INFORMATION

The shipper/consignor/sender is responsible to ensure that the packaging, labeling, and markings are in compliance with the selected mode of transport.

Land transport

Proper shipping name	:	FLAMMABLE LIQUID, CORROSIVE, N.O.S.
Technical name(s):	:	Isopropanol, Formic Acid
UN/ID No.	:	UN 2924
Transport hazard class(es)	:	3, 8
Packing group	:	II
IERG No	:	18
Hazchem Code	:	●3WE
Special precautions for user	:	Dangerous goods of Class 3 (Flammable Liquid) Subsidiary Class 8 (Alkali) are incompatible in a placard load with any of

the following:
and are incompatible with food or food packaging in any quantity.
Class 1 Explosives
Class 2.1 Flammable gases (where both are in bulk)
Class 2.3 Poisonous gases
Class 4.2 Spontaneously combustible substances
Class 4.3 Dangerous when wet substances
Class 5.1 Oxidising agents
Class 5.2 Organic peroxides
Class 7 Radioactive substances

Air transport (IATA)

UN/ID No.	:	UN 2924
Proper shipping name	:	FLAMMABLE LIQUID, CORROSIVE, N.O.S.
Technical name(s)	:	Isopropanol, Formic Acid
Transport hazard class(es)	:	3, 8
Packing group	:	II

Sea transport (IMDG/IMO)

UN/ID No.	:	UN 2924
Proper shipping name	:	FLAMMABLE LIQUID, CORROSIVE, N.O.S.
Technical name(s)	:	Isopropanol, Formic Acid
Transport hazard class(es)	:	3, 8
Packing group	:	II

Section: 15. REGULATORY INFORMATION

Standard for the Uniform Scheduling of Medicines and Poisons : Schedule 6

INTERNATIONAL CHEMICAL CONTROL LAWS :

TOXIC SUBSTANCES CONTROL ACT (TSCA)
The substances in this preparation are included on or exempted from the TSCA 8(b) Inventory (40 CFR 710)

CANADIAN ENVIRONMENTAL PROTECTION ACT (CEPA)
The substance(s) in this preparation are included in or exempted from the Domestic Substance List (DSL).

AUSTRALIA
All substances in this product comply with the National Industrial Chemicals Notification & Assessment Scheme (NICNAS).

CHINA
This product contains substance(s) which are not in compliance with the Provisions on the Environmental Administration of New Chemical Substances and may require additional review.

JAPAN
This product contains substance(s) which are not in compliance with the Law Regulating the Manufacture and Importation Of Chemical Substances and are not listed on the Existing and New Chemical Substances list (ENCS).

KOREA
This product contains substance(s) which are not in compliance with the Chemical Control Act (CCA) and may require additional review.

PHILIPPINES
All substances in this product comply with the Republic Act 6969 (RA 6969) and are listed on the Philippines Inventory of Chemicals & Chemical Substances (PICCS).

Section: 16. OTHER INFORMATION

REFERENCES

Hazardous Substances Data Bank, National Library of Medicine, Bethesda, Maryland (TOMES CPS™ CD-ROM Version), Micromedex, Inc., Englewood, CO.

IARC Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man, Geneva: World Health Organization, International Agency for Research on Cancer.

Integrated Risk Information System, U.S. Environmental Protection Agency, Washington, D.C. (TOMES CPS™ CD-ROM Version),
Micromedex, Inc., Englewood, CO.

Annual Report on Carcinogens, National Toxicology Program, U.S. Department of Health and Human Services, Public Health Service.

Registry of Toxic Effects of Chemical Substances, National Institute for Occupational Safety and Health, Cincinnati, OH,
(TOMES CPS™ CD-ROM Version), Micromedex, Inc., Englewood, CO.

The Teratogen Information System, University of Washington, Seattle, WA (TOMES CPS™ CD-ROM Version), Micromedex, Inc., Englewood, CO.

Revision Date	:	10.06.2016
Date of first issue	:	10.06.2016
Version Number	:	1.0
Prepared By	:	Regulatory Affairs

REVISED INFORMATION: Significant changes to regulatory or health information for this revision is indicated by a bar in the left-hand margin of the SDS.

The information provided in this Safety Data Sheet is correct to the best of our knowledge, information and belief at the date of its publication. The information given is designed only as a guidance for safe handling, use, processing, storage, transportation, disposal and release and is not to be considered a warranty or quality specification. The information relates only to the specific material designated and may not be valid for such material used in combination with any other materials or in any process, unless specified in the text.
For additional copies of an SDS visit www.nalco.com and request access.

HALLIBURTON

SAFETY DATA SHEET

FDP-S1246-16

Revision Date: 26-May-2016 **Revision Number:** 1

1. Product Identifier & Identity for the Chemical

Statement of Hazardous Nature Non-Hazardous according to the criteria of the 3rd Revised Edition of the Globally Harmonised System of Classification and Labelling of Chemicals (GHS), Non-Dangerous Goods according to the criteria of ADG.

1.1. Product Identifier

Product Name FDP-S1246-16

Other means of Identification

Synonyms None

Hazardous Material Number: HM008363

Recommended use of the chemical and restrictions on use

Recommended Use Viscosifier

Uses advised against Consumer use

Supplier's name, address and phone number

Manufacturer/Supplier

Halliburton/Baroid Australia Pty. Ltd.
15 Marriott Road
Jandakot
WA 6164
Australia

ACN Number: 009 000 775
Telephone Number: 61 (08) 9455 8300
Fax Number: 61 (08) 9455 5300

Product Emergency Telephone
Australia: + 61 1 800 686 951
Papua New Guinea: + 61 1 800 686 951
NewZealand: +64 800 451719

Fire, Police & Ambulance - Emergency Telephone
Australia: 000
Papua New Guinea: 000
New Zealand: 111

E-mail Address fdunexchem@halliburton.com

Emergency phone number

+ 61 1 800 686 951

Australian Poisons Information Centre
24 Hour Service: - 13 11 26
Police or Fire Brigade: - 000 (exchange): - 1100

2. Hazard Identification

Statement of Hazardous Nature Non-Hazardous according to the criteria of the 3rd Revised Edition of the Globally Harmonised System of Classification and Labelling of Chemicals (GHS), Non-Dangerous Goods according to the criteria of ADG.

Classification of the hazardous chemical

Not classified

Label elements, including precautionary statements

Hazard pictograms

Signal Word Not Hazardous

Hazard Statements: Not Classified

Precautionary Statements

Prevention None
Response None
Storage None
Disposal None

Contains

Substances	**CAS Number**
Contains no hazardous substances in concentrations above cut-off values according to the competent authority	NA

Other hazards which do not result in classification

This substance is not considered to be persistent, bioaccumulating nor toxic (PBT).
This substance is not considered to be very persistent nor very bioaccumulating (vPvB).

For the full text of the H-phrases mentioned in this Section, see Section 16

3. Composition/information on Ingredients

Substances	CAS Number	PERCENT (w/w)	GHS Classification - Australia
Contains no hazardous substances in concentrations above cut-off values according to the competent authority	NA	60 - 100%	Not Applicable

The specific chemical identity of the composition has been withheld as proprietary. The exact percentage (concentration) of the composition has been withheld as proprietary.

4. First aid measures

Description of necessary first aid measures

Inhalation If inhaled, remove from area to fresh air. Get medical attention if respiratory irritation develops or if breathing becomes difficult.

Eyes In case of contact, immediately flush eyes with plenty of water for at least 15 minutes and get medical attention if irritation persists.

Skin Flush skin with large amounts of water. If irritation persists, get medical attention.

Ingestion Rinse mouth with water many times. Get medical attention if symptoms occur

Symptoms caused by exposure

No information available

Medical Attention and Special Treatment

Notes to Physician Treat symptomatically

5. Fire Fighting Measures

Suitable extinguishing equipment

Suitable Extinguishing Media

Water fog, carbon dioxide, foam, dry chemical.

Extinguishing media which must not be used for safety reasons

Avoid creating dust clouds with extinguishers.

Specific hazards arising from the chemical

Special exposure hazards in a fire

Decomposition in fire may produce harmful gases. Organic dust in the presence of an ignition source can be explosive in high concentrations. Good housekeeping practices are required to minimize this potential.

Special protective equipment and precautions for fire fighters

Special protective equipment for firefighters

Full protective clothing and approved self-contained breathing apparatus required for fire fighting personnel.

6. Accidental release measures

6.1. Personal precautions, protective equipment and emergency procedures

Avoid creating and breathing dust. Ensure adequate ventilation. Use appropriate protective equipment. Remove sources of ignition. Take precautionary measures against static discharges All equipment used when handling the product must be grounded Avoid contact with skin, eyes and clothing. Use only competent persons for cleanup.

6.2. Environmental precautions

None known.

6.3. Methods and material for containment and cleaning up

Scoop up and remove. Remove ignition sources and work with non-sparking tools.

7. Handling and storage

7.1. Precautions for safe handling

Handling Precautions

Ensure adequate ventilation. Use appropriate protective equipment. Remove sources of ignition. Ground and bond containers when transferring from one container to another.

Hygiene Measures

Handle in accordance with good industrial hygiene and safety practice.

7.2. Conditions for safe storage, including any incompatibilities

Storage Information

Store in a cool well ventilated area. Use good housekeeping in storage and work areas to prevent accumulation of dust. Close container when not in use. Keep from heat, sparks, and open flames.

Other Guidelines

No information available

8. Exposure Controls/Personal Protection

Control parameters - exposure standards, biological monitoring

Exposure Limits

Substances	CAS Number	Australia NOHSC	ACGIH TLV-TWA
Contains no hazardous substances in concentrations above cut-off values according to the competent authority	NA	Not applicable	Not applicable

Appropriate engineering controls

Engineering Controls Localized ventilation should be used to control dust levels. Ensure adequate ventilation, especially in confined areas

Personal protective equipment (PPE)

Personal Protective Equipment If engineering controls and work practices cannot prevent excessive exposures, the selection and proper use of personal protective equipment should be determined by an

	industrial hygienist or other qualified professional based on the specific application of this product.
Respiratory Protection	If engineering controls and work practices cannot keep exposure below occupational exposure limits or if exposure is unknown, wear a NIOSH certified, European Standard EN 149, AS/NZS 1715:2009, or equivalent respirator when using this product. Selection of and instruction on using all personal protective equipment, including respirators, should be performed by an Industrial Hygienist or other qualified professional. Dust/mist respirator. (N95, P2/P3)
Hand Protection	Use gloves which are suitable for the chemicals present in this product as well as other environmental factors in the workplace.
Skin Protection	Wear protective clothing appropriate for the work environment.
Eye Protection	Wear safety glasses or goggles to protect against exposure.
Other Precautions	Eyewash fountains and safety showers must be easily accessible.
Environmental Exposure Controls	Do not allow material to contaminate ground water system

9. Physical and Chemical Properties

9.1. Information on basic physical and chemical properties

Physical State:	Powder	**Color**	Clear
Odor:	Sweet	**Odor Threshold:**	No information available

Property Remarks/ - Method	Values
pH:	No data available
Freezing Point / Range	No data available
Melting Point / Range	
Boiling Point / Range	No data available
Flash Point	No data available
Evaporation rate	No data available
Vapor Pressure	No data available
Vapor Density	No data available
Specific Gravity	1.25
Water Solubility	Insoluble in water
Solubility in other solvents	No data available
Partition coefficient: n-octanol/water	No data available
Autoignition Temperature	No data available
Decomposition Temperature	No data available
Viscosity	No data available
Explosive Properties	No information available
Oxidizing Properties	No information available

9.2. Other information

VOC Content (%)	No data available
Bulk Density	54.5 lbs/ft3

10. Stability and Reactivity

10.1. Reactivity
Not expected to be reactive.
10.2. Chemical stability
Stable
10.3. Possibility of hazardous reactions
Will Not Occur
10.4. Conditions to avoid
Keep away from heat, sparks and flame.
10.5. Incompatible materials
Strong oxidizers. Strong acids. Strong alkalis.
10.6. Hazardous decomposition products
Toxic fumes. Aldehydes. Carbon monoxide and carbon dioxide.

11. Toxicological Information

Information on routes of exposure

Principle Route of Exposure Eye or skin contact, inhalation. Ingestion.

Symptoms related to exposure

Numerical measures of toxicity

Toxicology data for the components

Substances	CAS Number	LD50 Oral	LD50 Dermal	LC50 Inhalation
Contains no hazardous substances in concentrations above cut-off values according to the competent authority	NA	No data available	No data available	No data available

Immediate, delayed and chronic health effects from exposure

Inhalation May cause mild respiratory irritation.
Eye Contact May cause mild eye irritation.
Skin Contact May cause mild skin irritation.
Ingestion May cause abdominal pain, vomiting, nausea, and diarrhea.

Chronic Effects/Carcinogenicity No data available to indicate product or components present at greater than 0.1% are chronic health hazards.

Exposure Levels
No data available

Interactive effects
None known.

Data limitations
No data available

Substances	CAS Number	Skin corrosion/irritation
Contains no hazardous substances in concentrations above cut-off values according to the competent authority	NA	No information available

Substances	CAS Number	Serious eye damage/irritation
Contains no hazardous substances in concentrations above cut-off values according to the competent authority	NA	No information available

Substances	CAS Number	Skin Sensitization
Contains no hazardous substances in concentrations above cut-off values according to the competent authority	NA	No information available

Substances	CAS Number	Respiratory Sensitization
Contains no hazardous substances in concentrations above cut-off values according to the competent authority	NA	No information available

Substances	CAS Number	Mutagenic Effects
Contains no hazardous substances in concentrations above cut-off values according to the competent authority	NA	No information available

Substances	CAS Number	Carcinogenic Effects
Contains no hazardous substances in concentrations above cut-off values according to the competent authority	NA	No information available

Substances	CAS Number	Reproductive toxicity
Contains no hazardous substances in concentrations above cut-off values according to the competent authority	NA	No information available

Substances	CAS Number	STOT - single exposure
Contains no hazardous substances in concentrations above cut-off values according to the competent authority	NA	No information available

Substances	CAS Number	STOT - repeated exposure
Contains no hazardous substances in concentrations above cut-off values according to the competent authority	NA	No information available

Substances	CAS Number	Aspiration hazard
Contains no hazardous substances in concentrations above cut-off values according to the competent authority	NA	

12. Ecological Information

Ecotoxicity

Product Ecotoxicity Data

No data available

Substance Ecotoxicity Data

Substances	CAS Number	Toxicity to Algae	Toxicity to Fish	Toxicity to Microorganisms	Toxicity to Invertebrates
Contains no hazardous substances in concentrations above cut-off values according to the competent authority	NA	No information available	No information available	No information available	No information available

12.2. Persistence and degradability

Substances	CAS Number	Persistence and Degradability
Contains no hazardous substances in concentrations above cut-off values according to the competent authority	NA	No information available

12.3. Bioaccumulative potential

Substances	CAS Number	Log Pow
Contains no hazardous substances in concentrations above cut-off values according to the competent authority	NA	No information available

12.4. Mobility in soil

Substances	CAS Number	Mobility
Contains no hazardous substances in concentrations above cut-off values according to the competent authority	NA	No information available

12.6. Other adverse effects

Endocrine Disruptor Information
This product does not contain any known or suspected endocrine disruptors

13. Disposal Considerations

Safe handling and disposal methods
Follow all applicable community, national or regional regulations regarding waste management methods.

Disposal of any contaminated packaging
Follow all applicable national or local regulations.

Environmental regulations
Not applicable

14. Transport Information

Transportation Information

UN Number	Not restricted
UN proper shipping name:	Not restricted
Transport Hazard Class(es):	Not applicable
Packing Group:	Not applicable
Environmental Hazards:	Not applicable

Special precautions during transport
None

HazChem Code
None Allocated

15. Regulatory Information

Safety, health and environmental regulations specific for the product

International Inventories

Australian AICS Inventory	All components are listed on the AICS or are subject to a relevant exemption, permit, or assessment certificate.
New Zealand Inventory of Chemicals	All components are listed on the NZIoC or are subject to a relevant exemption, permit, or assessment certificate.
EINECS (European Inventory of Existing Chemical Substances)	This product, and all its components, complies with EINECS
US TSCA Inventory	All components listed on inventory or are exempt.
Canadian Domestic Substances List (DSL)	All components listed on inventory or are exempt.

Poisons Schedule number

None Allocated

International Agreements

Montreal Protocol - Ozone Depleting Substances:	Does not apply
Stolkhom Convention - Persistent Organic Pollutants:	Does not apply
Rotterdam Convention - Prior Informed Consent:	Does not apply
Basel Convention - Hazardous Waste:	Does not apply

16. Other information

Date of preparation or review

Revision Date: 26-May-2016

Revision Note

Full text of H-Statements referred to under sections 2 and 3
None

Additional information For additional information on the use of this product, contact your local Halliburton representative.

For questions about the Safety Data Sheet for this or other Halliburton products, contact Chemical Stewardship at 1-580-251-4335.

Key abreviations or acronyms used
bw – body weight
CAS – Chemical Abstracts Service
EC50 – Effective Concentration 50%
LC50 – Lethal Concentration 50%
LD50 – Lethal Dose 50%
LL50 – Lethal Loading 50%
mg/kg – milligram/kilogram
mg/L – milligram/liter
NOEC – No Observed Effect Concentration
OEL – Occupational Exposure Limit
PBT – Persistent Bioaccumulative and Toxic
ppm – parts per million
STEL – Short Term Exposure Limit
TWA – Time-Weighted Average
vPvB – very Persistent and very Bioaccumulative
h - hour
mg/m^3 - milligram/cubic meter
mm - millimeter
mmHg - millimeter mercury
w/w - weight/weight
d - day

Key literature references and sources for data
www.ChemADVISOR.com/

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End of Safety Data Sheet

HALLIBURTON

SAFETY DATA SHEET

FE-2

Revision Date: 16-Apr-2015 **Revision Number:** 28

1. Product Identifier & Identity for the Chemical

Statement of Hazardous Nature Hazardous according to the criteria of the 3rd Revised Edition of the Globally Harmonised System of Classification and Labelling of Chemicals (GHS), Non-Dangerous Goods according to the criteria of ADG.

1.1. Product Identifier

Product Name FE-2

Other means of Identification

Synonyms: None

Product Code: HM000682

Recommended use of the chemical and restrictions on use

Recommended Use Iron Control Agent

Uses Advised Against No information available

Supplier's name, address and phone number

Manufacturer/Supplier

Halliburton Australia Pty. Ltd.
15 Marriott Road
Jandakot
WA 6164
Australia

ACN Number: 009 000 775
Telephone Number: + 61 1 800 686 951
Fax Number: 61 (08) 9455 5300

E-Mail address: fdunexchem@halliburton.com

Emergency phone number

+ 61 1 800 686 951

Australian Poisons Information Centre

24 Hour Service: - 13 11 26

Police or Fire Brigade: - 000 (exchange): - 1100

2. Hazard Identification

Statement of Hazardous Nature Hazardous according to the criteria of the 3rd Revised Edition of the Globally Harmonised System of Classification and Labelling of Chemicals (GHS), Non-Dangerous Goods according to the criteria of ADG.

Classification of the hazardous chemical

Serious Eye Damage / Eye Irritation	Category 2 - H319

Label elements, including precautionary statements

Hazard Pictograms

Signal Word Warning

Hazard Statements H319 - Causes serious eye irritation

Precautionary Statements

Prevention P264 - Wash face, hands and any exposed skin thoroughly after handling
P280 - Wear eye protection/face protection

Response P305 + P351 + P338 - IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing
P337 + P313 - If eye irritation persists: Get medical advice/attention

Storage None

Disposal None

Contains

Substances	**CAS Number**
Citric acid	77-92-9

Other hazards which do not result in classification
This substance is not considered to be persistent, bioaccumulating nor toxic (PBT).
This substance is not considered to be very persistent nor very bioaccumulating (vPvB).

Australia Classification
For the full text of the H-phrases mentioned in this Section, see Section 16

Classification Xi - Irritant.

Risk Phrases R36 Irritating to eyes.

3. Composition/information on Ingredients

Substances	CAS Number	PERCENT (w/w)	GHS Classification - Australia
Citric acid	77-92-9	60 - 100%	Eye Irrit. 2A (H319)

4. First aid measures

Description of necessary first aid measures

Inhalation If inhaled, remove from area to fresh air. Get medical attention if respiratory irritation develops or if breathing becomes difficult.

Eyes In case of contact, or suspected contact, immediately flush eyes with plenty of water for at least 15 minutes and get medical attention immediately after flushing.

Skin Wash with soap and water. Get medical attention if irritation persists.

Ingestion Do NOT induce vomiting. Give nothing by mouth. Obtain immediate medical attention.

Symptoms caused by exposure

Causes eye irritation.

Medical Attention and Special Treatment

Notes to Physician Treat symptomatically

5. Fire Fighting Measures

Suitable extinguishing equipment

Suitable Extinguishing Media

Water fog, carbon dioxide, foam, dry chemical.

Extinguishing media which must not be used for safety reasons

None known.

Specific hazards arising from the chemical

Special Exposure Hazards

Decomposition in fire may produce harmful gases. Organic dust in the presence of an ignition source can be explosive in high concentrations. Good housekeeping practices are required to minimize this potential.

Special protective equipment and precautions for fire fighters

Special Protective Equipment for Fire-Fighters

Full protective clothing and approved self-contained breathing apparatus required for fire fighting personnel.

6. Accidental release measures

6.1. Personal precautions, protective equipment and emergency procedures

Use appropriate protective equipment. Avoid creating and breathing dust. Avoid contact with skin, eyes and clothing. Ensure adequate ventilation.

6.2. Environmental precautions

Prevent from entering sewers, waterways, or low areas.

6.3. Methods and material for containment and cleaning up

Scoop up and remove.

7. Handling and storage

7.1. Precautions for Safe Handling

Handling Precautions

Avoid contact with eyes, skin, or clothing. Avoid creating or inhaling dust. Ensure adequate ventilation. Wash hands after use. Launder contaminated clothing before reuse. Use appropriate protective equipment.

Hygiene Measures

Handle in accordance with good industrial hygiene and safety practice.

7.2. Conditions for safe storage, including any incompatibilities

Storage Information

Store away from alkalis. Store away from oxidizers. Store in a cool, dry location. Product has a shelf life of 60 months.

Other Guidelines

No information available

8. Exposure Controls/Personal Protection

Control parameters - exposure standards, biological monitoring

Exposure Limits

Substances	CAS Number	Australia NOHSC	ACGIH TLV-TWA
Citric acid	77-92-9	Not applicable	Not applicable

Appropriate engineering controls

Engineering Controls Use in a well ventilated area.

Personal protective equipment (PPE)

Respiratory Protection If engineering controls and work practices cannot keep exposure below occupational exposure limits or if exposure is unknown, wear a NIOSH certified, European Standard EN 149, AS/NZS 1715:2009, or equivalent respirator when using this product. Selection of and instruction on using all personal protective equipment, including respirators, should be performed by an Industrial Hygienist or other qualified professional.
Dust/mist respirator. (N95, P2/P3)

Hand Protection Chemical-resistant protective gloves (EN 374) Suitable materials for longer, direct contact (recommended: protection index 6, corresponding to > 480 minutes permeation time as per EN 374): Nitrile gloves. (>= 0.35 mm thickness)
This information is based on literature references and on information provided by glove manufacturers, or is derived by analogy with similar substances. Please note that in practice the working life of chemical-resistant protective gloves may be considerably shorter than the permeation time determined in accordance with EN 374 as a result of the many influencing factors (e.g. temperature). If signs of wear and tear are noticed then the gloves should be replaced. Manufacturer's directions for use should be observed because of great diversity of types.

Skin Protection Normal work coveralls.

Eye Protection Chemical goggles; also wear a face shield if splashing hazard exists.

Other Precautions None known.

Environmental Exposure Controls Do not allow material to contaminate ground water system

9. Physical and Chemical Properties

9.1. Information on basic physical and chemical properties

Physical State: Solid
Color: White
Odor: Odorless
Odor Threshold: No information available

Property	Values	Remarks/ - Method
pH:	2 - 2.2	
Freezing Point/Range	No data available	
Melting Point/Range	No data available	
Boiling Point/Range	No data available	
Flash Point	No data available	
upper flammability limit	65	
lower flammability limit	8	
Evaporation rate	No data available	
Vapor Pressure	No data available	
Vapor Density	No data available	
Specific Gravity	1.665	
Water Solubility	Soluble in water	
Solubility in other solvents	No data available	
Partition coefficient: n-octanol/water	No data available	
Autoignition Temperature	1000 °C / 1832 °F	
Decomposition Temperature	No data available	
Viscosity	No data available	
Explosive Properties	No information available	
Oxidizing Properties	No information available	

9.2. Other information

Molecular Weight	192.13
VOC Content (%)	No data available

10. Stability and Reactivity

10.1. Reactivity

Not expected to be reactive.

10.2. Chemical Stability

Stable

10.3. Possibility of Hazardous Reactions

Will Not Occur

10.4. Conditions to Avoid

None anticipated

10.5. Incompatible Materials

Strong alkalis. Strong oxidizers.

10.6. Hazardous Decomposition Products

Carbon monoxide and carbon dioxide.

11. Toxicological Information

Information on routes of exposure

Principle Route of Exposure Eye or skin contact, inhalation.

Sympotoms related to exposure

Most Important Symptoms/Effects

Causes eye irritation.

Numerical measures of toxicity

Toxicology data for the components

Substances	CAS Number	LD50 Oral	LD50 Dermal	LC50 Inhalation
Citric acid	77-92-9	5400 mg/kg (Rat) 5790 mg/kg (Mouse) 11,700 mg/kg (Rat)	> 2000 mg/kg	No data available

Immediate, delayed and chronic health effects from exposure

Inhalation May cause mild respiratory irritation.

Eye Contact Causes eye irritation.

Skin Contact May cause mild skin irritation.

Ingestion Irritation of the mouth, throat, and stomach. May cause abdominal pain, vomiting, nausea, and diarrhea.

Chronic Effects/Carcinogenicity No data available to indicate product or components present at greater than 0.1% are chronic health hazards.

Exposure Levels

No data available

Interactive effects

None known.

Data limitations

No data available

Substances	CAS Number	Skin corrosion/irritation
Citric acid	77-92-9	Not irritating to skin in rabbits.

Substances	CAS Number	Eye damage/irritation
Citric acid	77-92-9	Causes severe eye irritation.

Substances	CAS Number	Skin Sensitization
Citric acid	77-92-9	Patch test on human volunteers did not demonstrate sensitization properties

Substances	CAS Number	Respiratory Sensitization
Citric acid	77-92-9	No information available

Substances	CAS Number	Mutagenic Effects
Citric acid	77-92-9	Did not show mutagenic effects in animal experiments

Substances	CAS Number	Carcinogenic Effects
Citric acid	77-92-9	Did not show carcinogenic effects in animal experiments

Substances	CAS Number	Reproductive toxicity
Citric acid	77-92-9	Animal testing did not show any effects on fertility. Did not show teratogenic effects in animal experiments.

Substances	CAS Number	STOT - single exposure
Citric acid	77-92-9	No data of sufficient quality are available.

Substances	CAS Number	STOT - repeated exposure
Citric acid	77-92-9	No significant toxicity observed in animal studies at concentration requiring classification.

Substances	CAS Number	Aspiration hazard
Citric acid	77-92-9	No adverse health effects are expected from swallowing.

12. Ecological Information

Ecotoxicity

Product Ecotoxicity Data

No data available

Substance Ecotoxicity Data

Substances	CAS Number	Toxicity to Algae	Toxicity to Fish	Toxicity to Microorganisms	Toxicity to Invertebrates
Citric acid	77-92-9	NOEC (8d) 425 mg/L (cell density) (Scenedesmus quadricauda) LOEC (8d) >80 mg/L (Microcystis aeruginosa)	LC50 (96h) 1516 mg/L (Lepomis macrochirus) LC50 (48h) 440 mg/L (Leuciscus idus melanotus) LC50 (96h) >100 mg/L (Pimephales promelas)	TT (72h) 485 mg/L (Entosiphon sulcatum)	TLM96 100-330 ppm (Crangon crangon) EC50 (24h) 1535 mg/L (Daphnia magna) LC50 (48h) 160 mg/L (Daphnia magna) EC50 (48h) >50 mg/L (Daphnia magna)

12.2. Persistence and degradability

Biodegradable.

Substances	CAS Number	Persistence and Degradability
Citric acid	77-92-9	Readily biodegradable (97% @ 28d)

12.3. Bioaccumulative potential

Does not bioaccumulate

Substances	CAS Number	Log Pow
Citric acid	77-92-9	-1.61 to -1.80

12.4. Mobility in soil

Substances	CAS Number	Mobility
Citric acid	77-92-9	No information available

12.6. Other adverse effects

Endocrine Disruptor Information

This product does not contain any known or suspected endocrine disruptors

13. Disposal Considerations

Safe handling and disposal methods

Bury in a licensed landfill according to federal, state, and local regulations.

Disposal of any contaminated packaging

Follow all applicable national or local regulations. Contaminated packaging may be disposed of by: rendering packaging incapable of containing any substance, or treating packaging to remove residual contents, or treating packaging to make sure the residual

contents are no longer hazardous, or by disposing of packaging into commercial waste collection.

Environmental regulations
Not applicable

14. Transport Information

Transportation Information

UN Number:	Not restricted
UN Proper Shipping Name:	Not restricted
Transport Hazard Class(es):	Not applicable
Packing Group:	Not applicable
Environmental Hazards:	Not applicable

Special precautions during transport
None

HazChem Code
None Allocated

15. Regulatory Information

Safety, health and environmental regulations specific for the product

International Inventories

Australian AICS Inventory	All components listed on inventory or are exempt.
New Zealand Inventory of Chemicals	All components listed on inventory or are exempt.
EINECS Inventory	This product, and all its components, complies with EINECS
US TSCA Inventory	All components listed on inventory or are exempt.
Canadian DSL Inventory	All components listed on inventory or are exempt.

Poisons Schedule number
None Allocated

16. Other information

Date of preparation or review

Revision Date: 16-Apr-2015

Revision Note Revision Note
SDS sections updated: 2

Full text of R-phrases referred to under Sections 2 and 3
R36 - Irritating to eyes

Full text of H-Statements referred to under sections 2 and 3
H319 - Causes serious eye irritation

Additional information For additional information on the use of this product, contact your local Halliburton representative.

For questions about the Safety Data Sheet for this or other Halliburton products, contact Chemical Stewardship at 1-580-251-4335.

Key abreviations or acronyms used
bw – body weight CAS – Chemical Abstracts Service EC50 – Effective Concentration 50% LC50 – Lethal Concentration 50% LD50

– Lethal Dose 50% LL50 – Lethal Loading 50% mg/kg – milligram/kilogram mg/L – milligram/liter NOEC – No Observed Effect Concentration OEL – Occupational Exposure Limit PBT – Persistent Bioaccumulative and Toxic ppm – parts per million STEL – Short Term Exposure Limit TWA – Time-Weighted Average vPvB – very Persistent and very Bioaccumulative h - hour mg/m^3 - milligram/cubic meter mm - millimeter mmHg - millimeter mercury w/w - weight/weight d - day

Key literature references and sources for data
www.ChemADVISOR.com/
NZ CCID

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End of Safety Data Sheet

HALLIBURTON

SAFETY DATA SHEET

HC-2A

Revision Date: 12-Jun-2018 **Revision Number:** 2

1. Product Identifier & Identity for the Chemical

Statement of Hazardous Nature Hazardous according to the criteria of the 3rd Revised Edition of the Globally Harmonised System of Classification and Labelling of Chemicals (GHS), Non-Dangerous Goods according to the criteria of ADG.

1.1. Product Identifier

Product Name HC-2A

Other means of Identification

Synonyms None

Hazardous Material Number: HM008835

Recommended use of the chemical and restrictions on use

Recommended Use Surfactant

Uses advised against No information available

Supplier's name, address and phone number

Manufacturer/Supplier Halliburton Australia Pty. Ltd.
15 Marriott Road, Jandakot, WA 6164
Australia
ACN Number: 009 000 775
Telephone Number: + 61 1 800 686 951
Fax Number: 61 (08) 9455 5300

E-mail Address fdunexchem@halliburton.com

Emergency phone number

+ 61 1 800 686 951
Global Incident Response Access Code: 334305
Contract Number: 14012

Australian Poisons Information Centre
24 Hour Service: - 13 11 26
Police or Fire Brigade: - 000 (exchange): - 1100

2. Hazard Identification

Statement of Hazardous Nature Hazardous according to the criteria of the 3rd Revised Edition of the Globally Harmonised System of Classification and Labelling of Chemicals (GHS), Non-Dangerous Goods according to the criteria of ADG.

Classification of the hazardous chemical

Serious Eye Damage/Irritation	Category 1 - H318
Acute Aquatic Toxicity	Category 2 - H401
Chronic Aquatic Toxicity	Category 2 - H411

Label elements, including precautionary statements

Hazard Pictograms

Signal Word DANGER

Hazard Statements:
H318 - Causes serious eye damage
H401 - Toxic to aquatic life
H411 - Toxic to aquatic life with long lasting effects

Precautionary Statements

Prevention
P273 - Avoid release to the environment
P280 - Wear eye protection/face protection

Response
P305 + P351 + P338 - IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing
P310 - Immediately call a POISON CENTER or doctor/physician
P391 - Collect spillage

Storage None

Disposal
P501 - Dispose of contents/container in accordance with local/regional/national/international regulations

Contains Substances	**CAS Number**
Inner salt of alkyl amines	Proprietary

Other hazards which do not result in classification
None known

For the full text of the H-phrases mentioned in this Section, see Section 16

3. Composition/information on Ingredients

Substances	CAS Number	PERCENT (w/w)	GHS Classification - Australia
Inner salt of alkyl amines	Proprietary	10 - 30%	Eye Corr. 1 (H318) Aquatic Acute 2 (H401) Aquatic Chronic 2 (H411)

4. First aid measures

Description of necessary first aid measures

Inhalation If inhaled, remove from area to fresh air. Get medical attention if respiratory irritation develops or if breathing becomes difficult.

Eyes Immediately flush eyes with large amounts of water for at least 30 minutes. Seek prompt medical attention.

Skin Wash with soap and water. Get medical attention if irritation persists.

Ingestion Rinse mouth with water many times. Get medical attention if symptoms occur

Symptoms caused by exposure
Causes severe eye irritation which may damage tissue.

Medical Attention and Special Treatment

Notes to Physician Treat symptomatically

5. Fire Fighting Measures

Suitable extinguishing equipment

Suitable Extinguishing Media

Water fog, carbon dioxide, foam, dry chemical.

Extinguishing media which must not be used for safety reasons

None known.

Specific hazards arising from the chemical

Special exposure hazards in a fire

Use water spray to cool fire exposed surfaces. Decomposition in fire may produce harmful gases.

Special protective equipment and precautions for fire fighters

Special protective equipment for firefighters

Full protective clothing and approved self-contained breathing apparatus required for fire fighting personnel.

6. Accidental release measures

6.1. Personal precautions, protective equipment and emergency procedures

Use appropriate protective equipment.

6.2. Environmental precautions

Prevent from entering sewers, waterways, or low areas.

6.3. Methods and material for containment and cleaning up

Isolate spill and stop leak where safe. Contain spill with sand or other inert materials. Scoop up and remove.

7. Handling and storage

7.1. Precautions for safe handling

Handling Precautions

Avoid contact with eyes, skin, or clothing. Avoid breathing vapors.

Hygiene Measures

Handle in accordance with good industrial hygiene and safety practice.

7.2. Conditions for safe storage, including any incompatibilities

Storage Information

Store away from oxidizers. Store in a cool well ventilated area. Keep container closed when not in use. Product has a shelf life of 60 months.

Other Guidelines

No information available

8. Exposure Controls/Personal Protection

Control parameters - exposure standards, biological monitoring

Exposure Limits

Substances	CAS Number	Australia NOHSC	ACGIH TLV-TWA
Inner salt of alkyl amines	Proprietary	Not applicable	Not applicable

Appropriate engineering controls

Engineering Controls Use in a well ventilated area.

Personal protective equipment (PPE)

Personal Protective Equipment If engineering controls and work practices cannot prevent excessive exposures, the selection and proper use of personal protective equipment should be determined by an industrial hygienist or other qualified professional based on the specific application of this product.

Respiratory Protection	If engineering controls and work practices cannot keep exposure below occupational exposure limits or if exposure is unknown, wear a NIOSH certified, European Standard EN 149, AS/NZS 1715:2009, or equivalent respirator when using this product. Selection of and instruction on using all personal protective equipment, including respirators, should be performed by an Industrial Hygienist or other qualified professional. Dust/mist respirator. (N95, P2/P3)
Hand Protection	Use gloves which are suitable for the chemicals present in this product as well as other environmental factors in the workplace.
Skin Protection	Wear protective clothing appropriate for the work environment.
Eye Protection	Chemical goggles; also wear a face shield if splashing hazard exists.
Other Precautions	Eyewash fountains and safety showers must be easily accessible.
Environmental Exposure Controls	No information available

9. Physical and Chemical Properties

9.1. Information on basic physical and chemical properties

Physical State:	Liquid	**Color**	Clear light amber
Odor:	Surfactant	**Odor Threshold:**	No information available

Property Remarks/ - Method	Values
pH:	6.5-7.5
Freezing Point / Range	0 °C
Melting Point / Range	No data available
Boiling Point / Range	100 °C / 212 °F
Flash Point	> 100 °C / > 212 °F PMCC
Evaporation rate	No data available
Vapor Pressure	< 17.5 mmHg
Vapor Density	No data available
Specific Gravity	1.12
Water Solubility	Soluble in water
Solubility in other solvents	No data available
Partition coefficient: n-octanol/water	No data available
Autoignition Temperature	No data available
Decomposition Temperature	No data available
Viscosity	No data available
Explosive Properties	No information available
Oxidizing Properties	No information available

9.2. Other information

VOC Content (%)	No data available

10. Stability and Reactivity

10.1. Reactivity
Not expected to be reactive.
10.2. Chemical stability
Stable
10.3. Possibility of hazardous reactions
Will Not Occur
10.4. Conditions to avoid
Keep away from heat, sparks and flame.
10.5. Incompatible materials
Strong oxidizers.
10.6. Hazardous decomposition products
Oxides of nitrogen. Carbon monoxide and carbon dioxide. Hydrogen chloride.

11. Toxicological Information

Information on routes of exposure

Principle Route of Exposure	Eye or skin contact, inhalation.

Symptoms related to exposure

Most Important Symptoms/Effects

Causes severe eye irritation which may damage tissue.

Toxicology data for the components

Substances	CAS Number	LD50 Oral	LD50 Dermal	LC50 Inhalation
Inner salt of alkyl amines	Proprietary	>5000 mg/kg-bw (rat)	>2000 mg/kg-bw (rat)	No data available

Immediate, delayed and chronic health effects from exposure

Inhalation May cause mild respiratory irritation.

Eye Contact Causes severe eye irritation which may damage tissue. May cause corneal injury.

Skin Contact May cause mild skin irritation.

Ingestion May cause abdominal pain, vomiting, nausea, and diarrhea.

Chronic Effects/Carcinogenicity No data available to indicate product or components present at greater than 0.1% are chronic health hazards.

Exposure Levels

No data available

Interactive effects

None known.

Data limitations

No data available

Substances	CAS Number	Skin corrosion/irritation
Inner salt of alkyl amines		Not irritating to skin in rabbits.

Substances	CAS Number	Serious eye damage/irritation
Inner salt of alkyl amines		Causes severe eye irritation (Rabbit)

Substances	CAS Number	Skin Sensitization
Inner salt of alkyl amines		Did not cause sensitization on laboratory animals (guinea pig)

Substances	CAS Number	Respiratory Sensitization
Inner salt of alkyl amines		No information available

Substances	CAS Number	Mutagenic Effects
Inner salt of alkyl amines		In vitro tests did not show mutagenic effects. In vivo tests did not show mutagenic effects.

Substances	CAS Number	Carcinogenic Effects
Inner salt of alkyl amines		Did not show carcinogenic effects in animal experiments

Substances	CAS Number	Reproductive toxicity
Inner salt of alkyl amines		Animal testing did not show any effects on fertility. Did not show teratogenic effects in animal experiments.

Substances	CAS Number	STOT - single exposure
Inner salt of alkyl amines		No significant toxicity observed in animal studies at concentration requiring classification.

Substances	CAS Number	STOT - repeated exposure
Inner salt of alkyl amines		No significant toxicity observed in animal studies at concentration requiring classification.

Substances	CAS Number	Aspiration hazard
Inner salt of alkyl amines		Not applicable

12. Ecological Information

Ecotoxicity

Substance Ecotoxicity Data

Substances	CAS Number	Toxicity to Algae	Toxicity to Fish	Toxicity to Microorganisms	Toxicity to Invertebrates
Inner salt of alkyl amines	Proprietary	EC50 (96 h) 0.55 mg/L (Desmodesmus subspicatus) EC50 (72 h) 17.2 mg/L (Scenedesmus subspicatus) EC50 (72 h) 9.86 mg/L (Scenedesmus subspicatus) EC50 (72 h) 30 mg/L (Scenedesmus subspicatus)	LC50 (96 h) 2 mg/L (Brachydanio rerio) NOEC (28 d) 16 mg/L (Oncorhynchus mykiss)	No information available	EC50 (48 h) 6.5 mg/L (Daphnia magna) NOEC (21 d) 0.9 mg/L (Daphnia magna) NOEC (21 d) 0.932 mg/L (Daphnia magna) NOEC (21 d) 2.98 mg/L (Daphnia magna) NOEC (21 d) 0.03 mg/L (Daphnia magna) NOEC (21 d) 0.065 mg/L (Daphnia magna)

12.2. Persistence and degradability

Substances	CAS Number	Persistence and Degradability
Inner salt of alkyl amines	Proprietary	Readily biodegradable (>90% @ 28d)

12.3. Bioaccumulative potential

Substances	CAS Number	Log Pow
Inner salt of alkyl amines	Proprietary	Log Pow =0.9

12.4. Mobility in soil

Substances	CAS Number	Mobility
Inner salt of alkyl amines	Proprietary	No information available

12.6. Other adverse effects

Endocrine Disruptor Information

This product does not contain any known or suspected endocrine disruptors

13. Disposal Considerations

Safe handling and disposal methods

Follow all applicable community, national or regional regulations regarding waste management methods.

Disposal of any contaminated packaging

Follow all applicable national or local regulations.

Environmental regulations

Not applicable

14. Transport Information

Transportation Information

Australia ADG

UN Number UN3082
UN proper shipping name: Environmentally Hazardous Substance, Liquid, N.O.S. (Contains Inner salt of alkyl amines)
Transport Hazard Class(es): 9
Packing Group: III
Environmental Hazards: Marine Pollutant

IMDG/IMO

UN Number	UN3082
UN proper shipping name:	Environmentally Hazardous Substance, Liquid, N.O.S. (Contains Inner salt of alkyl amines)
Transport Hazard Class(es):	9
Packing Group:	III
Environmental Hazards:	Marine Pollutant
EMS:	EmS F-A, S-F

IATA/ICAO

UN Number	UN3082
UN proper shipping name:	Environmentally Hazardous Substance, Liquid, N.O.S. (Contains Inner salt of alkyl amines)
Transport Hazard Class(es):	9
Packing Group:	III
Environmental Hazards:	Marine Pollutant

Special precautions during transport
None

HazChem Code
None Allocated

15. Regulatory Information

Safety, health and environmental regulations specific for the product

International Inventories

Australian AICS Inventory	All components are listed on the AICS or are subject to a relevant exemption, permit, or assessment certificate.
New Zealand Inventory of Chemicals	All components are listed on the NZIoC or are subject to a relevant exemption, permit, or assessment certificate.
EINECS (European Inventory of Existing Chemical Substances)	This product does not comply with EINECS
US TSCA Inventory	All components listed on inventory or are exempt.
Canadian Domestic Substances List (DSL)	All components listed on inventory or are exempt.

Poisons Schedule number
None Allocated

International Agreements

Montreal Protocol - Ozone Depleting Substances:	Does not apply.
Stockholm Convention - Persistent Organic Pollutants:	Does not apply
Rotterdam Convention - Prior Informed Consent:	Does not apply.
Basel Convention - Hazardous Waste:	Does not apply.

16. Other information

Date of preparation or review

Revision Date: 12-Jun-2018

Revision Note
SDS sections updated:
2

Full text of H-Statements referred to under sections 2 and 3
H318 - Causes serious eye damage
H401 - Toxic to aquatic life
H411 - Toxic to aquatic life with long lasting effects

Additional information For additional information on the use of this product, contact your local Halliburton representative.

For questions about the Safety Data Sheet for this or other Halliburton products, contact Chemical Stewardship at 1-580-251-4335.

Key abreviations or acronyms used

bw – body weight
CAS – Chemical Abstracts Service
EC50 – Effective Concentration 50%
LC50 – Lethal Concentration 50%
LD50 – Lethal Dose 50%
LL50 – Lethal Loading 50%
mg/kg – milligram/kilogram
mg/L – milligram/liter
NOEC – No Observed Effect Concentration
OEL – Occupational Exposure Limit
PBT – Persistent Bioaccumulative and Toxic
ppm – parts per million
STEL – Short Term Exposure Limit
TWA – Time-Weighted Average
vPvB – very Persistent and very Bioaccumulative
h - hour
mg/m^3 - milligram/cubic meter
mm - millimeter
mmHg - millimeter mercury
w/w - weight/weight
d - day

Key literature references and sources for data

www.ChemADVISOR.com/

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End of Safety Data Sheet

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A HALLIBURTON SERVICE

SAFETY DATA SHEET

HYDROCHLORIC ACID 32%

Revision Date: 01-Sep-2016 **Revision Number:** 2

1. Product Identifier & Identity for the Chemical

Statement of Hazardous Nature Hazardous according to the criteria of the 3rd Revised Edition of the Globally Harmonised System of Classification and Labelling of Chemicals (GHS), Dangerous Goods according to the criteria of ADG.

1.1. Product Identifier

Product Name HYDROCHLORIC ACID 32%

Other means of Identification

Synonyms None

Hazardous Material Number: MC600136

Recommended use of the chemical and restrictions on use

Recommended Use Solvent

Uses advised against No information available

Supplier's name, address and phone number

Manufacturer/Supplier

Multi-Chem Mintech
1 Ward Road
East Rockingham
WA 6168
Australia

Telephone Number: 61 (08) 9419 5300
Fax Number: 61 (08) 9439 1055
Emergency Telephone Number: + 61 1 800 686 951

E-mail Address fdunexchem@halliburton.com

Emergency phone number

+ 61 1 800 686 951

Australian Poisons Information Centre

24 Hour Service: - 13 11 26

Police or Fire Brigade: - 000 (exchange): - 1100

2. Hazard Identification

Statement of Hazardous Nature Hazardous according to the criteria of the 3rd Revised Edition of the Globally Harmonised System of Classification and Labelling of Chemicals (GHS), Dangerous Goods according to the criteria of ADG.

Classification of the hazardous chemical

Acute inhalation toxicity - vapor	Category 4 - H332
Skin Corrosion/Irritation	Category 1 - H314
Serious Eye Damage/Irritation	Category 1 - H318
Specific Target Organ Toxicity - (Single Exposure)	Category 3 - H335
Substances/mixtures corrosive to metal	Category 1 - H290

Label elements, including precautionary statements

Hazard pictograms

Signal Word Danger

Hazard Statements:
H290 - May be corrosive to metals
H314 - Causes severe skin burns and eye damage
H318 - Causes serious eye damage
H331 - Toxic if inhaled
H335 - May cause respiratory irritation

Precautionary Statements

Prevention
P103 - Read label before use
P234 - Keep only in original container
P260 - Do not breathe dust/fume/gas/mist/vapors/spray
P271 - Use only outdoors or in a well-ventilated area
P280 - Wear protective gloves/protective clothing/eye protection/face protection

Response
P301 + P330 + P331 - IF SWALLOWED: rinse mouth. Do NOT induce vomiting
P303 + P361 + P353 - IF ON SKIN (or hair): Take off immediately all contaminated clothing. Rinse skin with water/shower
P363 - Wash contaminated clothing before reuse
P304 + P340 - IF INHALED: Remove victim to fresh air and keep at rest in a position comfortable for breathing
P310 - Immediately call a POISON CENTER or doctor/physician
P305 + P351 + P338 - IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing
P390 - Absorb spillage to prevent material damage

Storage
P403 + P233 - Store in a well-ventilated place. Keep container tightly closed
P405 - Store locked up
P406 - Store in corrosive resistant container with a resistant inner liner.

Disposal
P501 - Dispose of contents/container in accordance with local/regional/national/international regulations

Contains Substances	**CAS Number**
Hydrochloric acid	7647-01-0

Other hazards which do not result in classification
Chronic exposure to corrosive fumes/gases may cause erosion of the teeth followed by jaw necrosis. Bronchial irritation with chronic cough and frequent attacks of pneumonia are common. Gastrointestinal disturbances may also be seen
This mixture contains no substance considered to be persistent, bioaccumulating nor toxic (PBT).
This mixture contains no substance considered to be very persistent nor very bioaccumulating (vPvB).

For the full text of the H-phrases mentioned in this Section, see Section 16

3. Composition/information on Ingredients

Substances	CAS Number	PERCENT (w/w)	GHS Classification - Australia
Hydrochloric acid	7647-01-0	30 - 60%	Acute Tox. 3 (H331) Skin Corr. 1A (H314)

			Eye Corr. 1 (H318) STOT SE 3 (H335) Met. Corr. 1 (H290)

4. First aid measures

Description of necessary first aid measures

Inhalation If inhaled, move victim to fresh air and seek medical attention.

Eyes In case of contact, or suspected contact, immediately flush eyes with plenty of water for at least 15 minutes and get medical attention immediately after flushing.

Skin In case of contact, immediately flush skin with plenty of soap and water for at least 15 minutes. Get medical attention. Remove contaminated clothing and launder before reuse.

Ingestion Do NOT induce vomiting. Give nothing by mouth. Obtain immediate medical attention.

Symptoms caused by exposure

Causes severe eye irritation which may damage tissue. Causes severe skin irritation with tissue destruction. May cause respiratory irritation. Harmful if inhaled.

Medical Attention and Special Treatment

Notes to Physician Treat symptomatically

5. Fire Fighting Measures

Suitable extinguishing equipment

Suitable Extinguishing Media

Water fog, carbon dioxide, foam, dry chemical.

Extinguishing media which must not be used for safety reasons

None known.

Specific hazards arising from the chemical

Special exposure hazards in a fire

May form explosive mixtures with strong alkalis. Decomposition in fire may produce harmful gases. Reaction with steel and certain other metals generates flammable hydrogen gas. Do not allow runoff to enter waterways.

Special protective equipment and precautions for fire fighters

Special protective equipment for firefighters

Full protective clothing and approved self-contained breathing apparatus required for fire fighting personnel.

6. Accidental release measures

6.1. Personal precautions, protective equipment and emergency procedures

Use appropriate protective equipment. Ensure adequate ventilation. Avoid contact with skin, eyes and clothing. Avoid breathing vapors. Evacuate all persons from the area.

6.2. Environmental precautions

Prevent from entering sewers, waterways, or low areas. Consult local authorities.

6.3. Methods and material for containment and cleaning up

Isolate spill and stop leak where safe. Contain spill with sand or other inert materials. Neutralize to pH of 6-8. Scoop up and remove.

7. Handling and storage

7.1. Precautions for safe handling

Handling Precautions

Avoid contact with eyes, skin, or clothing. Avoid breathing vapors. Ensure adequate ventilation. Wash hands after use. Launder

contaminated clothing before reuse. Use appropriate protective equipment.

Hygiene Measures

Handle in accordance with good industrial hygiene and safety practice.

7.2. Conditions for safe storage, including any incompatibilities

Storage Information

Store away from alkalis. Store in a cool well ventilated area. Keep container closed when not in use. Store locked up. Product has a shelf life of 24 months.

Other Guidelines

No information available

8. Exposure Controls/Personal Protection

Control parameters - exposure standards, biological monitoring

Exposure Limits

Substances	CAS Number	Australia NOHSC	ACGIH TLV-TWA
Hydrochloric acid	7647-01-0	5 ppm	TWA: 2 ppm (Ceiling)

Appropriate engineering controls

Engineering Controls Use in a well ventilated area. Local exhaust ventilation should be used in areas without good cross ventilation.

Personal protective equipment (PPE)

Personal Protective Equipment If engineering controls and work practices cannot prevent excessive exposures, the selection and proper use of personal protective equipment should be determined by an industrial hygienist or other qualified professional based on the specific application of this product.

Respiratory Protection If engineering controls and work practices cannot keep exposure below occupational exposure limits or if exposure is unknown, wear a NIOSH certified, European Standard EN 149, AS/NZS 1715:2009, or equivalent respirator when using this product. Selection of and instruction on using all personal protective equipment, including respirators, should be performed by an Industrial Hygienist or other qualified professional.
Acid gas respirator.

Hand Protection Chemical-resistant protective gloves (EN 374) Suitable materials for longer, direct contact (recommended: protection index 6, corresponding to > 480 minutes permeation time as per EN 374): Butyl rubber gloves. (>= 0.7 mm thickness)
This information is based on literature references and on information provided by glove manufacturers, or is derived by analogy with similar substances. Please note that in practice the working life of chemical-resistant protective gloves may be considerably shorter than the permeation time determined in accordance with EN 374 as a result of the many influencing factors (e.g. temperature). If signs of wear and tear are noticed then the gloves should be replaced. Manufacturer's directions for use should be observed because of great diversity of types.

Skin Protection Full protective chemical resistant clothing. Rubber boots

Eye Protection Chemical goggles; also wear a face shield if splashing hazard exists.

Other Precautions Eyewash fountains and safety showers must be easily accessible.

Environmental Exposure Controls Do not allow material to contaminate ground water system

9. Physical and Chemical Properties

9.1. Information on basic physical and chemical properties

Physical State: Liquid
Color Clear colorless
Odor: Pungent acrid
Odor Threshold: No information available

Property	Values	Remarks/ - Method
pH:	0.8	
Freezing Point / Range	-46 °C	
Melting Point / Range	No data available	
Boiling Point / Range	110 °C / 230 °F	

Flash Point	No data available
Evaporation rate	No data available
Vapor Pressure	26
Vapor Density	No data available
Specific Gravity	1.18
Water Solubility	Soluble in water
Solubility in other solvents	No data available
Partition coefficient: n-octanol/water	No data available
Autoignition Temperature	No data available
Decomposition Temperature	No data available
Viscosity	No data available
Explosive Properties	No information available
Oxidizing Properties	No information available

9.2. Other information

Molecular Weight	36.5
VOC Content (%)	No data available

10. Stability and Reactivity

10.1. Reactivity
Not expected to be reactive.
10.2. Chemical stability
Stable
10.3. Possibility of hazardous reactions
Will Not Occur
10.4. Conditions to avoid
None anticipated
10.5. Incompatible materials
Strong alkalis.
10.6. Hazardous decomposition products
Flammable hydrogen gas. Chlorine. Hydrogen sulfide.

11. Toxicological Information

Information on routes of exposure
Principle Route of Exposure Eye or skin contact, inhalation.

Symptoms related to exposure
Most Important Symptoms/Effects
Causes severe eye irritation which may damage tissue. Causes severe skin irritation with tissue destruction. May cause respiratory irritation. Harmful if inhaled.

Numerical measures of toxicity

Toxicology data for the components

Substances	CAS Number	LD50 Oral	LD50 Dermal	LC50 Inhalation
Hydrochloric acid	7647-01-0	No data available	No data available	No data available

Immediate, delayed and chronic health effects from exposure

Inhalation	Harmful if inhaled. Causes severe respiratory irritation.
Eye Contact	Causes eye burns
Skin Contact	Causes severe burns. Did not cause sensitization on laboratory animals (guinea pig)
Ingestion	Causes burns of the mouth, throat and stomach.

Chronic Effects/Carcinogenicity Prolonged, excessive exposure may cause erosion of the teeth.

Exposure Levels
No data available

Interactive effects

Skin disorders.

Data limitations
No data available

Substances	CAS Number	Skin corrosion/irritation
Hydrochloric acid	7647-01-0	Causes severe burns Causes severe skin irritation with tissue destruction.

Substances	CAS Number	Serious eye damage/irritation
Hydrochloric acid	7647-01-0	Causes severe burns Causes severe eye irritation. Will damage tissue.

Substances	CAS Number	Skin Sensitization
Hydrochloric acid	7647-01-0	Did not cause sensitization on laboratory animals (guinea pig)

Substances	CAS Number	Respiratory Sensitization
Hydrochloric acid	7647-01-0	No information available

Substances	CAS Number	Mutagenic Effects
Hydrochloric acid	7647-01-0	Not regarded as mutagenic. In vitro tests did not show mutagenic effects.

Substances	CAS Number	Carcinogenic Effects
Hydrochloric acid	7647-01-0	No data of sufficient quality are available.

Substances	CAS Number	Reproductive toxicity
Hydrochloric acid	7647-01-0	Embryo and fetotoxicity has been observed in female rats exposed to maternally toxic levels of hydrogen chloride (450 mg/m^3, 1hr.). When tested at maternally toxic doses, no adverse effects on fertility, teratogenicity, or development were observed.

Substances	CAS Number	STOT - single exposure
Hydrochloric acid	7647-01-0	May cause respiratory irritation. No information available

Substances	CAS Number	STOT - repeated exposure
Hydrochloric acid	7647-01-0	No significant toxicity observed in animal studies at concentration requiring classification.

Substances	CAS Number	Aspiration hazard
Hydrochloric acid	7647-01-0	Not applicable

12. Ecological Information

Ecotoxicity
Product Ecotoxicity Data
No data available

Substance Ecotoxicity Data

Substances	CAS Number	Toxicity to Algae	Toxicity to Fish	Toxicity to Microorganisms	Toxicity to Invertebrates
Hydrochloric acid	7647-01-0	No information available	LC50 282 mg/L (Gambusia affinis) LC50 20.5 mg/L (Lepomis macrochirus) LC50 (96h) 3.25 – 3.5 (pH) (Lepomis macrochirus)	EC50 (3h) >= 5 and <= 5.5 (pH) (Activated sludge, domestic)	EC50 (48 h) 4.92 mg/L (Daphnia magna)

12.2. Persistence and degradability
The methods for determining biodegradability are not applicable to inorganic substances.

Substances	CAS Number	Persistence and Degradability
Hydrochloric acid	7647-01-0	The methods for determining biodegradability are not applicable to inorganic substances.

12.3. Bioaccumulative potential
Does not bioaccumulate.

Substances	CAS Number	Log Pow
Hydrochloric acid	7647-01-0	LogKow -2.65

12.4. Mobility in soil

Substances	CAS Number	Mobility
Hydrochloric acid	7647-01-0	No information available

12.6. Other adverse effects

Endocrine Disruptor Information

This product does not contain any known or suspected endocrine disruptors

13. Disposal Considerations

Safe handling and disposal methods

Disposal should be made in accordance with federal, state, and local regulations. Substance should NOT be deposited into a sewage facility.

Disposal of any contaminated packaging

Follow all applicable national or local regulations.

Environmental regulations

Not applicable

14. Transport Information

Transportation Information

Australia ADG

UN Number UN1789
UN proper shipping name: Hydrochloric Acid Solution
Transport Hazard Class(es): 8
Packing Group: II
Environmental Hazards: Not applicable

IMDG/IMO

UN Number UN1789
UN proper shipping name: Hydrochloric Acid Solution
Transport Hazard Class(es): 8
Packing Group: II
Environmental Hazards: Not applicable
EMS: EmS F-A, S-B

IATA/ICAO

UN Number UN1789
UN proper shipping name: Hydrochloric Acid Solution
Transport Hazard Class(es): 8
Packing Group: II
Environmental Hazards: Not applicable

Special precautions during transport

None

HazChem Code

2R

15. Regulatory Information

Safety, health and environmental regulations specific for the product

International Inventories

Australian AICS Inventory	All components are listed on the AICS or are subject to a relevant exemption, permit, or assessment certificate.
New Zealand Inventory of Chemicals	All components are listed on the NZIoC or are subject to a relevant exemption, permit, or assessment certificate.
EINECS (European Inventory of Existing Chemical Substances)	This product, and all its components, complies with EINECS
US TSCA Inventory	All components listed on inventory or are exempt.
Canadian Domestic Substances List (DSL)	All components listed on inventory or are exempt.

Poisons Schedule number
S6

International Agreements

Montreal Protocol - Ozone Depleting Substances:	Does not apply
Stolkhom Convention - Persistent Organic Pollutants:	Does not apply
Rotterdam Convention - Prior Informed Consent:	Does not apply
Basel Convention - Hazardous Waste:	Does not apply

16. Other information

Date of preparation or review

Revision Date: 01-Sep-2016

Revision Note
SDS sections updated: 2

Full text of H-Statements referred to under sections 2 and 3
H290 - May be corrosive to metals
H314 - Causes severe skin burns and eye damage
H318 - Causes serious eye damage
H331 - Toxic if inhaled
H332 - Harmful if inhaled
H335 - May cause respiratory irritation

Additional information For additional information on the use of this product, contact your local Halliburton representative.

For questions about the Safety Data Sheet for this or other Halliburton products, contact Chemical Stewardship at 1-580-251-4335.

Key abreviations or acronyms used
bw – body weight
CAS – Chemical Abstracts Service
EC50 – Effective Concentration 50%
LC50 – Lethal Concentration 50%
LD50 – Lethal Dose 50%
LL50 – Lethal Loading 50%
mg/kg – milligram/kilogram
mg/L – milligram/liter
NOEC – No Observed Effect Concentration
OEL – Occupational Exposure Limit
PBT – Persistent Bioaccumulative and Toxic
ppm – parts per million
STEL – Short Term Exposure Limit
TWA – Time-Weighted Average
vPvB – very Persistent and very Bioaccumulative
h - hour
mg/m^3 - milligram/cubic meter
mm - millimeter
mmHg - millimeter mercury

w/w - weight/weight
d - day

Key literature references and sources for data
www.ChemADVISOR.com/
NZ CCID

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End of Safety Data Sheet

HALLIBURTON

SAFETY DATA SHEET

MSA-III US

Revision Date: 25-Jan-2017 **Revision Number:** 14

1. Product Identifier & Identity for the Chemical

Statement of Hazardous Nature Hazardous according to the criteria of the 3rd Revised Edition of the Globally Harmonised System of Classification and Labelling of Chemicals (GHS), Dangerous Goods according to the criteria of ADG.

1.1. Product Identifier

Product Name MSA-III US

Other means of Identification

Synonyms None

Hazardous Material Number: HM005253

Recommended use of the chemical and restrictions on use

Recommended Use Corrosion Inhibitor

Uses advised against Consumer use

Supplier's name, address and phone number

Manufacturer/Supplier Halliburton Australia Pty. Ltd.
15 Marriott Road, Jandakot, WA 6164
Australia
ACN Number: 009 000 775
Telephone Number: + 61 1 800 686 951
Fax Number: 61 (08) 9455 5300

E-mail Address fdunexchem@halliburton.com

Emergency phone number

+ 61 1 800 686 951
Global Incident Response Access Code: 334305
Contract Number: 14012

Australian Poisons Information Centre
24 Hour Service: - 13 11 26
Police or Fire Brigade: - 000 (exchange): - 1100

2. Hazard Identification

Statement of Hazardous Nature Hazardous according to the criteria of the 3rd Revised Edition of the Globally Harmonised System of Classification and Labelling of Chemicals (GHS), Dangerous Goods according to the criteria of ADG.

Classification of the hazardous chemical

Acute Oral Toxicity	Category 4 - H302
Skin Corrosion/Irritation	Category 1 - H314
Serious Eye Damage/Irritation	Category 1 - H318
Specific Target Organ Toxicity - (Single Exposure)	Category 3 - H336
Acute Aquatic Toxicity	Category 3 - H402
Chronic Aquatic Toxicity	Category 3 - H412
Flammable liquids.	Category 2 - H225

Label elements, including precautionary statements

Hazard Pictograms

(Bad file name)

Signal Word DANGER

Hazard Statements:
H225 - Highly flammable liquid and vapor
H302 - Harmful if swallowed
H314 - Causes severe skin burns and eye damage
H318 - Causes serious eye damage
H336 - May cause drowsiness or dizziness
H402 - Harmful to aquatic life
H412 - Harmful to aquatic life with long lasting effects

Precautionary Statements

Prevention
P210 - Keep away from heat, hot surfaces, sparks, open flames and other ignition sources. No smoking.
P233 - Keep container tightly closed
P240 - Ground and bond container and receiving equipment.
P241 - Use explosion-proof electrical/ventilating/lighting/equipment
P242 - Use only non-sparking tools
P243 - Take action to prevent static discharges.
P260 - Do not breathe dust/fume/gas/mist/vapors/spray
P264 - Wash face, hands and any exposed skin thoroughly after handling
P270 - Do not eat, drink or smoke when using this product
P271 - Use only outdoors or in a well-ventilated area
P280 - Wear protective gloves/protective clothing/eye protection/face protection

Response
P301 + P312 - IF SWALLOWED: Call a POISON CENTER or doctor/physician if you feel unwell
P330 - Rinse mouth
P303 + P361 + P353 - IF ON SKIN (or hair): Take off immediately all contaminated clothing. Rinse skin with water [or shower].
P363 - Wash contaminated clothing before reuse
P312 - Call a POISON CENTER or doctor/physician if you feel unwell
P310 - Immediately call a POISON CENTER or doctor/physician
P305 + P351 + P338 - IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing
P370 + P378 - In case of fire: Use water spray for extinction
P304 + P340 - IF INHALED: Remove victim to fresh air and keep at rest in a position comfortable for breathing

Storage
P403 + P233 - Store in a well-ventilated place. Keep container tightly closed
P403 + P235 - Store in a well-ventilated place. Keep cool
P405 - Store locked up

Disposal
P501 - Dispose of contents/container in accordance with local/regional/national/international regulations

Contains

Substances	**CAS Number**
Isopropanol	67-63-0
Rosin amines	61790-47-4
Thioglycolic acid	68-11-1
Ethoxylated alkyl amines	Proprietary

Other hazards which do not result in classification
None known

For the full text of the H-phrases mentioned in this Section, see Section 16

3. Composition/information on Ingredients

Substances	CAS Number	PERCENT (w/w)	GHS Classification - Australia
Isopropanol	67-63-0	30 - 60%	Eye Irrit. 2 (H319) STOT SE 3 (H336) Flam. Liq. 2 (H225)
Rosin amines	61790-47-4	10 - 30%	Acute Tox. 4 (H302) Skin Corr. 1C (H314) Eye Corr. 1 (H318)
Thioglycolic acid	68-11-1	10 - 30%	Acute Tox. 3 (H301) Acute Tox. 3 (H311) Acute Tox. 2 (H330) Skin Corr. 1B (H314) Eye Corr. 1 (H318) Skin Sens. 1 (H317) STOT SE 3 (H335) STOT RE 2 (H373) Aquatic Acute 3 (H402)
Ethoxylated alkyl amines	Proprietary	5 - 10%	Acute Tox. 4 (H302) Skin Irrit. 2 (H315) Eye Corr. 1 (H318) Aquatic Acute 2 (H401) Aquatic Chronic 2 (H411)

4. First aid measures

Description of necessary first aid measures

Inhalation If inhaled, move victim to fresh air and seek medical attention.

Eyes In case of contact, immediately flush eyes with plenty of water for at least 30 minutes. Remove contact lenses after the first 5 minutes and continue washing. Seek immediate medical attention/advice. Suitable emergency eye wash facility should be immediately available

Skin Remove contaminated clothing and launder before reuse. Remove contaminated shoes and discard. In case of contact, immediately flush skin with plenty of soap and water for at least 30 minutes and remove contaminated clothing, shoes and leather goods immediately. Get medical attention immediately.

Ingestion Do NOT induce vomiting. Give nothing by mouth. Obtain immediate medical attention.

Symptoms caused by exposure

Causes severe eye irritation which may damage tissue. Causes severe skin irritation with tissue destruction. Harmful if swallowed. May cause headache, dizziness, and other central nervous system effects.

Medical Attention and Special Treatment

Notes to Physician Treat symptomatically

5. Fire Fighting Measures

Suitable extinguishing equipment

Suitable Extinguishing Media

Water fog, carbon dioxide, foam, dry chemical.

Extinguishing media which must not be used for safety reasons

None known.

Specific hazards arising from the chemical

Special exposure hazards in a fire
May be ignited by heat, sparks or flames Use water spray to cool fire exposed surfaces. Closed containers may explode in fire. Decomposition in fire may produce harmful gases. Fight fire from a safe distance and from a protected location.

Special protective equipment and precautions for fire fighters
Special protective equipment for firefighters
Full protective clothing and approved self-contained breathing apparatus required for fire fighting personnel.

6. Accidental release measures

6.1. Personal precautions, protective equipment and emergency procedures
Remove sources of ignition. Evacuate all persons from the area. Use only competent persons for cleanup. Use appropriate protective equipment. Avoid contact with skin, eyes and clothing. Avoid breathing vapors. Ensure adequate ventilation.

6.2. Environmental precautions
Prevent from entering sewers, waterways, or low areas. Prevent contamination of soil.

6.3. Methods and material for containment and cleaning up
Isolate spill and stop leak where safe. Remove ignition sources and work with non-sparking tools. Neutralize to pH of 6-8. Contain spill with sand or other inert materials. Scoop up and remove.

7. Handling and storage

7.1. Precautions for safe handling
Handling Precautions
Avoid contact with eyes, skin, or clothing. Avoid breathing vapors. Wash hands after use. Launder contaminated clothing before reuse. Ground and bond containers when transferring from one container to another.
Hygiene Measures
Handle in accordance with good industrial hygiene and safety practice.

7.2. Conditions for safe storage, including any incompatibilities
Storage Information
Store away from oxidizers. Store away from alkalis. Keep from heat, sparks, and open flames. Keep container closed when not in use. Product has a shelf life of 24 months.
Other Guidelines
No information available

8. Exposure Controls/Personal Protection

Control parameters - exposure standards, biological monitoring
Exposure Limits

Substances	CAS Number	Australia NOHSC	ACGIH TLV-TWA
Isopropanol	67-63-0	TWA: 400 ppm TWA: 983 mg/m^3 STEL: 500 ppm STEL: 1230 mg/m^3	TWA: 200 ppm STEL: 400 ppm
Rosin amines	61790-47-4	Not applicable	Not applicable
Thioglycolic acid	68-11-1	TWA: 1 ppm TWA: 3.8 mg/m^3	TWA: 1 ppm
Ethoxylated alkyl amines	Proprietary	Not applicable	Not applicable

Appropriate engineering controls
Engineering Controls Use in a well ventilated area. Local exhaust ventilation should be used in areas without good cross ventilation.

Personal protective equipment (PPE)
Personal Protective Equipment If engineering controls and work practices cannot prevent excessive exposures, the selection and proper use of personal protective equipment should be determined by an industrial hygienist or other qualified professional based on the specific application of this

	product.
Respiratory Protection	Organic vapor/acid gas respirator. Positive pressure self-contained breathing apparatus in enclosed areas.
Hand Protection	Impervious rubber gloves.
Skin Protection	Rubber apron.
Eye Protection	Chemical goggles; also wear a face shield if splashing hazard exists.
Other Precautions	Eyewash fountains and safety showers must be easily accessible.
Environmental Exposure Controls	No information available

9. Physical and Chemical Properties

9.1. Information on basic physical and chemical properties

Physical State:	Liquid	**Color**	Light amber
Odor:	Strong	**Odor Threshold:**	No information available

Property Remarks/ - Method	Values
pH:	2.1-2.3
Freezing Point / Range	No data available
Melting Point / Range	No data available
Boiling Point / Range	No data available
Flash Point	6 °C / 43 °F Tag Closed Cup (TCC)
Evaporation rate	> 1
Vapor Pressure	83.8 - 102.4 mm Hg
Vapor Density	> 1
Specific Gravity	0.934 - 0.946
Water Solubility	Dispersible
Solubility in other solvents	No data available
Partition coefficient: n-octanol/water	No data available
Autoignition Temperature	No data available
Decomposition Temperature	No data available
Viscosity	No data available
Explosive Properties	No information available
Oxidizing Properties	No information available

9.2. Other information

VOC Content (%)	No data available

10. Stability and Reactivity

10.1. Reactivity
Not expected to be reactive.
10.2. Chemical stability
Stable
10.3. Possibility of hazardous reactions
Will Not Occur
10.4. Conditions to avoid
Keep away from heat, sparks and flame.
10.5. Incompatible materials
Strong oxidizers. Strong alkalis.
10.6. Hazardous decomposition products
Oxides of nitrogen. Oxides of sulfur. Hydrogen chloride. Carbon monoxide and carbon dioxide.

11. Toxicological Information

Information on routes of exposure

Principle Route of Exposure	Eye or skin contact, inhalation.

Symptoms related to exposure

Most Important Symptoms/Effects
Causes severe eye irritation which may damage tissue. Causes severe skin irritation with tissue destruction. Harmful

if swallowed. May cause headache, dizziness, and other central nervous system effects.

Toxicology data for the components

Substances	CAS Number	LD50 Oral	LD50 Dermal	LC50 Inhalation
Isopropanol	67-63-0	5840 mg/kg-bw (rat)	12870 mg/kg-bw (rabbit)	72.6 mg/L (Rat, 4h, vapor)
Rosin amines	61790-47-4	2500 mg/kg (rat) (similar substance) 700 mg/kg (guinea pig) (similar substance)	No data available	No data available
Thioglycolic acid	68-11-1	73 mg/kg-bw (rat)	848 mg/kg-bw (rabbit)	1.388 mg/L (rat, 4 hr, aerosol)
Ethoxylated alkyl amines	Proprietary	1200 mg/kg-bw (rat) (similar substance)	> 1260 mg/kg (rabbits) (similar substance)	No data available

Immediate, delayed and chronic health effects from exposure

Inhalation Massive inhalation immediately dangerous to life and health. Causes severe respiratory irritation. May cause central nervous system depression including headache, dizziness, drowsiness, incoordination, slowed reaction time, slurred speech, giddiness and unconsciousness.

Eye Contact Causes severe eye burns.

Skin Contact Causes severe burns. May be absorbed through the skin and produce effects similar to those caused by inhalation and/or ingestion.

Ingestion Harmful if swallowed. Causes burns of the mouth, throat and stomach. May cause headache, dizziness, nausea, vomiting, gastrointestinal irritation and central nervous system depression.

Chronic Effects/Carcinogenicity No data available to indicate product or components present at greater than 0.1% are chronic health hazards.

Exposure Levels

No data available

Interactive effects

Skin disorders. Lung disorders.

Data limitations

No data available

Substances	CAS Number	Skin corrosion/irritation
Isopropanol	67-63-0	Non-irritating to the skin (Rabbit)
Rosin amines	61790-47-4	Skin, rabbit: Causes burns
Thioglycolic acid	68-11-1	Corrosive to skin
Ethoxylated alkyl amines		Causes moderate skin irritation. (similar substances)

Substances	CAS Number	Serious eye damage/irritation
Isopropanol	67-63-0	Causes moderate eye irritation (Rabbit)
Rosin amines	61790-47-4	Causes eye burns
Thioglycolic acid	68-11-1	Corrosive to eyes
Ethoxylated alkyl amines		Causes severe eye irritation. Will damage tissue. (similar substances)

Substances	CAS Number	Skin Sensitization
Isopropanol	67-63-0	Did not cause sensitization on laboratory animals (guinea pig)
Rosin amines	61790-47-4	May cause sensitization by skin contact
Thioglycolic acid	68-11-1	Not regarded as a sensitizer.
Ethoxylated alkyl amines		No information available

Substances	CAS Number	Respiratory Sensitization
Isopropanol	67-63-0	No information available
Rosin amines	61790-47-4	No information available
Thioglycolic acid	68-11-1	No information available
Ethoxylated alkyl amines		No information available

Substances	CAS Number	Mutagenic Effects
Isopropanol	67-63-0	In vitro tests did not show mutagenic effects. In vivo tests did not show mutagenic effects.
Rosin amines	61790-47-4	No information available
Thioglycolic acid	68-11-1	In vitro tests did not show mutagenic effects. In vivo tests did not show mutagenic effects.
Ethoxylated alkyl amines		In vitro tests did not show mutagenic effects. In vivo tests did not show mutagenic effects. (similar substances)

Substances	CAS Number	Carcinogenic Effects
Isopropanol	67-63-0	Did not show carcinogenic effects in animal experiments
Rosin amines	61790-47-4	No information available
Thioglycolic acid	68-11-1	Did not show carcinogenic effects in animal experiments
Ethoxylated alkyl amines		No information available

Substances	CAS Number	Reproductive toxicity
Isopropanol	67-63-0	Animal testing did not show any effects on fertility.
Rosin amines	61790-47-4	No information available
Thioglycolic acid	68-11-1	Animal testing did not show any effects on fertility. Did not show teratogenic effects in animal experiments.
Ethoxylated alkyl amines		No data of sufficient quality are available.

Substances	CAS Number	STOT - single exposure
Isopropanol	67-63-0	May cause headache, dizziness, and other central nervous system effects.
Rosin amines	61790-47-4	May cause respiratory irritation.
Thioglycolic acid	68-11-1	May cause respiratory irritation.
Ethoxylated alkyl amines		No information available

Substances	CAS Number	STOT - repeated exposure
Isopropanol	67-63-0	No significant toxicity observed in animal studies at concentration requiring classification. (similar substances)
Rosin amines	61790-47-4	No information available
Thioglycolic acid	68-11-1	Not applicable due to corrosivity of the substance.
Ethoxylated alkyl amines		No significant toxicity observed in animal studies at concentration requiring classification.

Substances	CAS Number	Aspiration hazard
Isopropanol	67-63-0	Not applicable
Rosin amines	61790-47-4	No information available
Thioglycolic acid	68-11-1	Not applicable
Ethoxylated alkyl amines		No information available

12. Ecological Information

Ecotoxicity

Substance Ecotoxicity Data

Substances	CAS Number	Toxicity to Algae	Toxicity to Fish	Toxicity to Microorganisms	Toxicity to Invertebrates
Isopropanol	67-63-0	EC50 (72h) > 1000 mg/L (Desmodesmus subspicatus) EC50 (7d) 1800 mg/L (Scenedesmus quadricauda)	LC50 (96h) 9640 mg/L (Pimephales promelas) LC50 (7d) 7060 mg/L (Poecilia reticulata)	TT (16h) 1050 mg/L (Pseudomonas putida)	EC50 (48h) 13,299 mg/L (Daphnia magna) EC50 (24h) > 10,000 mg/L (Daphnia magna)
Rosin amines	61790-47-4	No information available	No information available	No information available	No information available
Thioglycolic acid	68-11-1	EC50 (72h) > 100 mg/L (Scenedesmus subspicatus) (similar substance)	LC50 (96h) > 100 mg/L (Oncorhynchus mykiss)	EC50 (3h) 530 mg/L (Activated sludge) (similar substance)	EC50 (48h) 38 mg/L (Daphnia magna)
Ethoxylated alkyl amines	Proprietary	No information available	LC50 (96h) 4.31 mg/L (Danio rerio)	No information available	LC50 (48h) 12.1 mg/L (Daphnia magna)

12.2. Persistence and degradability

Substances	CAS Number	Persistence and Degradability
Isopropanol	67-63-0	Readily biodegradable (53% @ 5d)

Rosin amines	61790-47-4	No information available
Thioglycolic acid	68-11-1	(67% @ 28d)
Ethoxylated alkyl amines	Proprietary	(27% @ 28d)

12.3. Bioaccumulative potential

Substances	CAS Number	Log Pow
Isopropanol	67-63-0	0.05
Rosin amines	61790-47-4	Log Kow = 6.29
Thioglycolic acid	68-11-1	Log Pow <0
Ethoxylated alkyl amines	Proprietary	No information available

12.4. Mobility in soil

Substances	CAS Number	Mobility
Isopropanol	67-63-0	No information available
Rosin amines	61790-47-4	No information available
Thioglycolic acid	68-11-1	No information available
Ethoxylated alkyl amines	Proprietary	No information available

12.6. Other adverse effects

Endocrine Disruptor Information

This product does not contain any known or suspected endocrine disruptors

13. Disposal Considerations

Safe handling and disposal methods

Follow all applicable community, national or regional regulations regarding waste management methods.

Disposal of any contaminated packaging

Follow all applicable national or local regulations.

Environmental regulations

Not applicable

14. Transport Information

Transportation Information

Australia ADG

UN Number UN2924
UN proper shipping name: Flammable Liquid, Corrosive, N.O.S. (Contains Isopropanol, Thioglycolic Acid)
Transport Hazard Class(es): 3 (8)
Packing Group: II
Environmental Hazards: Not applicable

IMDG/IMO

UN Number UN2924
UN proper shipping name: Flammable Liquid, Corrosive, N.O.S. (Contains Isopropanol, Thioglycolic Acid)
Transport Hazard Class(es): 3 (8)
Packing Group: II
Environmental Hazards: Not applicable
EMS: EmS F-E, S-C

IATA/ICAO

UN Number UN2924
UN proper shipping name: Flammable Liquid, Corrosive, N.O.S. (Contains Isopropanol, Thioglycolic Acid)
Transport Hazard Class(es): 3 (8)
Packing Group: II
Environmental Hazards: Not applicable

Special precautions during transport
None

HazChem Code
•3W

15. Regulatory Information

Safety, health and environmental regulations specific for the product

International Inventories

Australian AICS Inventory	All components are listed on the AICS or are subject to a relevant exemption, permit, or assessment certificate.
New Zealand Inventory of Chemicals	All components are listed on the NZIoC or are subject to a relevant exemption, permit, or assessment certificate.
EINECS (European Inventory of Existing Chemical Substances)	This product, and all its components, complies with EINECS
US TSCA Inventory	All components listed on inventory or are exempt.
Canadian Domestic Substances List (DSL)	All components listed on inventory or are exempt.

Poisons Schedule number
None Allocated

International Agreements

Montreal Protocol - Ozone Depleting Substances:	Does not apply
Stockholm Convention - Persistent Organic Pollutants:	Does not apply
Rotterdam Convention - Prior Informed Consent:	Does not apply
Basel Convention - Hazardous Waste:	Does not apply

16. Other information

Date of preparation or review

Revision Date: 25-Jan-2017

Revision Note
SDS sections updated:
2

Full text of H-Statements referred to under sections 2 and 3
H225 - Highly flammable liquid and vapor
H301 - Toxic if swallowed
H302 - Harmful if swallowed
H314 - Causes severe skin burns and eye damage
H318 - Causes serious eye damage
H319 - Causes serious eye irritation
H331 - Toxic if inhaled
H336 - May cause drowsiness or dizziness
H401 - Toxic to aquatic life
H411 - Toxic to aquatic life with long lasting effects

Additional information For additional information on the use of this product, contact your local Halliburton representative.

For questions about the Safety Data Sheet for this or other Halliburton products, contact Chemical Stewardship at 1-580-251-4335.

Key abreviations or acronyms used
bw – body weight

CAS – Chemical Abstracts Service
EC50 – Effective Concentration 50%
LC50 – Lethal Concentration 50%
LD50 – Lethal Dose 50%
LL50 – Lethal Loading 50%
mg/kg – milligram/kilogram
mg/L – milligram/liter
NOEC – No Observed Effect Concentration
OEL – Occupational Exposure Limit
PBT – Persistent Bioaccumulative and Toxic
ppm – parts per million
STEL – Short Term Exposure Limit
TWA – Time-Weighted Average
vPvB – very Persistent and very Bioaccumulative
h - hour
mg/m^3 - milligram/cubic meter
mm - millimeter
mmHg - millimeter mercury
w/w - weight/weight
d - day

Key literature references and sources for data
www.ChemADVISOR.com/
ECHA C&L
OSHA
NZ CCID

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End of Safety Data Sheet

HALLIBURTON

SAFETY DATA SHEET

SAND - COMMON WHITE

Revision Date: 27-Jun-2016 **Revision Number:** 9

1. Product Identifier & Identity for the Chemical

Statement of Hazardous Nature Hazardous according to the criteria of the 3rd Revised Edition of the Globally Harmonised System of Classification and Labelling of Chemicals (GHS), Non-Dangerous Goods according to the criteria of ADG.

1.1. Product Identifier

Product Name SAND - COMMON WHITE

Other means of Identification

Synonyms None

Hazardous Material Number: HM005278

Recommended use of the chemical and restrictions on use

Recommended Use Proppant

Uses advised against No information available

Supplier's name, address and phone number

Manufacturer/Supplier Halliburton Australia Pty. Ltd.
15 Marriott Road
Jandakot
WA 6164
Australia

ACN Number: 009 000 775
Telephone Number: + 61 1 800 686 951
Fax Number: 61 (08) 9455 5300

E-mail Address fdunexchem@halliburton.com

Emergency phone number

+ 61 1 800 686 951

Australian Poisons Information Centre
24 Hour Service: - 13 11 26
Police or Fire Brigade: - 000 (exchange): - 1100

2. Hazard Identification

Statement of Hazardous Nature Hazardous according to the criteria of the 3rd Revised Edition of the Globally Harmonised System of Classification and Labelling of Chemicals (GHS), Non-Dangerous Goods according to the criteria of ADG.

Classification of the hazardous chemical

Carcinogenicity	Category 2 - H351
Specific Target Organ Toxicity - (Repeated Exposure)	Category 1 - H372

Label elements, including precautionary statements

Hazard pictograms

Signal Word Danger

Hazard Statements:
H351 - Suspected of causing cancer
H372 - Causes damage to organs through prolonged or repeated exposure

Precautionary Statements

Prevention
P201 - Obtain special instructions before use
P202 - Do not handle until all safety precautions have been read and understood
P260 - Do not breathe dust/fume/gas/mist/vapors/spray
P264 - Wash face, hands and any exposed skin thoroughly after handling
P270 - Do not eat, drink or smoke when using this product
P281 - Use personal protective equipment as required

Response
P308 + P313 - IF exposed or concerned: Get medical advice/attention
P314 - Get medical attention/advice if you feel unwell

Storage
P405 - Store locked up

Disposal
P501 - Dispose of contents/container in accordance with local/regional/national/international regulations

Contains Substances	**CAS Number**
Crystalline silica, quartz	14808-60-7

Other hazards which do not result in classification
This substance is not considered to be persistent, bioaccumulating nor toxic (PBT).
This substance is not considered to be very persistent nor very bioaccumulating (vPvB).

For the full text of the H-phrases mentioned in this Section, see Section 16

3. Composition/information on Ingredients

Substances	CAS Number	PERCENT (w/w)	GHS Classification - Australia
Crystalline silica, quartz	14808-60-7	60 - 100%	Carc. 2 (H351) STOT RE 1 (H372)

4. First aid measures

Description of necessary first aid measures

Inhalation If inhaled, remove from area to fresh air. Get medical attention if respiratory irritation develops or if breathing becomes difficult.

Eyes In case of contact, immediately flush eyes with plenty of water for at least 15 minutes and get medical attention if irritation persists.

Skin Wash with soap and water.

Ingestion Under normal conditions, first aid procedures are not required.

Symptoms caused by exposure
Breathing crystalline silica can cause lung disease, including silicosis and lung cancer. Crystalline silica has also been associated with scleroderma and kidney disease.

Medical Attention and Special Treatment
Notes to Physician Treat symptomatically

5. Fire Fighting Measures

Suitable extinguishing equipment
Suitable Extinguishing Media
None - does not burn.
Extinguishing media which must not be used for safety reasons
None known.

Specific hazards arising from the chemical
Special exposure hazards in a fire
None anticipated

Special protective equipment and precautions for fire fighters
Special protective equipment for firefighters
Full protective clothing and approved self-contained breathing apparatus required for fire fighting personnel.

6. Accidental release measures

6.1. Personal precautions, protective equipment and emergency procedures
Use appropriate protective equipment. Avoid creating and breathing dust. Avoid contact with skin, eyes and clothing. Ensure adequate ventilation.

6.2. Environmental precautions
Prevent from entering sewers, waterways, or low areas.

6.3. Methods and material for containment and cleaning up
Collect using dustless method and hold for appropriate disposal. Consider possible toxic or fire hazards associated with contaminating substances and use appropriate methods for collection, storage and disposal.

7. Handling and storage

7.1. Precautions for safe handling
Handling Precautions
This product contains quartz, cristobalite, and/or tridymite which may become airborne without a visible cloud. Avoid breathing dust. Avoid creating dusty conditions. Use only with adequate ventilation to keep exposure below recommended exposure limits. Wear a NIOSH certified, European Standard En 149, or equivalent respirator when using this product. Material is slippery when wet.
Hygiene Measures
Handle in accordance with good industrial hygiene and safety practice.

7.2. Conditions for safe storage, including any incompatibilities
Storage Information
Use good housekeeping in storage and work areas to prevent accumulation of dust. Close container when not in use. Product has a shelf life of 36 months.
Other Guidelines
No information available

8. Exposure Controls/Personal Protection

Control parameters - exposure standards, biological monitoring
Exposure Limits

Substances	CAS Number	Australia NOHSC	ACGIH TLV-TWA
Crystalline silica, quartz	14808-60-7	TWA: 0.1 mg/m^3	TWA: 0.025 mg/m^3

Appropriate engineering controls

Engineering Controls	Use approved industrial ventilation and local exhaust as required to maintain exposures below applicable exposure limits.

Personal protective equipment (PPE)

Personal Protective Equipment	If engineering controls and work practices cannot prevent excessive exposures, the selection and proper use of personal protective equipment should be determined by an industrial hygienist or other qualified professional based on the specific application of this product.
Respiratory Protection	Wear a NIOSH certified, European Standard EN 149 (FFP2/FFP3), AS/NZS 1715, or equivalent respirator when using this product.
Hand Protection	Normal work gloves.
Skin Protection	Wear clothing appropriate for the work environment. Dusty clothing should be laundered before reuse. Use precautionary measures to avoid creating dust when removing or laundering clothing.
Eye Protection	Wear safety glasses or goggles to protect against exposure.
Other Precautions	None known.
Environmental Exposure Controls	No information available

9. Physical and Chemical Properties

9.1. Information on basic physical and chemical properties

Physical State:	Solid	**Color**	White
Odor:	Odorless	**Odor Threshold:**	No information available

Property Remarks/ - Method	Values
pH:	No data available
Freezing Point / Range	No data available
Melting Point / Range	No data available
Boiling Point / Range	No data available
Flash Point	No data available
Evaporation rate	No data available
Vapor Pressure	No data available
Vapor Density	No data available
Specific Gravity	2.63 - 2.67
Water Solubility	Insoluble in water
Solubility in other solvents	No data available
Partition coefficient: n-octanol/water	No data available
Autoignition Temperature	No data available
Decomposition Temperature	No data available
Viscosity	No data available
Explosive Properties	No information available
Oxidizing Properties	No information available

9.2. Other information

Molecular Weight	65 g/mol
VOC Content (%)	No data available

10. Stability and Reactivity

10.1. Reactivity
Not expected to be reactive.
10.2. Chemical stability
Stable
10.3. Possibility of hazardous reactions
Will Not Occur
10.4. Conditions to avoid
None anticipated
10.5. Incompatible materials
Hydrofluoric acid.

10.6. Hazardous decomposition products

Amorphous silica may transform at elevated temperatures to tridymite (870 C) or cristobalite (1470 C).

11. Toxicological Information

Information on routes of exposure

Principle Route of Exposure Eye or skin contact, inhalation.

Symptoms related to exposure

Most Important Symptoms/Effects

Breathing crystalline silica can cause lung disease, including silicosis and lung cancer. Crystalline silica has also been associated with scleroderma and kidney disease.

Numerical measures of toxicity

Toxicology data for the components

Substances	CAS Number	LD50 Oral	LD50 Dermal	LC50 Inhalation
Crystalline silica, quartz	14808-60-7	> 15000 mg/kg (human)	No information available	No data available

Immediate, delayed and chronic health effects from exposure

Inhalation Inhaled crystalline silica in the form of quartz or cristobalite from occupational sources is carcinogenic to humans (IARC, Group 1). There is sufficient evidence in experimental animals for the carcinogenicity of tridymite (IARC, Group 2A).

Breathing silica dust may cause irritation of the nose, throat, and respiratory passages. Breathing silica dust may not cause noticeable injury or illness even though permanent lung damage may be occurring. Inhalation of dust may also have serious chronic health effects (See "Chronic Effects/Carcinogenicity" subsection below).

Eye Contact May cause mechanical irritation to eye.

Skin Contact None known.

Ingestion None known.

Chronic Effects/Carcinogenicity Silicosis: Excessive inhalation of respirable crystalline silica dust may cause a progressive, disabling, and sometimes-fatal lung disease called silicosis. Symptoms include cough, shortness of breath, wheezing, non-specific chest illness, and reduced pulmonary function. This disease is exacerbated by smoking. Individuals with silicosis are predisposed to develop tuberculosis.

Cancer Status: The International Agency for Research on Cancer (IARC) has determined that crystalline silica inhaled in the form of quartz or cristobalite from occupational sources can cause lung cancer in humans (Group 1 - carcinogenic to humans) and has determined that there is sufficient evidence in experimental animals for the carcinogenicity of tridymite (Group 2A - possible carcinogen to humans). Refer to IARC Monograph 68, Silica, Some Silicates and Organic Fibres (June 1997) in conjunction with the use of these minerals. The National Toxicology Program classifies respirable crystalline silica as "Known to be a human carcinogen". Refer to the 9th Report on Carcinogens (2000). The American Conference of Governmental Industrial Hygienists (ACGIH) classifies crystalline silica, quartz, as a suspected human carcinogen (A2). There is some evidence that breathing respirable crystalline silica or the disease silicosis is associated with an increased incidence of significant disease endpoints such as scleroderma (an immune system disorder manifested by scarring of the lungs, skin, and other internal organs) and kidney disease.

Exposure Levels

No data available

Interactive effects
Individuals with respiratory disease, including but not limited to asthma and bronchitis, or subject to eye irritation, should not be exposed to quartz dust.

Data limitations
No data available

Substances	CAS Number	Skin corrosion/irritation
Crystalline silica, quartz	14808-60-7	Non-irritating to the skin

Substances	CAS Number	Serious eye damage/irritation
Crystalline silica, quartz	14808-60-7	Mechanical irritation of the eyes is possible. No information available

Substances	CAS Number	Skin Sensitization
Crystalline silica, quartz	14808-60-7	No information available.

Substances	CAS Number	Respiratory Sensitization
Crystalline silica, quartz	14808-60-7	No information available

Substances	CAS Number	Mutagenic Effects
Crystalline silica, quartz	14808-60-7	Not regarded as mutagenic.

Substances	CAS Number	Carcinogenic Effects
Crystalline silica, quartz	14808-60-7	Contains crystalline silica which may cause silicosis, a delayed and progressive lung disease. The IARC and NTP have determined there is sufficient evidence in humans of the carcinogenicity of crystalline silica with repeated respiratory exposure. Based on available scientific evidence, this substance is a threshold carcinogen with a mode of action involving indirect genotoxicity secondary to lung injury.

Substances	CAS Number	Reproductive toxicity
Crystalline silica, quartz	14808-60-7	No information available

Substances	CAS Number	STOT - single exposure
Crystalline silica, quartz	14808-60-7	No significant toxicity observed in animal studies at concentration requiring classification.

Substances	CAS Number	STOT - repeated exposure
Crystalline silica, quartz	14808-60-7	Causes damage to organs through prolonged or repeated exposure if inhaled: (Lungs)

Substances	CAS Number	Aspiration hazard
Crystalline silica, quartz	14808-60-7	Not applicable

12. Ecological Information

Ecotoxicity
Product Ecotoxicity Data
No data available

Substance Ecotoxicity Data

Substances	CAS Number	Toxicity to Algae	Toxicity to Fish	Toxicity to Microorganisms	Toxicity to Invertebrates
Crystalline silica, quartz	14808-60-7	EC50 (72 h) =440 mg/L (Selenastrum capricornutum)	LL0 (96 h) =10000 mg/L (Danio rerio)	No information available	LL50 (24 h) >10000 mg/L (Daphnia magna)

12.2. Persistence and degradability

Substances	CAS Number	Persistence and Degradability
Crystalline silica, quartz	14808-60-7	The methods for determining biodegradability are not applicable to inorganic substances.

12.3. Bioaccumulative potential

Substances	CAS Number	Log Pow
Crystalline silica, quartz	14808-60-7	No information available

12.4. Mobility in soil

Substances	CAS Number	Mobility
Crystalline silica, quartz	14808-60-7	No information available

12.6. Other adverse effects

Endocrine Disruptor Information
This product does not contain any known or suspected endocrine disruptors

13. Disposal Considerations

Safe handling and disposal methods
Bury in a licensed landfill according to federal, state, and local regulations.

Disposal of any contaminated packaging
Follow all applicable national or local regulations.

Environmental regulations
Not applicable

14. Transport Information

Transportation Information

UN Number Not restricted
UN proper shipping name: Not restricted
Transport Hazard Class(es): Not applicable
Packing Group: Not applicable
Environmental Hazards: Not applicable

Special precautions during transport
None

HazChem Code
None Allocated

15. Regulatory Information

Safety, health and environmental regulations specific for the product

International Inventories

Australian AICS Inventory All components are listed on the AICS or are subject to a relevant exemption, permit, or assessment certificate.
New Zealand Inventory of Chemicals All components are listed on the NZIoC or are subject to a relevant exemption, permit, or assessment certificate.
EINECS (European Inventory of Existing Chemical Substances) This product, and all its components, complies with EINECS
US TSCA Inventory All components listed on inventory or are exempt.
Canadian Domestic Substances List (DSL) All components listed on inventory or are exempt.

Poisons Schedule number
None Allocated

International Agreements

Montreal Protocol - Ozone Depleting Substances: Does not apply

Stolkhom Convention - Persistent Organic Pollutants:	Does not apply
Rotterdam Convention - Prior Informed Consent:	Does not apply
Basel Convention - Hazardous Waste:	Does not apply

16. Other information

Date of preparation or review

Revision Date: 27-Jun-2016

Revision Note
SDS sections updated: 2

Full text of H-Statements referred to under sections 2 and 3
H351 - Suspected of causing cancer if inhaled
H372 - Causes damage to organs through prolonged or repeated exposure if inhaled

Additional information

For additional information on the use of this product, contact your local Halliburton representative.

For questions about the Safety Data Sheet for this or other Halliburton products, contact Chemical Stewardship at 1-580-251-4335.

Key abreviations or acronyms used
bw – body weight
CAS – Chemical Abstracts Service
EC50 – Effective Concentration 50%
LC50 – Lethal Concentration 50%
LD50 – Lethal Dose 50%
LL50 – Lethal Loading 50%
mg/kg – milligram/kilogram
mg/L – milligram/liter
NOEC – No Observed Effect Concentration
OEL – Occupational Exposure Limit
PBT – Persistent Bioaccumulative and Toxic
ppm – parts per million
STEL – Short Term Exposure Limit
TWA – Time-Weighted Average
vPvB – very Persistent and very Bioaccumulative
h - hour
mg/m^3 - milligram/cubic meter
mm - millimeter
mmHg - millimeter mercury
w/w - weight/weight
d - day

Key literature references and sources for data
www.ChemADVISOR.com/

Disclaimer Statement
This information is furnished without warranty, expressed or implied, as to accuracy or completeness. The information is obtained from various sources including the manufacturer and other third party sources. The information may not be valid under all conditions nor if this material is used in combination with other materials or in any process. Final determination of suitability of any material is the sole responsibility of the user.

End of Safety Data Sheet

HALLIBURTON

SAFETY DATA SHEET

SuperFlo 2000

Revision Date: 11-Apr-2017 **Revision Number:** 10

1. Product Identifier & Identity for the Chemical

Statement of Hazardous Nature Hazardous according to the criteria of the 3rd Revised Edition of the Globally Harmonised System of Classification and Labelling of Chemicals (GHS), Dangerous Goods according to the criteria of ADG.

1.1. Product Identifier

Product Name SuperFlo 2000

Other means of Identification

Synonyms None

Hazardous Material Number: HM006792

Recommended use of the chemical and restrictions on use

Recommended Use Surfactant

Uses advised against No information available

Supplier's name, address and phone number

Manufacturer/Supplier Halliburton Australia Pty. Ltd.
15 Marriott Road, Jandakot, WA 6164
Australia
ACN Number: 009 000 775
Telephone Number: + 61 1 800 686 951
Fax Number: 61 (08) 9455 5300

E-mail Address fdunexchem@halliburton.com

Emergency phone number

+ 61 1 800 686 951
Global Incident Response Access Code: 334305
Contract Number: 14012

Australian Poisons Information Centre
24 Hour Service: - 13 11 26
Police or Fire Brigade: - 000 (exchange): - 1100

2. Hazard Identification

Statement of Hazardous Nature Hazardous according to the criteria of the 3rd Revised Edition of the Globally Harmonised System of Classification and Labelling of Chemicals (GHS), Dangerous Goods according to the criteria of ADG.

Classification of the hazardous chemical

Aspiration Toxicity	Category 1 - H304
Acute Oral Toxicity	Category 4 - H302
Skin Corrosion/Irritation	Category 1 - H314
Serious Eye Damage/Irritation	Category 1 - H318
Skin Sensitization	Category 1 - H317
Reproductive Toxicity	Category 1 - H360
Specific Target Organ Toxicity - (Single Exposure)	Category 2 - H371
Flammable liquids.	Category 3 - H226

Label elements, including precautionary statements

Hazard Pictograms

(Bad file name)

Signal Word DANGER

Hazard Statements:
H226 - Flammable liquid and vapor
H302 - Harmful if swallowed
H304 - May be fatal if swallowed and enters airways
H314 - Causes severe skin burns and eye damage
H317 - May cause an allergic skin reaction
H318 - Causes serious eye damage
H360 - May damage fertility or the unborn child
H371 - May cause damage to organs
H400 - Very toxic to aquatic life
H411 - Toxic to aquatic life with long lasting effects

Precautionary Statements

Prevention
P201 - Obtain special instructions before use
P202 - Do not handle until all safety precautions have been read and understood
P210 - Keep away from heat, hot surfaces, sparks, open flames and other ignition sources. No smoking.
P233 - Keep container tightly closed
P240 - Ground and bond container and receiving equipment.
P241 - Use explosion-proof electrical/ventilating/lighting/equipment
P243 - Take action to prevent static discharges.
P242 - Use only non-sparking tools
P260 - Do not breathe dust/fume/gas/mist/vapors/spray
P261 - Avoid breathing dust/fume/gas/mist/vapors/spray
P264 - Wash face, hands and any exposed skin thoroughly after handling
P270 - Do not eat, drink or smoke when using this product
P272 - Contaminated work clothing should not be allowed out of the workplace
P280 - Wear protective gloves/eye protection/face protection
P281 - Use personal protective equipment as required

Response
P301 + P312 - IF SWALLOWED: Call a POISON CENTER or doctor/physician if you feel unwell
P330 - Rinse mouth
P303 + P361 + P353 - IF ON SKIN (or hair): Take off immediately all contaminated clothing. Rinse skin with water [or shower].
P363 - Wash contaminated clothing before reuse
P310 - Immediately call a POISON CENTER or doctor/physician
P305 + P351 + P338 - IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing
P370 + P378 - In case of fire: Use water spray for extinction
P304 + P340 - IF INHALED: Remove victim to fresh air and keep at rest in a position comfortable for breathing
P308 + P313 - IF exposed or concerned: Get medical advice/attention

Storage
P403 + P235 - Store in a well-ventilated place. Keep cool
P405 - Store locked up

Disposal
P501 - Dispose of contents/container to an approved incineration plant

Contains

Substances	**CAS Number**
Terpene hydrocarbon by-products	68956-56-9

Methanol	67-56-1
Coco diethanolamide	Proprietary
Quaternary ammonium compounds, benzyl-C12-18-alkyldimethyl, chlorides	68391-01-5
Nonylphenol ethoxylate	Proprietary
Linanool	Proprietary
2,6-Octadien-1-ol, 3,7-dimethyl-, (2Z)-	106-25-2
2,6-Octadien-1-ol, 3,7-dimethyl-, (2E)-	106-24-1
Citronellol	106-22-9
Isopropanol	67-63-0

Other hazards which do not result in classification
None known

For the full text of the H-phrases mentioned in this Section, see Section 16

3. Composition/information on Ingredients

Substances	CAS Number	PERCENT (w/w)	GHS Classification - Australia
Terpene hydrocarbon by-products	68956-56-9	10 - 30%	Skin Irrit. 2 (H315) Eye Irrit. 2 (H319) Skin Sens. 1 (H317) Asp. Tox. 1 (H304) Aquatic Acute 2 (H401) Aquatic Chronic 2 (H411) Flam. Liq. 3 (H226)
Methanol	67-56-1	5 - 10%	Acute Tox. 3 (H301) Acute Tox. 3 (H311) Acute Tox. 3 (H331) Repr. 1B (H360) STOT SE 1 (H370) Flam. Liq. 2 (H225)
Coco diethanolamide	Proprietary	5 - 10%	Skin Irrit. 2 (H315) Eye Corr. 1 (H318) Aquatic Acute 2 (H401) Aquatic Chronic 2 (H411)
Quaternary ammonium compounds, benzyl-C12-18-alkyldimethyl, chlorides	68391-01-5	5 - 10%	Acute Tox. 4 (H302) Acute Tox. 4 (H312) Skin Corr. 1 (H314) Eye Corr. 1 (H318) Aquatic Acute 1 (H400) Aquatic Chronic 1 (H410)
Nonylphenol ethoxylate	Proprietary	5 - 10%	Acute Tox. 4 (H302) Skin Irrit. 2 (H315) Eye Irrit. 2 (H319) Aquatic Acute 3 (H402) Aquatic Chronic 2 (H411)
Linanool	Proprietary	1 - 5%	Skin Irrit. 2 (H315) Eye Irrit. 2 (H319) Aquatic Acute 3 (H402) Flam. Liq. 4 (H227)
2,6-Octadien-1-ol, 3,7-dimethyl-, (2Z)-	106-25-2	1 - 5%	Skin Irrit. 2 (H315) Eye Irrit. 2A (H319) Skin Sens. 1 (H317) STOT SE 3 (H335) Aquatic Acute 2 (H401)
2,6-Octadien-1-ol, 3,7-dimethyl-, (2E)-	106-24-1	1 - 5%	Skin Irrit. 2 (H315) Eye Corr. 1 (H318) Skin Sens. 1 (H317) STOT SE 3 (H335) Aquatic Acute 3 (H402)
Citronellol	106-22-9	1 - 5%	Skin Irrit. 2 (H315) Eye Irrit. 2 (H319) Skin Sens. 1 (H317)

			Aquatic Acute 2 (H401)
Isopropanol	67-63-0	1 - 5%	Eye Irrit. 2 (H319) STOT SE 3 (H336) Flam. Liq. 2 (H225)

4. First aid measures

Description of necessary first aid measures

Inhalation If inhaled, move victim to fresh air and seek medical attention.

Eyes Immediately flush eyes with large amounts of water for at least 30 minutes. Seek prompt medical attention.

Skin In case of contact, immediately flush skin with plenty of soap and water for at least 30 minutes and remove contaminated clothing, shoes and leather goods immediately. Get medical attention immediately.

Ingestion Do NOT induce vomiting. Give nothing by mouth. Obtain immediate medical attention. Get medical attention! If vomiting occurs, keep head lower than hips to prevent aspiration. Rinse mouth. Never give anything by mouth to an unconscious person.

Symptoms caused by exposure

Causes severe eye irritation which may damage tissue. Causes severe skin irritation with tissue destruction. May cause allergic skin reaction. Harmful if swallowed. Potential reproductive hazard. May cause birth defects. May cause damage to internal organs.

Medical Attention and Special Treatment

Notes to Physician Treat symptomatically

5. Fire Fighting Measures

Suitable extinguishing equipment

Suitable Extinguishing Media

Carbon dioxide, dry chemical, foam.

Extinguishing media which must not be used for safety reasons

None known.

Specific hazards arising from the chemical

Special exposure hazards in a fire

May be ignited by heat, sparks or flames Use water spray to cool fire exposed surfaces. Closed containers may explode in fire. Decomposition in fire may produce harmful gases. Runoff to sewer may cause fire or explosion hazard.

Special protective equipment and precautions for fire fighters

Special protective equipment for firefighters

Full protective clothing and approved self-contained breathing apparatus required for fire fighting personnel.

6. Accidental release measures

6.1. Personal precautions, protective equipment and emergency procedures

Use appropriate protective equipment. Wear self-contained breathing apparatus in enclosed areas.

6.2. Environmental precautions

Prevent from entering sewers, waterways, or low areas.

6.3. Methods and material for containment and cleaning up

Isolate spill and stop leak where safe. Remove ignition sources and work with non-sparking tools. Contain spill with sand or other inert materials. Scoop up and remove.

7. Handling and storage

7.1. Precautions for safe handling

Handling Precautions

Wash hands after use. Launder contaminated clothing before reuse. Ground and bond containers when transferring from one container to another. Avoid contact with eyes, skin, or clothing. Avoid breathing vapors. Avoid breathing mist.

Hygiene Measures

Handle in accordance with good industrial hygiene and safety practice.

7.2. Conditions for safe storage, including any incompatibilities

Storage Information

Store away from oxidizers. Keep from heat, sparks, and open flames. Keep container closed when not in use.

Other Guidelines

No information available

8. Exposure Controls/Personal Protection

Control parameters - exposure standards, biological monitoring

Exposure Limits

Substances	CAS Number	Australia NOHSC	ACGIH TLV-TWA
Terpene hydrocarbon by-products	68956-56-9	Not applicable	Not applicable
Methanol	67-56-1	TWA: 200 ppm TWA: 262 mg/m^3 STEL: 250 ppm STEL: 328 mg/m^3	TWA: 200 ppm STEL: 250 ppm
Coco diethanolamide	Proprietary	Not applicable	Not applicable
Quaternary ammonium compounds, benzyl-C12-18-alkyldimethyl, chlorides	68391-01-5	Not applicable	Not applicable
Nonylphenol ethoxylate	Proprietary	Not applicable	Not applicable
Linanool	Proprietary	Not applicable	Not applicable
2,6-Octadien-1-ol, 3,7-dimethyl-, (2Z)-	106-25-2	Not applicable	Not applicable
2,6-Octadien-1-ol, 3,7-dimethyl-, (2E)-	106-24-1	Not applicable	Not applicable
Citronellol	106-22-9	Not applicable	Not applicable
Isopropanol	67-63-0	TWA: 400 ppm TWA: 983 mg/m^3 STEL: 500 ppm STEL: 1230 mg/m^3	TWA: 200 ppm STEL: 400 ppm

Appropriate engineering controls

Engineering Controls Use in a well ventilated area. Local exhaust ventilation should be used in areas without good cross ventilation.

Personal protective equipment (PPE)

Personal Protective Equipment If engineering controls and work practices cannot prevent excessive exposures, the selection and proper use of personal protective equipment should be determined by an industrial hygienist or other qualified professional based on the specific application of this product.

Respiratory Protection If engineering controls and work practices cannot keep exposure below occupational exposure limits or if exposure is unknown, wear a NIOSH certified, European Standard EN 149, AS/NZS 1715:2009, or equivalent respirator when using this product. Selection of and instruction on using all personal protective equipment, including respirators, should be performed by an Industrial Hygienist or other qualified professional.
Positive pressure self-contained breathing apparatus if methanol is released.

Hand Protection Use gloves which are suitable for the chemicals present in this product as well as other environmental factors in the workplace. Manufacturer's directions for use should be observed because of great diversity of types.

Skin Protection Rubber apron.

Eye Protection Chemical goggles; also wear a face shield if splashing hazard exists.

Other Precautions Eyewash fountains and safety showers must be easily accessible.

Environmental Exposure Controls No information available

9. Physical and Chemical Properties

9.1. Information on basic physical and chemical properties

Physical State: Liquid
Color Straw
Odor: Alcohol
Odor Threshold: No information available

Property Remarks/ - Method	Values
pH:	No data available
Freezing Point / Range	-29 °C
Melting Point / Range	No data available
Boiling Point / Range	No data available
Flash Point	30 °C / 86 °F PMCC
Evaporation rate	No data available
Vapor Pressure	No data available
Vapor Density	No data available
Specific Gravity	0.99
Water Solubility	Soluble in water
Solubility in other solvents	No data available
Partition coefficient: n-octanol/water	No data available
Autoignition Temperature	No data available
Decomposition Temperature	No data available
Viscosity	No data available
Explosive Properties	No information available
Oxidizing Properties	No information available

9.2. Other information

VOC Content (%) No data available

10. Stability and Reactivity

10.1. Reactivity
Not expected to be reactive.
10.2. Chemical stability
Stable
10.3. Possibility of hazardous reactions
Will Not Occur
10.4. Conditions to avoid
Keep away from heat, sparks and flame.
10.5. Incompatible materials
Strong oxidizers.
10.6. Hazardous decomposition products
Carbon monoxide and carbon dioxide.

11. Toxicological Information

Information on routes of exposure
Principle Route of Exposure Eye or skin contact, inhalation.

Symptoms related to exposure

Most Important Symptoms/Effects

Causes severe eye irritation which may damage tissue. Causes severe skin irritation with tissue destruction. May cause allergic skin reaction. Harmful if swallowed. Potential reproductive hazard. May cause birth defects. May cause damage to internal organs.

Toxicology data for the components

Substances	CAS Number	LD50 Oral	LD50 Dermal	LC50 Inhalation
Terpene hydrocarbon by-products	68956-56-9	> 2000 mg/kg (Rat)	> 2000 mg/kg (Rat)	No data available

Methanol	67-56-1	300 mg/kg-bw (human) < 790 to 13,000 mg/kg (rat)	1000 mg/kg-bw (human) 17,100 mg/kg (rabbit)	10 mg/L (human, 4h, vapor)
Coco diethanolamide	Proprietary	>5000 mg/kg-bw (rat)	>2000 mg/kg-bw (rabbit)	No data available
Quaternary ammonium compounds, benzyl-C12-18-alkyldimethyl, chlorides	68391-01-5	340.5 mg/kg-bw (Rat)	1420 mg/kg-bw (Rat)	No data available
Nonylphenol ethoxylate	Proprietary	1310 mg/kg (Rat)	> 2000 mg/kg (Rabbit) (similar substance)	No data available
Linanool	Proprietary	2790 mg/kg (Rat)	5610 mg/kg (Rat)	> 3.2 mg/L (Rat, 4 h, aerosol)
2,6-Octadien-1-ol, 3,7-dimethyl-, (2Z)-	106-25-2	4500 mg/kg (Rat)	> 5000 mg/kg (Rabbit)	No data available
2,6-Octadien-1-ol, 3,7-dimethyl-, (2E)-	106-24-1	3600 mg/kg (Rat)	> 5000 mg/kg (Rabbit)	No data available
Citronellol	106-22-9	3450 mg/kg (rat)	2650 mg/kg (rabbits)	No information available
Isopropanol	67-63-0	5840 mg/kg-bw (rat)	12870 mg/kg-bw (rabbit)	72.6 mg/L (Rat, 4h, vapor)

Immediate, delayed and chronic health effects from exposure

Inhalation May cause respiratory irritation. May cause central nervous system depression including headache, dizziness, drowsiness, incoordination, slowed reaction time, slurred speech, giddiness and unconsciousness.

Eye Contact Causes severe eye irritation

Skin Contact Causes severe skin irritation with tissue destruction. May cause an allergic skin reaction.

Ingestion Harmful if swallowed. May cause headache, dizziness, nausea, vomiting, gastrointestinal irritation and central nervous system depression. Ingestion may result in blindness. Aspiration can be a hazard if this material is swallowed.

Chronic Effects/Carcinogenicity No data available to indicate product or components present at greater than 0.1% are chronic health hazards.

Exposure Levels

No data available

Interactive effects

Eye ailments. Skin disorders.

Data limitations

No data available

Substances	CAS Number	Skin corrosion/irritation
Terpene hydrocarbon by-products	68956-56-9	Causes moderate skin irritation. (Rabbit)
Methanol	67-56-1	Non-irritating to the skin (Rabbit)
Coco diethanolamide		Irritating to skin. (Rabbit)
Quaternary ammonium compounds, benzyl-C12-18-alkyldimethyl, chlorides	68391-01-5	Causes severe skin irritation with tissue destruction. (Rabbit)
Nonylphenol ethoxylate		Irritating to skin. (similar substances)
Linanool		Causes moderate skin irritation. (Rabbit)
2,6-Octadien-1-ol, 3,7-dimethyl-, (2Z)-	106-25-2	Causes skin irritation.
2,6-Octadien-1-ol, 3,7-dimethyl-, (2E)-	106-24-1	Causes moderate skin irritation.
Citronellol	106-22-9	Causes moderate skin irritation. (Rabbit)
Isopropanol	67-63-0	Non-irritating to the skin (Rabbit)

Substances	CAS Number	Serious eye damage/irritation
Terpene hydrocarbon by-products	68956-56-9	Causes moderate eye irritation (Rabbit) (similar substances)
Methanol	67-56-1	Non-irritating to the eye (Rabbit)
Coco diethanolamide		Causes severe eye irritation (Rabbit) (similar substances)
Quaternary ammonium compounds,	68391-01-5	Causes severe eye irritation which may damage tissue. (Rabbit)

benzyl-C12-18-alkyldimethyl, chlorides		
Nonylphenol ethoxylate		Irritating to eyes (similar substances)
Linanool		Causes moderate eye irritation (Rabbit)
2,6-Octadien-1-ol, 3,7-dimethyl-, (2Z)-	106-25-2	Causes severe eye irritation
2,6-Octadien-1-ol, 3,7-dimethyl-, (2E)-	106-24-1	Causes severe eye irritation which may damage tissue.
Citronellol	106-22-9	Causes moderate eye irritation (Rabbit)
Isopropanol	67-63-0	Causes moderate eye irritation (Rabbit)

Substances	**CAS Number**	**Skin Sensitization**
Terpene hydrocarbon by-products	68956-56-9	May cause an allergic skin reaction. (mouse) (similar substances)
Methanol	67-56-1	Did not cause sensitization on laboratory animals (guinea pig)
Coco diethanolamide		Did not cause sensitization on laboratory animals (guinea pig)
Quaternary ammonium compounds, benzyl-C12-18-alkyldimethyl, chlorides	68391-01-5	Did not cause sensitization on laboratory animals (guinea pig) (similar substances)
Nonylphenol ethoxylate		Did not cause sensitization on laboratory animals (guinea pig) (similar substances)
Linanool		Patch test on human volunteers did not demonstrate irritating properties
2,6-Octadien-1-ol, 3,7-dimethyl-, (2Z)-	106-25-2	May cause sensitization by skin contact (guinea pig) (mouse)
2,6-Octadien-1-ol, 3,7-dimethyl-, (2E)-	106-24-1	May cause sensitization by skin contact (mouse)
Citronellol	106-22-9	May cause sensitization by skin contact (mouse)
Isopropanol	67-63-0	Did not cause sensitization on laboratory animals (guinea pig)

Substances	**CAS Number**	**Respiratory Sensitization**
Terpene hydrocarbon by-products	68956-56-9	No information available
Methanol	67-56-1	No information available
Coco diethanolamide		No information available
Quaternary ammonium compounds, benzyl-C12-18-alkyldimethyl, chlorides	68391-01-5	No information available
Nonylphenol ethoxylate		No information available
Linanool		No information available
2,6-Octadien-1-ol, 3,7-dimethyl-, (2Z)-	106-25-2	No information available
2,6-Octadien-1-ol, 3,7-dimethyl-, (2E)-	106-24-1	No information available
Citronellol	106-22-9	No information available
Isopropanol	67-63-0	No information available

Substances	**CAS Number**	**Mutagenic Effects**
Terpene hydrocarbon by-products	68956-56-9	In vitro tests did not show mutagenic effects
Methanol	67-56-1	The weight of evidence from available in vitro and in vivo studies indicates that this substance is not expected to be mutagenic.
Coco diethanolamide		In vitro tests did not show mutagenic effects Some in vivo tests have shown mutagenic effects.
Quaternary ammonium compounds, benzyl-C12-18-alkyldimethyl, chlorides	68391-01-5	In vitro tests did not show mutagenic effects (similar substances)
Nonylphenol ethoxylate		In vitro tests did not show mutagenic effects (similar substances)
Linanool		In vitro tests did not show mutagenic effects In vivo tests did not show mutagenic effects.
2,6-Octadien-1-ol, 3,7-dimethyl-, (2Z)-	106-25-2	In vitro tests did not show mutagenic effects In vivo tests did not show mutagenic effects. (similar substances)
2,6-Octadien-1-ol, 3,7-dimethyl-, (2E)-	106-24-1	In vitro tests did not show mutagenic effects In vivo tests did not show mutagenic effects.
Citronellol	106-22-9	In vitro tests did not show mutagenic effects In vivo tests did not show mutagenic effects.
Isopropanol	67-63-0	In vitro tests did not show mutagenic effects. In vivo tests did not show mutagenic effects.

Substances	**CAS Number**	**Carcinogenic Effects**

Terpene hydrocarbon by-products	68956-56-9	Did not show carcinogenic effects in animal experiments (similar substances)
Methanol	67-56-1	No data of sufficient quality are available.
Coco diethanolamide		No data of sufficient quality are available.
Quaternary ammonium compounds, benzyl-C12-18-alkyldimethyl, chlorides	68391-01-5	Did not show carcinogenic effects in animal experiments (similar substances)
Nonylphenol ethoxylate		Did not show carcinogenic effects in animal experiments (similar substances)
Linanool		No data of sufficient quality are available.
2,6-Octadien-1-ol, 3,7-dimethyl-, (2Z)-	106-25-2	Did not show carcinogenic effects in animal experiments (similar substances)
2,6-Octadien-1-ol, 3,7-dimethyl-, (2E)-	106-24-1	Did not show carcinogenic effects in animal experiments (similar substances)
Citronellol	106-22-9	Did not show carcinogenic effects in animal experiments (similar substances)
Isopropanol	67-63-0	Did not show carcinogenic effects in animal experiments

Substances	**CAS Number**	**Reproductive toxicity**
Terpene hydrocarbon by-products	68956-56-9	Did not show teratogenic effects in animal experiments. (similar substances)
Methanol	67-56-1	Experiments have shown reproductive toxicity effects on laboratory animals
Coco diethanolamide		Did not show teratogenic effects in animal experiments.
Quaternary ammonium compounds, benzyl-C12-18-alkyldimethyl, chlorides	68391-01-5	Animal testing did not show any effects on fertility. Did not show teratogenic effects in animal experiments. (similar substances)
Nonylphenol ethoxylate		Not a confirmed teratogen or embryotoxin. (similar substances)
Linanool		Animal testing did not show any effects on fertility. Did not show teratogenic effects in animal experiments.
2,6-Octadien-1-ol, 3,7-dimethyl-, (2Z)-	106-25-2	Animal testing did not show any effects on fertility. Did not show teratogenic effects in animal experiments. (similar substances)
2,6-Octadien-1-ol, 3,7-dimethyl-, (2E)-	106-24-1	Animal testing did not show any effects on fertility.
Citronellol	106-22-9	Animal testing did not show any effects on fertility. Did not show teratogenic effects in animal experiments.
Isopropanol	67-63-0	Animal testing did not show any effects on fertility.

Substances	**CAS Number**	**STOT - single exposure**
Terpene hydrocarbon by-products	68956-56-9	No significant toxicity observed in animal studies at concentration requiring classification. (similar substances)
Methanol	67-56-1	May cause disorder and damage to the Central Nervous System (CNS)
Coco diethanolamide		No significant toxicity observed in animal studies at concentration requiring classification.
Quaternary ammonium compounds, benzyl-C12-18-alkyldimethyl, chlorides	68391-01-5	No data of sufficient quality are available.
Nonylphenol ethoxylate		No significant toxicity observed in animal studies at concentration requiring classification. (similar substances)
Linanool		No data of sufficient quality are available.
2,6-Octadien-1-ol, 3,7-dimethyl-, (2Z)-	106-25-2	May cause respiratory irritation.
2,6-Octadien-1-ol, 3,7-dimethyl-, (2E)-	106-24-1	May cause respiratory irritation.
Citronellol	106-22-9	No information available
Isopropanol	67-63-0	May cause headache, dizziness, and other central nervous system effects.

Substances	**CAS Number**	**STOT - repeated exposure**
Terpene hydrocarbon by-products	68956-56-9	No significant toxicity observed in animal studies at concentration requiring classification. (similar substances)
Methanol	67-56-1	No data of sufficient quality are available.
Coco diethanolamide		No data of sufficient quality are available.
Quaternary ammonium compounds, benzyl-C12-18-alkyldimethyl, chlorides	68391-01-5	No data of sufficient quality are available.
Nonylphenol ethoxylate		No significant toxicity observed in animal studies at concentration requiring classification. (similar substances)

Linanool		No significant toxicity observed in animal studies at concentration requiring classification.
2,6-Octadien-1-ol, 3,7-dimethyl-, (2Z)-	106-25-2	No significant toxicity observed in animal studies at concentration requiring classification.
2,6-Octadien-1-ol, 3,7-dimethyl-, (2E)-	106-24-1	No significant toxicity observed in animal studies at concentration requiring classification.
Citronellol	106-22-9	No significant toxicity observed in animal studies at concentration requiring classification.
Isopropanol	67-63-0	No significant toxicity observed in animal studies at concentration requiring classification. (similar substances)

Substances	CAS Number	Aspiration hazard
Terpene hydrocarbon by-products	68956-56-9	Aspiration into the lungs may cause chemical pneumonitis including coughing, difficulty breathing, wheezing, coughing up blood and pneumonia, which can be fatal.
Methanol	67-56-1	Not applicable
Coco diethanolamide		Not applicable
Quaternary ammonium compounds, benzyl-C12-18-alkyldimethyl, chlorides	68391-01-5	Not applicable
Nonylphenol ethoxylate		Not applicable
Linanool		Not applicable
2,6-Octadien-1-ol, 3,7-dimethyl-, (2Z)-	106-25-2	Not applicable
2,6-Octadien-1-ol, 3,7-dimethyl-, (2E)-	106-24-1	Not applicable
Citronellol	106-22-9	Not applicable
Isopropanol	67-63-0	Not applicable

12. Ecological Information

Ecotoxicity

Substance Ecotoxicity Data

Substances	CAS Number	Toxicity to Algae	Toxicity to Fish	Toxicity to Microorganisms	Toxicity to Invertebrates
Terpene hydrocarbon by-products	68956-56-9	ErC50 (72h) 4.779 mg/L (Pseudokirchnerella subcapitata) EC50 (72h) 63.59 mg/L (Skeletonema costatum)	LC50 (96h) 5.07 mg/L (Danio rerio) LC50 (96h) > 65 mg/L (Cyprinodon variegatus)	No information available	EL50 (48h) 1.4 - 2.7 mg/L (Daphnia magna) EC50 (48h) 155 mg/L (Acartia tonsa)
Methanol	67-56-1	EC50 (96 h) =22000 mg/L (Pseudokirchnerella subcapitata) NOEC (8 d) =8000 mg/L (Scenedesmus quadricauda)	LC50 (96 h) =15400 mg/L (Lepomis macrochirus) EC50 (200 h) =14536 mg/L (Oryzias latipes)	IC50 (3h) > 1000 mg/L (activated sludge)	EC50 (96 h) =18260 mg/L (Dapnia magna) NOEC (21 d) =208 mg/L (Dapnia magna)
Coco diethanolamide	Proprietary	EC50(72h) 2.2 mg/L (Scenedesmus subspicatus)	LC50(96h) 3.6 mg/L (Brachydanio rerio) NOEC(28d)=0.32 mg/L (Oncorhynchus mykiss)	No information available	EC50(48h) 2.25 mg/L (Ceriodaphnia dubia) NOEC(21d) 0.07 mg/L (Daphnia magna)
Quaternary ammonium compounds, benzyl-C12-18-alkyldi methyl, chlorides	68391-01-5	No information available	LC50 (96 h) 0.515 mg/L (Lepomis macrochirus)	No information available	EC50 (48 h) 0.092 mg/L (Mysidopsis bahia) NOEC (34 d) 0.032 mg/L (Daphnia magna)
Nonylphenol ethoxylate	Proprietary	EC50 (48h) 15 mg/L (Lemna minor) EC50 (48h) 17 mg/L (Scenedesmus quadricauda)	LC50 (48h) 16.4 mg/L (Poecilia reticulata)	No information available	LC50 (48h) 18.2 mg/L (Daphnia magna)
Linanool	Proprietary	EC50(96h): 88.3 mg/L (Desmodesmus subspicatus)	LC50(96h): 27.8 mg/L (Oncorhynchus mykiss)	EC50(3h): > 100 mg/L (activated sludge, domestic)	No information available
2,6-Octadien-1-ol, 3,7-dimethyl-, (2Z)-	106-25-2	ErC50(72h): 9.54 mg/L (Pseudokirchnerella subcapitata)	LC50(96h): 20.3 mg/L (Danio rerio)	EC50(3h): 241 mg/L (activated sludge)	EC50(48h): 32.4 mg/L (Daphnia magna)
2,6-Octadien-1-ol, 3,7-dimethyl-, (2E)-	106-24-1	EC50(72h): 13.1 mg/L (Desmodesmus subspicatus)	LC50(96h): 22 mg/L (Danio rerio)	EC50(30m): 70 mg/L (Activated sludge)	EC50(48h): 10.8 mg/L (Daphnia magna)

Citronellol	106-22-9	EC50 (72 h) 2.4 mg/L (Scenedesmus subspicatus)	LC50 (96 h) 14.66 mg/L (Leuciscus idus)	No information available	EC50 (48 h) 17.48 mg/L (Daphnia magna)
Isopropanol	67-63-0	EC50 (72h) > 1000 mg/L (Desmodesmus subspicatus) EC50 (7d) 1800 mg/L (Scenedesmus quadricauda)	LC50 (96h) 9640 mg/L (Pimephales promelas) LC50 (7d) 7060 mg/L (Poecilia reticulata)	TT (16h) 1050 mg/L (Pseudomonas putida)	EC50 (48h) 13,299 mg/L (Daphnia magna) EC50 (24h) > 10,000 mg/L (Daphnia magna)

12.2. Persistence and degradability

Substances	CAS Number	Persistence and Degradability
Terpene hydrocarbon by-products	68956-56-9	Readily biodegradable (83% @ 28d)
Methanol	67-56-1	Readily biodegradable (95% @ 20d)
Coco diethanolamide	Proprietary	Readily biodegradable (92.5% @ 28d)
Quaternary ammonium compounds, benzyl-C12-18-alkyldimethyl, chlorides	68391-01-5	Readily biodegradable (60% @ 15d)
Nonylphenol ethoxylate	Proprietary	No information available
Linanool	Proprietary	Readily biodegradable (62.4% @ 28d)
2,6-Octadien-1-ol, 3,7-dimethyl-, (2Z)-	106-25-2	Readily biodegradable (90% @ 28d)
2,6-Octadien-1-ol, 3,7-dimethyl-, (2E)-	106-24-1	Readily biodegradable (94% @ 28d)
Citronellol	106-22-9	Readily biodegradable (80 - 90% @ 28d)
Isopropanol	67-63-0	Readily biodegradable (53% @ 5d)

12.3. Bioaccumulative potential

Substances	CAS Number	Log Pow
Terpene hydrocarbon by-products	68956-56-9	5.7
Methanol	67-56-1	Not Bioaccumulative; BCF=1
Coco diethanolamide	Proprietary	Not Bioaccumulative; BCF=65.4 L/kg (similar substance)
Quaternary ammonium compounds, benzyl-C12-18-alkyldimethyl, chlorides	68391-01-5	LogKow 3.91
Nonylphenol ethoxylate	Proprietary	3.93 BCF: 7.6 - 16 (Oryzias latipes)
Linanool	Proprietary	2.84
2,6-Octadien-1-ol, 3,7-dimethyl-, (2Z)-	106-25-2	2.76
2,6-Octadien-1-ol, 3,7-dimethyl-, (2E)-	106-24-1	2.6
Citronellol	106-22-9	log Kow =3.55
Isopropanol	67-63-0	0.05

12.4. Mobility in soil

Substances	CAS Number	Mobility
Terpene hydrocarbon by-products	68956-56-9	No information available
Methanol	67-56-1	No information available
Coco diethanolamide	Proprietary	No information available
Quaternary ammonium compounds, benzyl-C12-18-alkyldimethyl, chlorides	68391-01-5	No information available
Nonylphenol ethoxylate	Proprietary	No information available
Linanool	Proprietary	No information available
2,6-Octadien-1-ol, 3,7-dimethyl-, (2Z)-	106-25-2	KOC = 94.15 L/kg
2,6-Octadien-1-ol, 3,7-dimethyl-, (2E)-	106-24-1	KOC = 70.79
Citronellol	106-22-9	KOC = 70.79
Isopropanol	67-63-0	No information available

12.6. Other adverse effects

Endocrine Disruptor Information

This product contains ethoxylated nonylphenols

13. Disposal Considerations

Safe handling and disposal methods
Disposal should be made in accordance with federal, state, and local regulations.

Disposal of any contaminated packaging
Follow all applicable national or local regulations.

Environmental regulations
Not applicable

14. Transport Information

Transportation Information
Australia ADG

UN Number	UN1993
UN proper shipping name:	Flammable Liquid, N.O.S. (Contains Methanol, Terpenes)
Transport Hazard Class(es):	3
Packing Group:	III
Environmental Hazards:	Marine Pollutant

IMDG/IMO

UN Number	UN1993
UN proper shipping name:	Flammable Liquid, N.O.S. (Contains Methanol, Terpenes)
Transport Hazard Class(es):	3
Packing Group:	III
Environmental Hazards:	Marine Pollutant
EMS:	EmS F-E, S-E

IATA/ICAO

UN Number	UN1993
UN proper shipping name:	Flammable Liquid, N.O.S. (Contains Methanol, Terpenes)
Transport Hazard Class(es):	3
Packing Group:	III
Environmental Hazards:	Marine Pollutant

Special precautions during transport
None

HazChem Code
•3Y

15. Regulatory Information

Safety, health and environmental regulations specific for the product

International Inventories

Australian AICS Inventory	All components are listed on the AICS or are subject to a relevant exemption, permit, or assessment certificate.
New Zealand Inventory of Chemicals	All components are listed on the NZIoC or are subject to a relevant exemption, permit, or assessment certificate.
EINECS (European Inventory of Existing Chemical Substances)	This product, and all its components, complies with EINECS
US TSCA Inventory	All components listed on inventory or are exempt.
Canadian Domestic Substances List (DSL)	All components listed on inventory or are exempt.

Poisons Schedule number
S6

International Agreements

Montreal Protocol - Ozone Depleting Substances:	Does not apply
Stockholm Convention - Persistent Organic Pollutants:	Does not apply

Rotterdam Convention - Prior Informed Consent:	Does not apply
Basel Convention - Hazardous Waste:	Does not apply

16. Other information

Date of preparation or review

Revision Date: 11-Apr-2017

Revision Note
Update to Format
SECTION:
2

Full text of H-Statements referred to under sections 2 and 3
H225 - Highly flammable liquid and vapor
H226 - Flammable liquid and vapor
H301 - Toxic if swallowed
H302 - Harmful if swallowed
H304 - May be fatal if swallowed and enters airways
H311 - Toxic in contact with skin
H312 - Harmful in contact with skin
H314 - Causes severe skin burns and eye damage
H315 - Causes skin irritation
H317 - May cause an allergic skin reaction
H318 - Causes serious eye damage
H319 - Causes serious eye irritation
H331 - Toxic if inhaled
H335 - May cause respiratory irritation
H336 - May cause drowsiness or dizziness
H360 - May damage fertility or the unborn child
H370 - Causes damage to organs
H371 - May cause damage to organs
H400 - Very toxic to aquatic life
H410 - Very toxic to aquatic life with long lasting effects
H411 - Toxic to aquatic life with long lasting effects

Additional information

For additional information on the use of this product, contact your local Halliburton representative.

For questions about the Safety Data Sheet for this or other Halliburton products, contact Chemical Stewardship at 1-580-251-4335.

Key abreviations or acronyms used
bw – body weight
CAS – Chemical Abstracts Service
EC50 – Effective Concentration 50%
LC50 – Lethal Concentration 50%
LD50 – Lethal Dose 50%
LL50 – Lethal Loading 50%
mg/kg – milligram/kilogram
mg/L – milligram/liter
NOEC – No Observed Effect Concentration
OEL – Occupational Exposure Limit
PBT – Persistent Bioaccumulative and Toxic
ppm – parts per million
STEL – Short Term Exposure Limit
TWA – Time-Weighted Average
vPvB – very Persistent and very Bioaccumulative
h - hour
mg/m^3 - milligram/cubic meter
mm - millimeter

mmHg - millimeter mercury
w/w - weight/weight
d - day

Key literature references and sources for data
www.ChemADVISOR.com/

Disclaimer Statement
This information is furnished without warranty, expressed or implied, as to accuracy or completeness. The information is obtained from various sources including the manufacturer and other third party sources. The information may not be valid under all conditions nor if this material is used in combination with other materials or in any process. Final determination of suitability of any material is the sole responsibility of the user.

End of Safety Data Sheet

APPENDIX C

Tables

Table C1: **Chemical mass balance and estimated concentrations in typical hydraulic fracturing fluids**

GOLDER

Name For Report	CAS Number	HighTempAcid				DFS-BCG (H)				DFS-BCG				DeltaFrac (H)			
		Constituent Weight in Fluid (lbs)	Additive mass percent (ignores Proppant and Makeup Water)	Additive Mass Percent (total)	Equivalent Concentration (mg/L) **500gal**	Constituent Weight in Fluid (lbs)	Additive mass percent (ignores Proppant and Makeup Water)	Additive Mass Percent (total)	Equivalent Concentration (mg/L) **50,000gal**	Constituent Weight in Fluid (lbs)	Additive mass percent (ignores Proppant and Makeup Water)	Additive Mass Percent (total)	Equivalent Concentration (mg/L) **50,000gal**	Constituent Weight in Fluid (lbs)	Additive mass percent (ignores Proppant and Makeup Water)	Additive Mass Percent (total)	Equivalent Concentration (mg/L) **50,000gal**
Chemical Additives - Fluid Systems																	
2-Bromo-2-nitro-1,3- propanediol	52-51-7																
Acetic acid	64-19-7					288.973700	3.87527%	0.05388%		220.67110	3.12562%	0.04118%		94.57321	4.25535%	0.03978%	
Alcohol	-																
Alcohol	-																
Alcohols, C12-16, ethoxylated	68551-12-2	1.354373195	0.07252%	0.000411238													
Alkyl phenol alkyoxylates	-																
Alkylated quaternary chloride	-																
Amine	-																
Amine oxides, cocoalkyldimethyl	61788-90-7	6.771865974	0.36260%	0.002056192													
Ammonium Sulfate	7783-20-2																
Benzaldehyde	100-52-7	3.385932987	0.18130%	0.001028096													
Borate Salts	-																
Chlorous acid, sodium salt	7758-19-2					113.08750	1.51656%	0.02109%		113.08768	1.60179%	0.02110%		83.06430	3.73750%	0.03494%	
Cinnamaldehyde	104-55-2	24.37871751	1.30537%	0.007402291													
Citric acid	77-92-9	54.96264511	2.94300%	0.016688716													
Crystalline silica, quartz	14808-60-7																
Crystalline silica, quartz																	
diethylene glycol	111-46-6	23.70153091	1.26911%	0.007196672													
Disodium octaborate tetrahydrate	12008-41-2					35.97580	0.48245%	0.00671%		35.97582	0.50957%	0.00671%					
Ether Compound	-																
Ethylene glycol monobutyl ether	111-76-2																
Food red 10	3734-67-6																
Glycerine	56-81-5																
Glycol compound	-																
Glycol ether	-																
Glyoxal	107-22-2																
Hydrochloric acid	7647-01-0	560.5370361	30.01425%	0.170200023													
Hydrochloric acid	7647-01-0																
Hydroxylpropyl guar	39421-75-5					1516.01910	20.33052%	0.28269%						368.23208	16.56872%	0.15489%	
Inorganic oxide	-																
Inorganic Material	-																
Isopropanol	67-63-0																
Methanol	67-56-1					3.21550	0.04312%	0.00060%		3.21549	0.04554%	0.00060%		0.61247	0.02756%	0.00026%	
Oxyalkylated polymer	-																
Phenolic compound	-																
Polyacrylamide copolymer	-																
Polyacrylate	-																
Polyacrylate	-																
Polyacrylate	-																
Polymer	-																
Potassium carbonate	584-08-7																
Quaternary Amine	-																
Quaternary Amine	-																
Quaternary ammonium compound	-																
Red No 2	915-67-3																
Silica dioxide	112926-00-8																
Sodium carbonate	497-19-8					15.46960	0.20745%	0.00288%						3.75747	0.16907%	0.00158%	
Sodium chloride	7647-14-5					339.26260	4.54967%	0.06326%		339.26304	4.80538%	0.06331%		249.19291	11.21251%	0.10482%	
Sodium hydroxide	1310-73-2					771.62980	10.34791%	0.14389%		771.63078	10.92951%	0.14399%		92.98615	4.18394%	0.03911%	
Sodium hypochlorite	7681-52-9																
Sodium iodide	7681-82-5	1.354373195	0.07252%	0.000411238													
Sodium persulfate	7775-27-1																
Sodium sulfate	7757-82-6																
Terpene	-																
Terpene	-																
Violet 12	6625-46-3																
Xanthan gum	11138-66-2																

Table C1: **Chemical mass balance and estimated concentrations in typical hydraulic fracturing fluids**

Name For Report	CAS Number	HighTempAcid				DFS-BCG (H)				DFS-BCG				DeltaFrac (H)			
		Constituent Weight in Fluid (lbs)	Additive mass percent (ignores Proppant and Makeup Water)	Additive Mass Percent (total)	Equivalent Concentration (mg/L) **500gal**	Constituent Weight in Fluid (lbs)	Additive mass percent (ignores Proppant and Makeup Water)	Additive Mass Percent (total)	Equivalent Concentration (mg/L) **50,000gal**	Constituent Weight in Fluid (lbs)	Additive mass percent (ignores Proppant and Makeup Water)	Additive Mass Percent (total)	Equivalent Concentration (mg/L) **50,000gal**	Constituent Weight in Fluid (lbs)	Additive mass percent (ignores Proppant and Makeup Water)	Additive Mass Percent (total)	Equivalent Concentration (mg/L) **50,000gal**
Ulexite	**1319-33-1**					458.91770	6.15430%	0.08557%		285.99257	4.05085%	0.05337%					
Triethanol amine	**102-71-6**					233.28060	3.12840%	0.04350%		233.28087	3.30423%	0.04353%		97.20025	4.37356%	0.04089%	
Diethanolamine	**111-42-2**					103.19290	1.38386%	0.01924%		103.19301	1.46164%	0.01926%		42.26972	1.90194%	0.01778%	
Ethanol	**64-17-5**					64.30980	0.86242%	0.01199%		64.30986	0.91090%	0.01200%		12.24948	0.55117%	0.00515%	
Hydrotreated light petroleum distillate	**64742-47-8**					64.30980	0.86242%	0.01199%		64.30986	0.91090%	0.01200%		12.24948	0.55117%	0.00515%	
Sodium polyacrylate	**9003-04-7**					61.20990	0.82085%	0.01141%		61.20996	0.86699%	0.01142%		23.31805	1.04920%	0.00981%	
Alcohols, C12-15, ethoxylated	**68131-39-5**					40.19360	0.53901%	0.00749%		40.19366	0.56931%	0.00750%		7.65593	0.34448%	0.00322%	
Amides, tall-oil fatty, N,N-bis(hydroxyethyl)	**68155-20-4**					40.19360	0.53901%	0.00749%		40.19366	0.56931%	0.00750%		7.65593	0.34448%	0.00322%	
Fatty acids, tall-oil, ethoxylated	**61791-00-2**					40.19360	0.53901%	0.00749%		40.19366	0.56931%	0.00750%		7.65593	0.34448%	0.00322%	
Butyl alcohol	**71-36-3**					32.15490	0.43121%	0.00600%		32.15493	0.45545%	0.00600%		6.12474	0.27558%	0.00258%	
Tributyl tetradecyl phosphonium chloride	**81741-28-8**					10.42470	0.13980%	0.00194%		10.42475	0.14766%	0.00195%		3.75291	0.16886%	0.00158%	
Glutaraldehyde	**111-30-8**					0.03220	0.00043%	0.00001%		0.03215	0.00046%	0.00001%		0.00000	0.00000%	0.00000%	
Monoethanolamine borate	**26038-87-9**													127.69886	5.74585%	0.05371%	
Guar gum	**9000-30-0**									1546.96033	21.91141%	0.28867%					
Silica gel	**112926-00-8**					15.46960	0.20745%	0.00288%						3.75747	0.16907%	0.00158%	
Ethylene Glycol	**107-21-1**					250.31880	3.35689%	0.04668%		155.99595	2.20955%	0.02911%					
Sodium bisulfite	**7631-90-5**					10.20160	0.13681%	0.00190%		10.20166	0.14450%	0.00190%		3.88634	0.17487%	0.00163%	
Crystalline silica, quartz	**14808-60-7**					41.71980	0.55948%	0.00778%		25.99932	0.36826%	0.00485%					
Chemical Additives - Optional																	
Ammonium salt	-																
Quaternary amine	-																
Quaternary amine	-																
Quaternary amine	-																
Amine salt	-																
Amine salt	-																
Inner salt of alkyl amines	-																
Ethoxylated alcohol	-																
Almandite and pyrope garnet	**1302-62-1**																
Bentonite, benzyl(hydrogenated tallow alkyl) dimethylammonium stearate complex	**121888-68-4**																
Guar gum derivative	-																
Crystalline silica, quartz	**14808-60-7**																
EDTA/Copper chelate	-																
Glycerine	**56-81-5**																
Guar gum	**9000-30-0**																
Fatty acid ester	-																
Propanol	**71-23-8**																
Silica gel	**112926-00-8**																
Silica, amorphous - fumed	**7631-86-9**																
Sodium bicarbonate	**144-55-8**																
Sodium chloride	**7647-14-5**																
Triethanolamine zirconate	**101033-44-7**																
Choline Chloride	**67-48-1**																
Ethylene Glycol	**107-21-1**																
Acrylamide acrylate copolymer	**9003-06-9**																
Acrylonitrile	**107-13-1**																
Sodium bisulfite	**7631-90-5**																
Alcohols, C6-12, ethoxylated propoxylated	**68937-66-6**																
Alcohols, C10-16, ethoxylated propoxylated	**69227-22-1**																

Table C1: **Chemical mass balance and estimated concentrations in typical hydraulic fracturing fluids**

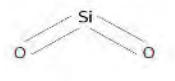
Name For Report	CAS Number	HighTempAcid				DFS-BCG (H)				DFS-BCG				DeltaFrac (H)			
		Constituent Weight in Fluid (lbs)	Additive mass percent (ignores Proppant and Makeup Water)	Additive Mass Percent (total)	Equivalent Concentration (mg/L) **500gal**	Constituent Weight in Fluid (lbs)	Additive mass percent (ignores Proppant and Makeup Water)	Additive Mass Percent (total)	Equivalent Concentration (mg/L) **50,000gal**	Constituent Weight in Fluid (lbs)	Additive mass percent (ignores Proppant and Makeup Water)	Additive Mass Percent (total)	Equivalent Concentration (mg/L) **50,000gal**	Constituent Weight in Fluid (lbs)	Additive mass percent (ignores Proppant and Makeup Water)	Additive Mass Percent (total)	Equivalent Concentration (mg/L) **50,000gal**
Polyethylene Glycol	**25322-68-3**																
Proppants																	
Aluminum silicate	**1302-76-7**					70000	0.0000%	13.05286%		70000	0.0000%	13.06251%		70000	0.0000%	29.44439%	
Aluminum oxide	**1344-28-1**					20000	0.0000%	3.72939%		20000	0.0000%	3.73215%		20000	0.0000%	8.41268%	
Crystalline silica, quartz	**14808-60-7**					10000		1.86469%		10000		1.86607%		10000		4.20634%	
Iron oxide	**1309-37-1**					5000	0.0000%	0.93235%		5000	0.0000%	0.93304%		5000	0.0000%	2.10317%	
Titanium dioxide	**13463-67-7**					3000	0.0000%	0.55941%		3000	0.0000%	0.55982%		3000	0.0000%	1.26190%	
Crystalline silica, cristobalite	**14464-46-1**					2000	0.0000%	0.37294%		2000	0.0000%	0.37321%		2000	0.0000%	0.84127%	
Water																	
Water in additives	**7732-18-5**	1191.123095	63.77932%	0.361669552		2907.10740	38.98566%	0.54209%		2861.57598	40.53186%	0.53399%		974.56017	43.85064%	0.40993%	
Make Up water	**No Cas Number**	1425.832073		42.1480%		418824.17550		78.09789%		418824.73147		78.15574%		125513.83314		52.79540%	
Total Mass Additives	lbs	676.446475				4549.7567				4198.490144				1247.893695			
Total Mass Proppant		0				110000				110000				110000			
Total Mass Water (in additives)		1191.123095				2907.10740				2861.57598				974.56017			
Total Mass Make Up Water		1425.832073				418824.17550				418824.7315				125513.83314			
Total Mass Additives	kg	307				2064				1904				566			
Total Mass Proppant		0				49895				49895				49895			
Total Mass Water (in additives)		540				1319				1298				442			
Total Mass Make Up Water		647				189975				189976				56932			
Total Mass Additives	%	20.5%				0.8%				0.8%				0.5%			
Total Mass Proppant		0.0%				20.5%				20.5%				46.3%			
Total Mass Water (in additives)		36.2%				0.5%				0.5%				0.4%			
Total Mass Make Up Water		43.3%				78.1%				78.2%				52.8%			
		1840.985759				12382.40955				11426.41857				3396.210352			
		122.7323839				825.4939698				761.7612379				226.4140235			
		736.3943035				4952.963819				4570.567427				1358.484141			

			Persistence										Bioaccumulation		Toxicity									
Name For Report	Constituent Name	CAS Number	ORGANIC Solubility in water (mg/L)	INORGANIC Solubility in water (mg/L)	Solubility Considered in Conjunction with Acute Toxicity	Log Koc	Henry's Law (atm m3/mole)	EPISUITE Ready Biodegradability	EPISUITE Biowin 3 Ultimate Survey Biodegradation	EPISUITE Biowin 4 Primary Biodegradation	EPISUITE Biowin 7 Anaerobic Biodegradation	Fish BCF	Log Kow / Log Pow	FISH Chronic NOEC (mg/L)	INVERT Chronic NOEC (mg/L)	PLANT Chronic NOEC (mg/L)	FISH Chronic LOEC/MATC/EC$_{<50}$ (mg/L)	INVERT Chronic LOEC/MATC/EC$_{<50}$ (mg/L)	PLANT Chronic LOEC/MATC/EC$_{<50}$ (mg/L)	FISH Acute LC/EC50 (mg/L)	INVERT Acute LC/EC50 (mg/L)	PLANT Acute LC/EC50 (mg/L)	Overall Score	Data Gaps %
Acetic acid	Acetic acid	64-19-7	○			○	◖	○	○	○	○	○	○						○	◖	◖		○	33%
Alcohols, C12-C16, Ethoxylated	Alcohols, C12-C16, Ethoxylated	68551-12-2	●			●							○				◖					●	●	◖	67%
Amine oxides, cocoalkydimethyl	Amine oxides, cocoalkydimethyl	61788-90-7	●			●	●	○	◖	○	●	○	◖						◖	●	●		◖	33%
Benzaldehyde	Benzaldehyde	100-52-7	●			○	◖	○	○	○	○	○	○	◖	○		○	○		◖	◖		○	17%
Cinnamaldehyde	Cinnamaldehyde	104-55-2	○			○	◖	○	◖	○	○	○	○						○	●	◖		◖	33%
Citric Acid	Citric Acid	77-92-9	○			○	●	○	○	○	○	○	○							○			○	44%
Diethylene glycol	Diethylene glycol	111-46-6	○			○	●	○	○	○	○	○	○							○	○		○	39%
Methanol	Methanol	67-56-1	○			○	◖	○	○	○	○	○	○	○		○	○		○	◖	◖		○	17%
Triethanol amine	Triethanol amine	102-71-6	○			○	●	○	○	○	○	●	○	○		○	○		○	◖	○	○	○	22%
Diethanol amine	Diethanol amine	111-42-2	○			○	●	○	○	○	○	○	○	○		○	○		○	○	◖	◖	○	17%
Ethanol	Ethanol	64-17-5	○			○	◖	○	○	○	○	○	○	○		○	○			○	○	○	○	22%
Hydrotreated light petroleum distillate	Hydrotreated light petroleum distillate	64742-47-8	●			◖	○	○	○	○	○	●	○	●		◖	◖		○	◖	◖	◖	◖	17%
Sodium polyacrylate	Sodium polyacrylate	9003-04-7	○												○	○	○			○	○	◖	○	61%
Alcohols, C12-C15, Ethoxylated	Alcohols, C12-C15, Ethoxylated	68131-39-5	●			○	●	●	◖	○	●	○	●	◖	◖	◖		○	○	◖	●	●	●	6%
Amides, tall-oil, fatty, N,N-bis(hydroxyethyl) (68	Amides, C18-unsatd., N,N-bis(hydroxyethyl)	93-83-4	●			◖	●	○	◖	○	●	○	●	◖	●		○	○		◖	◖	◖	●	11%
Fatty acids, tall-oil, ethoxylated	Fatty acids, tall-oil, ethoxylated	61791-00-2	●			◖	●	●	◖	○	●	○	●							○	◖	◖	◖	33%
Butyl alcohol	Butyl alcohol	71-36-3	○			○	◖	○	○	○	○	○	○			○	○			○	○		○	28%
Tributyl tetradecyl phosphonium chloride (8174	Tetra-n-butyl phosphonium chloride	2304-30-5	●			●	○	○	○	○	○	●	○	○						○	◖	◖	○	33%
Glutaraldehyde	Glutaraldehyde	111-30-8	○			○	◖	○	○	○	○	○	○	○	○	●	○			◖	●	●	◖	11%
Monoethanolamine borate (26038-87-9)	Reaction products of monoethanolamine and boric acid	94095-04-2	○			○								○						○	○	◖	○	67%
Guar gum	Guar gum	9000-30-0																		○	◖		◖	89%
Ethylene glycol	Ethylene glycol	107-21-1	○			○	◖	○	○	○	○	○	○	○	○				○	◖	○		○	22%
Aluminium oxide	Aluminium oxide	1344-28-1		○	●																		○	82%
Chlorous Acid, Sodium Salt	Chlorous Acid, Sodium Salt	7758-19-2		●	●										○		●	○		○	●	●	●	27%
Disodium Octaborate Tetrahydrate	Disodium Octaborate Tetrahydrate	12008-41-2		●	●										○	○	○			○	◖	◖	◖	18%
Hydrochloric Acid	Hydrochloric Acid	7647-01-0																		○	○		○	82%
Iron oxide	Iron oxide	1309-37-1		○	○																◖		○	73%
Sodium bisulfite	Sodium bisulfite	7631-90-5		●	●										○	○					◖	◖	●	36%
Sodium Carbonate	Sodium Carbonate	497-19-8																		○	○	◖	◖	64%
Sodium Chloride	Sodium Chloride	7647-14-5														○	○	○	○	○	○	○	○	27%
Sodium Hydroxide	Sodium Hydroxide	1310-73-2																		○	◖		◖	82%
Sodium Iodide	Sodium Iodide	7681-82-5																		○	●		●	82%
Titanium dioxide	Titanium dioxide	13463-67-7													◖	◖				○	◖	◖	◖	55%
Ulexite (1319-33-1)	Disodium Octaborate Tetrahydrate	12008-41-2		●	●									○	○	○			○	◖	◖	◖	●	18%
Guar gum derivative	Hydroxylpropyl guar																							100%
Aluminium silicate	Aluminium silicate	1302-76-7																						100%
Crystalline silica, cristobalite	Crystalline silica, cristobalite	14464-46-1																						100%
Crystalline Silica, Quartz	Crystalline Silica, Quartz	14808-60-7		◖	○															○	○		◖	64%
Silica Gel	Silica Gel	112926-00-8		◖	○															○	○		◖	64%

	Inorganic
	No information discussed in report
	Surrogate used
	Not assessed considered to be sand

APPENDIX D

Human Health Hazard Summary

Name	Silica gel
Synonyms	Precipitated silica; amorphous silica
CAS number	112926-00-8
Molecular formula	O_2-Si
Molecular structure	

Overview	References
Silica gel is part of a larger group of chemicals referred to as synthetic amorphous silica (SAS) registered under the overarching CAS No 7631-86-9. SAS (including silica gels) are white, fluffy and/or powdery amorphous forms of silicon dioxide (silica, SiO_2). It has a molecular weight of 60.08g/mol, a density of 2.2 at 20ºC and a melting point of approximately 1700 ºC. Commercialised since the 1950s, SAS are used in a wide variety of industrial applications and they are usually tailor-made to meet the users' requirements. Main uses of SAS include reinforcement and thickening agent in various systems such as elastomers, resins, inks and water for instance. Due to their high porosity, SAS is also used as an adsorbing agent. SAS is also used in consumers' products such as cosmetics, pharmaceuticals and foods. SAS have been studied less than crystalline silica. They are generally less toxic than crystalline silica and are cleared more rapidly from the lung. Furthermore, amorphous silica is chemically and biologically inert when ingested in any of its many physical forms such as amorphous siliceous earth (diatomaceous earth, diatomite, kieselguhr) or colloidal ***silica gels***. This explains why overall it is not considered as hazardous to humans. The human health toxicity information discussed below is based on SAS.	ECETOC (2006); IARC (1997); SIDS (2004); Gosselin *et al.(*1984)

Human Health Toxicity Summary	Reference
Carcinogenicity IARC rating for silica, amorphous (CAS No 7631-86-9): Group 3 (Amorphous silica *is not classifiable as to its carcinogenicity to humans)* The evaluations for amorphous silica pertain to inhalation resulting from workplace exposures. Very little epidemiological evidence was available to the Working Group. No association was detected for mesothelioma with biogenic amorphous silica fibres in the three community-based case-control studies. Separate analyses were not performed for cancer risks among a subset of diatomaceous earth industry workers exposed predominantly to amorphous silica. There is inadequate evidence in humans for the carcinogenicity of amorphous silica.	IARC (2018)
Mutagenicity/Genotoxicity No mutations were observed when SAS was tested in *in vitro* and *in vivo* standard methods. No evidence for mutagenic activity was found in an ex-vivo gene-mutation assays on isolated alveolar type-II cells after long-term inhalation exposure of rats to a distinctly noxious/inflammatory SAS concentration of 50 mg/m^3 (13 weeks).	SIDS (2004)
Reproductive Toxicity The reproductive toxicity properties of SAS were assessed with a one-generation on rats where animals were fed SAS at a dose of 500 mg/kg bw/day for a premating period of 4.5 months with continued exposure up to 6 months. While no adverse effects were observed, however, it was reported that the study had some shortcomings regarding the low number of pregnant animals used and that the mating ratio was too low according to current standards.	SIDS (2004)
Developmental Toxicity/Teratogenicity The potential for developmental effects of SAS were assessed in a comprehensive and reliable testing programme where various animal species (rat, mouse, rabbit, and hamster) were administered SAS orally at doses up to 1600 mg/kg bw/day. No significant signs of maternal or developmental toxic effects were observed in any species tested. Abnormalities noted in soft or skeletal tissues of the test groups were comparable to the frequencies occurring in the control groups. The NOEL for maternal and developmental toxicity was reported as the highest tested dose of 1600 mg/kg bw/d.	FDA (1972, 1973a,b) as cited in SIDS (2004)
Endocrine Disruption Not listed as an endocrine disruptor.	EC (2000)
Neurotoxicity NDF	

Acute Toxicity (oral, dermal or inhalation) SAS (aqueous suspension or gel) administered orally (gavage or in diet) and dermally did not cause mortality at the highest doses tested. LD_{50} values ranged from > 3100 to > 20000 mg/kg in rats and mice. One study established an oral LD_{50} for rats to be > 10000 mg/kg bw. Based on a rabbit study, a dermal LD_{50} > 5000 mg/kg bw was established for rabbits. No clinically or pathologically meaningful effects were observed after 4-hour exposure of rats to either pyrogenic or precipitated SAS. However, in the study where animals were exposed to precipitated SAS, signs of some discomfort and stress were observed and body weight of females was retarded for two days post-exposure.	SIDS (2004)
Chronic/repeat dose toxicity (oral, dermal, inhalation) *Oral* The chronic toxic effects of silica gel were assessed in a rat study. In this study, animals received an amorphous silica gel (Syloid 244) at dietary levels of 3.2 and 10% for 6 months, corresponding to average doses of 2170 to 2420 mg/kg bw/day and 7950 to 8980 mg/kg bw/day respectively. No adverse effects were observed. Isolated pathological findings were assessed to be unrelated to dosing and common in untreated rats. The microscopic examination did not show any changes in the kidneys or reproductive organs. *Dermal* No information was found regarding the chronic toxicity of silica gel or SAS via the dermal route. *Inhalation* No evidence of pneumoconiosis or silicosis was observed in occupational exposures to SAS. Other disorders of the respiratory tract could not be correlated to exposure to SAS alone. However, it is noted that the available epidemiological data base on workers is too limited to be able to draw firm conclusions.	Grace (1975) as cited in SIDS (2004); SIDS (2004)
Sensitisation of the skin or respiratory system There are no experimental data available on sensitisation. There is no evidence of skin sensitisation in workers over decades of practical experience.	SIDS (2004)
Corrosion (irreversible)/irritation (reversible) effects on the skin or eye **Effects on skin** Based on experimental data, SAS is not irritating to rabbit skin. However, it is noted that cases of dryness or degenerative eczema of the skin in workers with chronic contact have been reported by occupational physicians. When tested on the rabbit eye as a powder, SAS showed no or only weak and non-permanent irritating effects on the conjunctivae but neither the iris nor the cornea were affected.	SIDS (2004)

Physical Hazards	Reference
Flammable Potential Non flammable solid.	SIDS (2004)
Explosive Potential Not classified as an explosive substance.	SIDS (2004)

Toxicity Values	Value	Reference
Human Toxicity Data		
High Chronic/Repeat Dose Toxicity		
LOAEC	NDF	
LOAEL	NDF	
Animal Toxicity Data		
Acute Toxicity		
LD_{50}		
Rat, oral (gavage)	> 3100 to > 20000 mg/kg (aqueous suspension and gel SAS)	SIDS (2004)
Mouse, oral	> 3100 to > 20000 mg/kg (aqueous suspension and gel SAS)	SIDS (2004)
Rabbit, oral	NDF	
Rat, dermal	NDF	
Rabbit, dermal	> 5000 mg/kg (precipitated SAS)	SIDS (2004)
Mouse, dermal	NDF	
LC_{50}		
Rat	>0.14 - >2.0 mg/l (pyrogenic and precipitated SAS)	SIDS (2004)

High Chronic/Repeat Dose Toxicity		
LOAEL	NDF	
LOAEC	5 mg/m^3 (precipitated and gel SAS)	SIDS (2004)

Footnotes:
LD_{50} – lethal dose for 50% of experimental population
LC_{50} – lethal air concentration for 50% of experimental population
LOAEL – Lowest Observed Adverse Effect Level
LOAEC – Lowest Observed Adverse Effect Concentration
NDF – No data found within the limits of the search strategy

Human Health Toxicity Ranking		
	Hazard data	**Comment**
Hazard Band 4		
Carcinogenicity (IARC Group 1 or 2A)	No	IARC Group 3 – inadequate evidence to classify
Mutagenicity/Genotoxicity (GHS Category 1A and 1B)	No	SIDS, 2004
Reproductive Toxicity/Developmental toxicity (GHS Category 1, 1A and 1B)	No	Based on a study with some limitations (SIDS, 2004)
Endocrine Disruption[1]	No	EC, 2000
Hazard Band 3		
Carcinogenicity (IARC Group 2B)	No	
Mutagenicity/Genotoxicity (GHS Category 2)	No	SIDS, 2004
Reproductive Toxicity/Developmental toxicity (GHS Category 2)	No	Based on a study with some limitations (SIDS, 2004)
Acute Toxicity (oral, dermal or inhalation) Very Toxic/Toxic • oral LD_{50} ≤ 300 mg/kg [2] • dermal LD_{50} ≤ 1000 mg/kg • inhalation LC_{50} ≤ 10 mg/L [3] (or mg/m^3) (vapour)	No	SIDS, 2004
High Chronic/repeat dose toxicity • oral LOAEL ≤ 10 mg/kg/d [2]; • dermal LOAEL ≤ 2 0 mg/kg/d; • inhalation LOAEC (6 h/d) ≤ 50 ppm/d for gases, ≤ 0.2 mg/L/d for vapours or ≤ 0.02 mg/L/d for dust/mists/fumes [3]	No	SIDS (2004)
Corrosive (irreversible effect)	No	SIDS (2004)

Human Health Toxicity Ranking		
	Hazard data	**Comment**
Respiratory sensitiser	No	Based on widespread exposure and few reports of allergic responses.
Hazard Band 2		
Harmful chronic/repeat dose toxicity • oral LOAEL > 10 mg/kg/d and ≤ 100 mg/kg/d • dermal LOAEL > 20 mg/kg/d and ≤ 200 mg/kg/d • inhalation (6-h/d) LOAEC > 50 mg/L ≤ 250 mg/L/d for gases, > 0.2 mg/L ≤ 1 .0 mg/L/d for vapours or > 0.02 mg/L ≤ 0.2 mg/L/d for dust/mists/fumes [3]	No	SIDS (2004)
Skin Sensitiser	No	Based on widespread exposure and few reports of allergic responses.
Hazard Band 1		
Acute Toxicity-Harmful • oral LD_{50} > 300 mg/kg ≤ 2000 mg/kg • dermal LD_{50} >1 000 mg/kg ≤ 2000 mg/kg; • inhalation LC_{50} (6 h/d) > 10 mg/L ≤ 20 mg/L for vapours) [3]	No	SIDS (2004)
Irritant (reversible effect)	No	SIDS (2004)
Hazard Band 0 **All indicators outside criteria listed in Hazards 1-4**		
Physical Hazards		
Flammable potential	No	SIDS (2004)
Explosive potential	No	SIDS (2004)
Hazard Evaluation (highest band) not including physical hazards	**0**	

Human Health Toxicity Ranking		
	Hazard data	**Comment**
Data confidence (available points out of 12 parameters)	**12/12**	**83%**

* Based on IMAP Framework [NICNAS (2013) Inventory Multi-tiered Assessment and Prioritisation (IMAP) Framework. National Industrial Chemicals Notification and Assessment Scheme. Department of Health and Aging, Canberra].

"[1]Based on list of endocrine disrupting chemicals from the European Commission's Endocrine Disrupters website.

[2] milligrams per kilogram body mass (mg/kg) or milligrams per kilogram body mass per day (mg/kg/d)

[3] Based on GHS cut-offs for hazard classification. For chronic/repeat dose toxicity, GHS cut-offs are provided as guidance values (i.e. the dose/concentration at or below which significant health effects are observed)". (p 18, NICNAS 2013).

Human Health Guidelines		
Media	**Concentration (mg/m^3; mg/L; mg/kg)**	**Reference**
Occupational Exposure Limits		
Air (OEL)		
8-h TWA	10 mg/m^3	Work Safe Australia (2020)
STEL	NDF	
Peak Limitation	NDF	
Environmental Exposure		
Air, ambient, residential	NDF	
Air, commercial/industrial	NDF	
Water, potable	NDF	
Water, recreational	NDF	

Soil, residential	NDF	
Soil, commercial/industrial	NDF	
Soil, protection of groundwater	NDF	

Footnotes:

OEL = Occupational Exposure Limit

TWA = 8 h Time-Weighted Average

STEL = (15 min) Short-term Exposure Limit

Qualifying Summary Comments

Silica gel is a type of synthetic amorphous silica (SAS). Amorphous silica has been studied less than crystalline silica as they are generally less toxic than crystalline silica and are cleared more rapidly removed from the lung. It is noted that although effects on the lung have been observed at high concentrations these have been reversible following cessation of exposure. Amorphous silica is chemically and biologically inert when ingested in any of its many physical forms such as amorphous siliceous earth (diatomaceous earth**,** diatomite, kieselguhr) or colloidal silica gels and is not classifiable as to its carcinogenicity to humans. SAS is not considered as having acute or chronic health effects when administered via oral, dermal and inhalation exposure pathways nor as having any reproductive, development/teratogenicity and mutagenicity/genotoxicity effects. SAS is not classified as a skin sensitiser nor does it cause irreversible irritation of the skin or eye. For this reason it is categorized as Hazard Band 0. WorkSafe Australia has listed amorphous silica as a hazardous substance under the respective legislation and developed an exposure standard for amorphous silica dust which is the generic standard for dusts. Due to its low solubility, amorphous silica in aqueous solution and as introduced during chemical stimulation activities would settle into soils and sediments and become indistinguishable from those materials. The principle hazard is subsequently the generation of dusts under occupational settings which require management.

References

EC (2000) Towards the establishment of a priority list of substances for further evaluation of their role in endocrine disruption, preparation of a candidate list of substances as a basis for priority setting, Final Report. European Commission. (Incorporating corrigenda to final report dated 21 June 2000).

ECETOC (2006) Report No. 51 Synthetic Amorphous Silica (CAS No. 7631-86-9). ECETOC (European Centre for Ecotoxicology and Toxicology of Chemicals) JACC (Joint Assessment of Commodity Chemicals). Available at http://www.ecetoc.org/wp-content/uploads/2014/08/JACC-051.pdf . [Accessed 7 January 2020].

Gosselin et al. (1984) Clinical Toxicology of Commercial Products. 5th ed. Baltimore: Williams and Wilkins, 1984., p. II-95. Available at http://toxnet.nlm.nih.gov/cgi-bin/sis/search/f?./temp/~BKqIKF:1 [Accessed 10 December 2013].

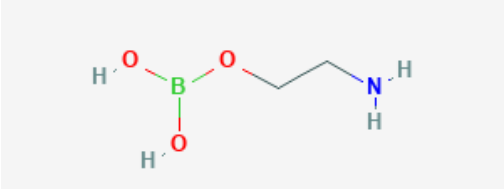
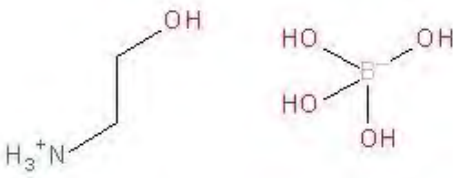
Safe Work Australia (2020) Hazardous Chemical Information System (HCIS), Safe Work Australia. Available at http://hcis.safeworkaustralia.gov.au/ExposureStandards/Details?exposureStandardID=509 . [Accessed 7 January 2020].

IARC (1997) *IARC Summary & Evaluation: Silica.* International Agency for Research on Cancer Accessed from http://www.inchem.org/documents/iarc/vol68/silica.html *(*International Programme on Chemical Safety Database (2010)), Volume 68, p 41. [Accessed 7 January 2020].

IARC (2018) Agents Classified by the *IARC Monographs*, Volumes 1–123. International Agency for Research on Cancer (IARC), 9 November 2018. Available at http://monographs.iarc.fr/ENG/Classification/ClassificationsCASOrder.pdf. [Accessed 7 January 2020] .

SIDS (2004) Organization for Economic Cooperation and Development (OECD) Screening Information Dataset (SIDS) Initial Assessment Report as maintained by United Nations Environment Programme (UNEP) Chemicals . Available at https://hpvchemicals.oecd.org/UI/SIDS_Details.aspx?key=7dc69270-2300-4a87-af67-8962ad98a749&idx=0. [Accessed 7 January 2020].

Created by:	LPA	Date: 18/12/2019
Reviewed by:	CLB	Date and Revision: 23/01/2020

Name	Monoethanolamine borate
Synonyms	Ethanolamine borate; boric acid, 2-aminoethyl ether; 2-Aminoethanol, monoester with boric acid; MEA borate; MEA polyborate
CAS number	26038-87-9
Molecular formula	$C_2H_8BNO_3$
Molecular structure	 (Source: U.S. NLM, 2020)
Surrogate	Limited data was found for monoethanolamine borate. Therefore, Reaction products of monoethanolaimne and boric acid (1:1) (CAS RN: 94095-04-2) has been adopted as a surrogate. Molecular formula: $C_2H_7NO.xBH_3O_3$  (Source: ECHA, 2020) In addition, NICNAS provides a group assessment for 'Salts of boric acid'. This group assessment considered 28 different salts of boric acid (metals, ammoniums and amines) of which CAS RN 26038-87-9 is one (NICNAS, 2017). The basis for this grouping outlined by NICNAS is that boric acid is expected to drive the toxicity of these chemicals, even though the individual cations, anions and organic acids may vary in toxicological properties.

Overview	References
Reaction products of monoethanolaimne and boric acid (1:1) is a clear, pale yellow solution (at 20°C and 1013 hPa), that only exists in aqueous solution. The freezing/melting point and boiling point are likely to be similar to that of water, noting the presence of the compound in solution would slightly depress the melting point and elevate the boiling point. The relative density was measured to be 1.270 g/cm^3 (at 20°C) and it is considered to be infinitely soluble in water. The vapour pressure is reported to	ECHA, 2020 and NICNAS, 2017

be < 0 Pa at 20°C and 25°C. Reaction products of monoethanolaimne and boric acid (1:1) is used in chemical manufacturing and is found in liquid and granular fertilisers, lubricant additives, lubricants and greases, in metal working fluids and hydraulic fluids. NICNAS report uses from CAS RN. 26038-87-9 internationally include cosmetic uses as a buffering agent and commercial uses in metal working fluids. Reaction products of monoethanolaimne and boric acid (1:1) is considered readily biodegradable and is considered to have a low potential for adsorb to soil. Based on a logKow of <3, it is also considered to have a low potential for bioaccumulation. Following oral exposure, simple inorganic borates are readily and completely absorbed in humans and animals. Absorption via the dermal route is expected to be very low. As the substance is a liquid and has a negligible vapour pressure, the potential for inhalation exposure of vapours is considered low. However, inhalation absorption is assumed to be high, as a worst-case scenario. If absorbed, the substance will likely be circulated by the blood to the liver and other tissues. Being hydrophilic, it is unlikely to be absorbed by cells of the organs and tissues, except for the kidney. NICNAS outlines that for compounds within the salts of boric acid group, undissociated boric acid is the main species likely present in mammalian blood following exposure. This is based on studies for simple inorganic borates, such as boric acid and borax. Once absorbed, it is likely the substance will be excreted rapidly via the kidneys and non-absorbed substance will be excreted in faeces. Boric acid has a half-life of <24 hours in humans and animals.	

Human Health Toxicity Summary	Reference
Carcinogenicity Monoethanolamine borate or reaction products of monoethanolaimne and boric acid (1:1) have not been evaluated by the International Agency for Research on Cancer (IARC) as to their carcinogenicity. Although there is limited data to assess carcinogenicity, NICNAS conclude that chemicals in this group are not likely to be carcinogenic based on data for surrogate compounds,	ECHA, 2020 NICNAS, 2017
Mutagenicity/Genotoxicity Reaction products of monoethanolaimne and boric acid (1:1) is not classifiable as mutagenic, based on available data. The key study cited by ECHA is an *in vitro* gene mutation study in bacteria, undertaken in accordance with OECD Guideline 471 and GLP compliant. The test system included Salmonella typhimurium bacteria and Escherichia coli bacteria. Results of this study were negative, and the substance was found to be not mutagenic to the cells tested. NICNAS also conclude that chemicals in this group are not likely to have mutagenic or genotoxic potential, based on available information for surrogate compounds.	ECHA, 2020
Reproductive Toxicity Data is currently not available to assess reproductive toxicity of Reaction products of monoethanolaimne and boric acid (1:1) (or Reaction products of monoethanolaimne and boric acid (1:3) as a read-across compound).	ECHA, 2020

Safe Work Australia (2020) has classified Monoethanolamine borate as Category 1B for reproductive and developmental toxicity (H360FD May damage fertility. May damage the unborn child). This is based on the classification of sodium borate, anhydrous (CAS No. 1330-43-4), tetraboron disodium heptaoxide, hydrate (CAS No. 12267-73-1) and orthoboric acid, sodium salt (CAS No. 13840-56-7) as Category 1B and the recommendation by NICNAS to extent this classification to the group ('salts of boric acid'). NICNAS outline that the testes and the developing foetus have been identified as the most sensitive targets of boron toxicity in animal studies. Testicular effects reported include reduced organ weight and organ:body ratio, atrophy and degeneration of the spermatogenic epithelium, impaired spermatogenesis and reduced fertility. Two-year and three-year generational studies in rats, determined the NOAEL for fertility of 100 mg/kg bw/day of boric acid (equivalent to 17.5 mg boron/kg bw/day), based on testicular effects.	Safe Work Australia (2020) and NICNAS, 2017.
Developmental Toxicity/Teratogenicity Data is currently not available to assess developmental toxicity of Reaction products of monoethanolaimne and boric acid (1:1) (or Reaction products of monoethanolaimne and boric acid (1:3) as a read-across compound). As discussed above, Safe Work Australia (2020) has classified Monoethanolamine borate as Category 1B for reproductive and developmental toxicity (H360FD May damage fertility. May damage the unborn child). NICNAS outline that the testes and the developing foetus have been identified as the most sensitive targets of boron toxicity in animal studies. Developmental effects reported include high prenatal mortality, reduced foetal body weight and malformations and variations of the eyes, CNS, cardiovascular system and axial skeleton. A NOAEL for developmental effects of 55 mg/kg bw/day of boric acid (equivalent to 9.6 mg boron/kg bw/day) was reported for rats.	ECHA, 2020 Safe Work Australia (2020)
Endocrine Disruption Monoethanolamine borate or Reaction products of monoethanolaimne and boric acid (1:1) are not identified in the European Commission (EC)'s report, "Towards the establishment of a priority list of substances for further evaluation of their role in endocrine disruption" as a substance of interest.	EC, 2000
Acute Toxicity (oral, dermal, inhalation) Reaction products of monoethanolaimne and boric acid (1:1) is not classifiable based on its acute oral or dermal toxicity, based on the available data. The key acute **oral** toxicity study referenced found a LD_{50} (female) of > 2000 mg/kg bw for rats. The study was undertaken in accordance with OECD Guideline 423 and was GLP compliant. The study involved female rats being administered a single dose of the test item via gavage, with dose being 5, 50, 300 and 2000 mg/kg body weight. The key acute **dermal** study referenced found a LD_{50} of >2000 mg/kg bw. The study was undertaken in accordance with OECD Guideline 402 and was GLP compliant. The study involved male and female rats being exposure to a single dose of 2000 mg/kg bw, via occlusive coverage.	ECHA, 2020

No study was available to assess acute toxicity via the inhalation route of exposure. NICNAS outlines that these compounds are expected to have low acute oral, dermal and inhalation toxicity. However, this is based on read-across substances due to limited data. NICNAS outlines that free amines (as in compounds with 2-aminoethanol) may be acutely toxic. This is based on studies which suggests free amines can induce acute toxicity by way of their strong alkalinity, which causes corrosive effects such as severe local damage to the gastrointestinal tract. However, the cations of these amines are not basic and do not have corrosive potential, or corresponding acute toxicity.	NICNAS, 2017
Chronic/repeat dose toxicity (oral, dermal, inhalation) Data is currently not available to assess chronic/ repeat dose toxicity of Reaction products of monoethanolaimne and boric acid (1:1) (or Reaction products of monoethanolaimne and boric acid (1:3) as a read-across compound). NICNAS also outline that there is no data available to assess the oral, dermal or inhalation repeat dose toxicity of these chemicals. However, based on surrogate compounds, it is considered that chemical in this group are not likely to cause serious damage to health from repeated oral exposure.	ECHA, 2020 NICNAS, 2017
Sensitisation of the skin or respiratory system Reaction products of monoethanolaimne and boric acid (1:1) is not classifiable based on skin sensitisation, based on a read-across approach and a study available for reaction products of monoethanolaimne and boric acid (1:3). The key study references concluded that reaction products of monoethanolaimne and boric acid (1:3) was practically devoid of potential to cause sensitisation in a guinea pig skin sensitisation study undertaken in accordance with OECD Guideline 406. No data is available to assess the respiratory system sensitisation. NICNAS concludes that based on the available information for surrogates, chemicals in this group are not likely to be skin sensitisers.	ECHA, 2020 NICNAS, 2017
Corrosion (irreversible)/irritation (reversible) effects on the skin or eye Reaction products of monoethanolaimne and boric acid (1:1) is not classifiable based on **skin** irritation, as the substance is considered not irritating to the skin, as outline by ECHA. The key skin irritation/corrosion study referenced is a study on rabbits, where the rabbits were exposed to for 4 hours with semiocclusive coverage and observed for 72 hours after patch removal. The substance was found to be not irritating. Reaction products of monoethanolaimne and boric acid (1:1) is not classifiable based on **eye** irritation, as the substance is considered not irritating or corrosive to the eyes, as outlined by ECHA. The key eye irritation study presented is a Bovine Corneal Opacity and Permeability test. The substance was tested by topical application for approximately 10 minutes and study concluded that the substance did not induce ocular irritation under the experimental conditions. NICNAS considered this group unlikely to be specific **skin** or **respiratory** irritants, based on the limited data available, Slight **eye** irritant effects were reported in animal studies for surrogate compounds,	ECHA, 2020

however, the effects were not sufficient to warrant a hazard classification for the chemicals in this group.	NICNAS, 2017.

Physical Hazards	Reference
Flammable Potential Non flammable. A study reports that the substance did not flash below the boiling temperature of water.	ECHA, 2020
Explosive Potential Non explosive. Reaction products of monoethanolaimne and boric acid (1:1) does not contain functional groups associated with explosive properties.	ECHA, 2020

Toxicity Values	Value	Reference
Human Toxicity Data		
High Chronic/Repeat Dose Toxicity		
LOAEC	NDF	
LOAEL	NDF	
Animal Toxicity Data		
Acute Toxicity		
LD_{50}		
Rat, oral	LD_{50} (female) > 2000 mg/kg bw	Cited by ECHA, 2020
Rat, dermal	LD_{50} >2000 mg/kg bw	Cited by ECHA, 2020
LC_{50}		
Rat	NDF	
High Chronic/Repeat Dose Toxicity		
LOAEL	NDF	
LOAEC	NDF	

Toxicity Values	Value	Reference
NOAEL	Developmental effects (rats): 55 mg/kg bw/day boric acid (equivalent to 9.6 mg boron/kg bw/day) Fertility, testicular effects (rats): 100 mg/kg bw/day boric acid (equivalent to 17.5 mg boron/kg bw/day)	Cited by NICNAS, 2017

Footnotes:
LD_{50} – lethal dose for 50% of experimental population
LC_{50} – lethal air concentration for 50% of experimental population
LOAEL – Lowest Observed Adverse Effect Level
LOAEC – Lowest Observed Adverse Effect Concentration
NDF – No data found within the limits of the search strategy

Human Health Toxicity Ranking		
	Hazard data	**Comment**
Hazard Band 4		
Carcinogenicity (IARC Group 1 or 2A)	No	
Mutagenicity/Genotoxicity (GHS Category 1A and 1B)	No	
Reproductive Toxicity/Developmental toxicity (GHS Category 1, 1A and 1B)	Yes	Category 1B for reproductive and developmental toxicity (H360FD May damage fertility. May damage the unborn child).
Endocrine Disruption[1]	No	
Hazard Band 3		
Carcinogenicity (IARC Group 2B)	No	
Mutagenicity/Genotoxicity (GHS Category 2)	No	
Reproductive Toxicity/Developmental toxicity (GHS Category 2)	-	See above
Acute Toxicity (oral, dermal or inhalation) Very Toxic/Toxic • oral $LD_{50} \leq 300$ mg/kg [2] • dermal $LD_{50} \leq 1000$ mg/kg • inhalation $LC_{50} \leq 10$ mg/L [3] (or mg/m^3) (vapour)	No	

Human Health Toxicity Ranking		
	Hazard data	**Comment**
High Chronic/repeat dose toxicity • oral LOAEL ≤ 10 mg/kg/d [2]; • dermal LOAEL ≤ 2 0 mg/kg/d; • inhalation LOAEC (6 h/d) ≤ 50 ppm/d for gases, ≤ 0.2 mg/L/d for vapours or ≤ 0.02 mg/L/d for dust/mists/fumes [3]	NDF	
Corrosive (irreversible effect)	No	
Respiratory sensitiser	NDF	
Hazard Band 2		
Harmful chronic/repeat dose toxicity • oral LOAEL > 10 mg/kg/d and ≤ 100 mg/kg/d • dermal LOAEL > 20 mg/kg/d and ≤ 200 mg/kg/d • inhalation (6-h/d) LOAEC > 50 mg/L ≤ 250 mg/L/d for gases, > 0.2 mg/L ≤ 1 .0 mg/L/d for vapours or > 0.02 mg/L ≤ 0.2 mg/L/d for dust/mists/fumes [3]	NDF	
Skin Sensitiser	No	
Hazard Band 1		
Acute Toxicity-Harmful • oral LD_{50} > 300 mg/kg ≤ 2000 mg/kg • dermal LD_{50} >1 000 mg/kg ≤ 2000 mg/kg; • inhalation LC_{50} (6 h/d) > 10 mg/L ≤ 20 mg/L for vapours) [3]	No	
Irritant (reversible effect)	No	
Hazard Band 0 **All indicators outside criteria listed in Hazards 1-4**		
Physical Hazards		
Flammable potential	No	

Human Health Toxicity Ranking		
	Hazard data	**Comment**
Explosive potential	No	
Hazard Evaluation (highest band) not including physical hazards	4	Based on potential reproductive and developmental toxicity of salts of boric acid.
Data confidence (available points out of 12 parameters)	10/12	83%

* Based on IMAP Framework [NICNAS (2013) Inventory Multi-tiered Assessment and Prioritisation (IMAP) Framework. National Industrial Chemicals Notification and Assessment Scheme. Department of Health and Aging, Canberra].

"[1]Based on list of endocrine disrupting chemicals from the European Commission's Endocrine Disrupters website.

[2] milligrams per kilogram body mass (mg/kg) or milligrams per kilogram body mass per day (mg/kg/d)

[3] Based on GHS cut-offs for hazard classification. For chronic/repeat dose toxicity, GHS cut-offs are provided as guidance values (i.e. the dose/concentration at or below which significant health effects are observed)". (p 18, NICNAS 2013).

Human Health Guidelines		
Media	**Concentration (mg/m^3; mg/L; mg/kg)**	**Reference**
Occupational Exposure Limits		
Air (OEL)		
8-h TWA	NDF	
STEL	NDF	
Peak Limitation	NDF	
Environmental Exposure		
Air, ambient, residential	NDF	
Air, commercial/industrial	NDF	

Human Health Guidelines		
Water, potable	NDF	
Water, recreational	NDF	
Soil, residential	NDF	
Soil, commercial/industrial	NDF	
Soil, protection of groundwater	NDF	

Footnotes:

OEL = Occupational Exposure Limit

TWA = 8 h Time-Weighted Average

STEL = (15 min) Short-term Exposure Limit

Qualifying Summary Comments

Reaction products of monoethanolaimne and boric acid is a clear, pale yellow solution. It is expected to have similar freezing points and boiling points of water. The substance is a used in chemical manufacturing and is found in cosmetics, liquid and granular fertilisers, lubricant additives, lubricants and greases, in metal working fluids and hydraulic fluids. It is readily biodegradable and considered to have a low potential for bioaccumulation. Following oral exposure, simple inorganic borates are readily and completely absorbed in humans and animals. Once absorbed, undissociated boric acid is the main species likely present in mammalian blood and it is likely the substance will be excreted rapidly via the kidneys. Boric acid has a half-life of <24 hours in humans and animals.

Reaction products of monoethanolaimne and boric acid has been ranked as Hazard Band 4, based on potential reproductive and developmental toxicity, Safe Work Australia (2020) has classified Monoethanolamine borate as Category 1B for reproductive and developmental toxicity (H360FD May damage fertility. May damage the unborn child). This is based on the classification of sodium borate, anhydrous (CAS No. 1330-43-4), tetraboron disodium heptaoxide, hydrate (CAS No. 12267-73-1) and orthoboric acid, sodium salt (CAS No. 13840-56-7) as Category 1B and the recommendation by NICNAS to extent this classification to the group (‘salts of boric acid’). Reaction products of monoethanolaimne and boric acid are considered to have low acute and repeat dose toxicity, are unlikely to be carcinogenic or mutagenic, and do not appear to be irritating to the skin or eyes.

References

European Chemicals Agency (ECHA), 2019. *Registration Dossier for* Reaction products of monoethanolaimne and boric acid (1:1). Available at https://echa.europa.eu/registration-dossier/-/registered-dossier/14325/1. Last modified 11/12/2019, accessed January 2020.

European Commission (EC), 2000. *Towards the establishment of a priority list of substances for further evaluation of their role in endocrine disruption, preparation of a candidate list of substances as a basis for priority setting, Final Report* (Incorporating corrigenda to final report dated 21 June 2000).

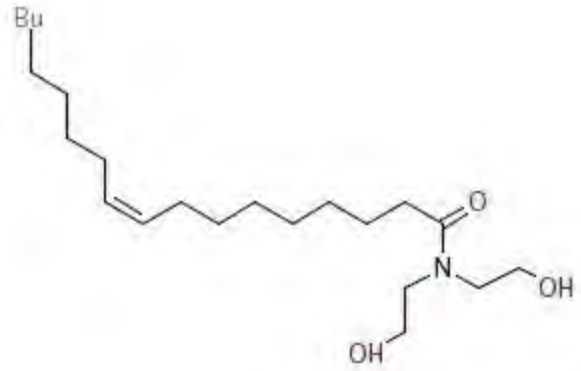
International Agency for Research on Cancer (IARC), 2019. Agents Classified by the IARC Monographs, Volumes 1–125, last updated 29 November, 2019. Available at https://monographs.iarc.fr/agents-classified-by-the-iarc/, accessed December 2019.

National Industrial Chemicals Notification and Assessment Scheme (NICNAS), 2017. IMAP Group Assessment Report for *Salts of boric acid: Human health tier II assessment*. Dated 30 June 2017. Available at: https://www.nicnas.gov.au/chemical-information/imap-assessments/imap-group-assessment-report?assessment_id=1332#health, accessed January 2020.

Safe Work Australia. HCIS (Hazardous Chemical Information System) 2020. *Hazardous Chemical Information System: MEA polyborate.* http://hcis.safeworkaustralia.gov.au/HazardousChemical/Details?chemicalID=4838, accessed January 2020.

U.S. National Library of Medicine (U.S. NLM), 2020. PubChem Compound Summary dossier for Monoethanolamine borate. Available at https://pubchem.ncbi.nlm.nih.gov/compound/Monoethanolamine-borate, accessed January 2020.

Created by:	MGT	Date: 03 February 2020
Reviewed by:	CLB	Date and Revision: 13 February 2020

Name	Amides, tall-oil fatty, N,N-bis(hydroxyethyl)
Synonyms	Diethanolamine tall oil acid amide; Tall oil fatty acid diethanolamide; Tallamide DEA; N,N-Bis(2-hydroxyethyl)tall oil fatty amides
CAS number	68155-20-4
Molecular formula	Unspecified
Molecular structure	Unspecified
Surrogate	Name: Oleamide, N,N-bis(2-hydroxyethyl)-; Amides, C18-unsatd., N,N-bis(hydroxyethyl). CAS RN: 93-83-4 Basis for adoption: Limited information available for CAS RN: 68155-20-4. U.S. EPA's Analog Identification Methodology (AIM) Tool software program identified CAS RN: 93-83-4 as an exact chemical match (U.S. EPA, 2019).
Molecular formula (surrogate)	$C_{22}H_{43}NO_3$
Molecular structure (surrogate)	 (Source: ECHA, 2019)

Overview	References
Amides, C18-unsatd., N,N-bis(hydroxyethyl) is a brown liquid (at 20°C and 1013 hPa) with a density of 0.967 g/cm^3 (at 20°C). It has a freezing point of <-80°C and is reported to decomposes before boiling at > 300°C. Modelling suggests a water solubility between 0.12 mg/L and 2.17 mg/L at 25°C.	ECHA, 2019

Overview	References
Amides, C18-unsatd., N,N-bis(hydroxyethyl) has numerous industrial and consumer uses, including in washing and cleaning products, in polymer manufacturing, textile treatment products and dyes, adhesives and sealants, lubricants and grease, pH regulators and water treatment products, and plant protections products. Household use of products containing this compound include machine wash liquids/detergents, automotive care products, paints and coating or adhesives, fragrances and air fresheners. The ECHA dossier identifies amides, C18-unsatd., N,N-bis(hydroxyethyl) as having low bioaccumulation potential. Studies on a surrogate compound, N,N-bis(2-hydroxyethyl)dodecanamide (C12 DEA) report that the substance is well absorbed via the oral route (approximately 50% oral absorption), then metabolised to polar metabolites and excreted principally in urine. A toxicokinetic study on a surrogate compound, N,N-bis(2-hydroxyethyl)dodecanamide (C12 DEA), reported that this substance was rapidly converted into 11- and 12- hydroxy derivatives in rat liver and kidney microsomes. The ECHA dossier also outlines dermal absorption of approximately 10% and inhalation of as 100% (data lacking).	ECHA, 2019

Human Health Toxicity Summary	Reference
Carcinogenicity Amides, C18-unsatd., N,N-bis(hydroxyethyl) (both CAS RN 93-83-4 and 68155-20-4) has not been evaluated by the International Agency for Research on Cancer (IARC) as to its carcinogenicity. The ECHA dossier outlines that no carcinogenic classification is warranted, according to CLP (EC 1272/2008) criteria. This is based on the results of a chronic dermal study in rats, where the absence of neoplastic lesions or carcinogenic activity in a chronic bioassay in rodents suggested that the test substance does not have carcinogenic potential.	IARC, 2019 ECHA, 2019
Mutagenicity/Genotoxicity The ECHA dossier did not classify amides, C18-unsatd., N,N-bis(hydroxyethyl) (and a surrogate compound) as genotoxic, based on negative results in short-term *in vitro* and *in vivo* genotoxicity test. An *in vitro* gene mutation study in mammalian cells cited on the ECHA dossier was performed in compliance with GLP. The study investigated the potential of the test substance to induce mutations at the mouse lymphoma thymidine kinase locus using the cell line L5178Y. The substance was tested under several conditions and the assess was performed both with and without rat liver microsomal (S9) activation. The results reported no increase in the frequency of mutant colonies of the cells after exposure to the test substance, based on the conditions of the study. Two *in vitro* gene mutation studies in bacteria were also cited on the ECHA dossier. Both studies report negative results, indicating the test substance is not mutagenic in the Salmonella typhimurium reverse mutation assay and the E.coli reverse mutation assay. An *in vivo* mammalian germ cell study cited in the ECHA dossier also reported negative results, with the test substance not increasing the frequency of micronucleated normochromatic erythrocytes (NCE) in peripheral blood of both male and female mice at the end of 13 weeks.	ECHA, 2019

Reproductive Toxicity The ECHA dossier outlines that there were no studies available to assess effects on fertility for exposure to amides, C18-unsatd., N,N-bis(hydroxyethyl) via the oral, dermal, and inhalation routes.	ECHA, 2019
Developmental Toxicity/Teratogenicity The ECHA dossier does not provide a developmental toxicity classification for amides, C18-unsatd., N,N-bis(hydroxyethyl). The ECHA dossier does cites a developmental toxicity study undertaken on a surrogate substance, being amides, C12-18 and C18-unsatd. N,N-bis (hydroxylethyl). The study assessed embryonic and foetal development in pregnant Sprague-Dawley CD rats according to OECD Guideline 414. During gestation days 6 to 15 inclusive, the substance was administered to groups of 30 female rats by gavage at does levels of 0, 100, 300 and 1,000 mg/kg bw/day. Observations were made on days 0, 6, 16 and 20, with all surviving females sacrificed on gestation day 20 and the foetuses removed by caesarean section. The NOAELs for parental toxicity and developmental toxicity were considered to be 1,000 mg/kg bw/day (the highest dose level), under the study conditions.	ECHA, 2019
Endocrine Disruption Amides, C18-unsatd., N,N-bis(hydroxyethyl) (both CAS RN 93-83-4 and 68155-20-4) is not identified in the European Commission (EC)'s report, "Towards the establishment of a priority list of substances for further evaluation of their role in endocrine disruption" as a substance of interest.	EC, 2000
Acute Toxicity (oral, dermal, inhalation) Amides, C18-unsatd., N,N-bis(hydroxyethyl) is reported to have low acute **oral** toxicity, with a LD_{50} reported as 10 000 mg/kg/bw in a rat study. Groups of 6 male rats were administered 0, 5 000, 10 000 and 20 000 mg/kg/bw of the test substance by gavage and the animals were observed for 14 d. The ECHA dossier outlines that GHS criteria were not met by the study. An acute **dermal** exposure LD_{50} of > 2 000 mg/kg/bw was established in a study of male and female rabbits. Information provided by ECHA outlines a 24 h exposure duration, exposure at one dose of 2 000 mg/kg/bw and that 3 animals with abraded skin and 3 animals with intact skin were exposed. No data available for exposure via the **inhalation** pathway.	ECHA, 2019
Chronic/repeat dose toxicity (oral, dermal, inhalation) The ECHA dossier concludes that amides, C18-unsatd., N,N-bis(hydroxyethyl) does not meet the requirement for repeated dose toxicity classification according to CLP (EC1272/2008) criteria. This was based on the NOAEL of > 750 mg/kg bw/day derived from an oral sub-acute study in rats and observed effected in a chronic dermal study in rats, where the NOAEL was 50 mg/kg bw/day for systemic effects and LOAEL of 50 mg/kg bw/day for local effects. The oral 28-day sub-acute study in groups of 10 male and 10 female rats was undertaken with a surrogate substance, amides, C12-18 (even numbered) and C18-unsaturated, N,N-bis(hydroxyethyl). No treatment-related effects were reported at any of the dose levels tested. The dermal 2-year chronic study in groups of 50 male and 50 female rats was undertaken on the test substance.	ECHA, 2019

Sensitisation of the skin or respiratory system A skin sensitising potential test undertaken on a surrogate compound, amides, C16-18 and C18-unsatd., N,N-bis(hydroxyethyl), cited by the ECHA dossier, found the test substance to not be sensitising to the skin. The test comprised at guinea-pig maximisation test, according to OECD Guideline 406. There was no study available to assess the respiratory sensitisation of the substance.	ECHA, 2019
Corrosion (irreversible)/irritation (reversible) effects on the skin or eye The ECHA dossier concludes that, based on the available data, amides, C18-unsatd., N,N-bis(hydroxyethyl) is considered irritating to both skin and eyes. ECHA classifies the substance as Skin Irrit. 2 H315 (causes skin irritation) and Eye Irrit. 2 H319 (causes serious eye irritation). A skin irritation study is cited, where 0.5 mL of undiluted substance was applied to 6 rabbits (with one abraded area and one area of intact skin), with the exposure period being 24 hours. Observations were made at 24h and 72 h, with moderate to severe erythema and defined edema observed at 24 h and moderate to severe erythema and moderate edema observed at 72 h on the abraded and intact rabbit skin. An eye irritation study is cited, where 0.1 mL of the undiluted substance was applied in a single instillation into one eye of each of the six rabbits, with the other eye acting as the control. Observations were made at 24 hr, 48 hr, 72 hr, 7 d and 14 d. The study cites that irritation (chemosis and discharge) reduced to almost 0 by day 14, with the exception of conjunctival redness, which was the most prominent response and was present in 3/6 animals.	ECHA, 2019

Physical Hazards	Reference
Flammable Potential Flash point of 218°C at 1019 hPa.	ECHA, 2019
Explosive Potential No data available. No chemical groups present in the molecule that are associated with explosive properties.	ECHA, 2019

Toxicity Values	Value	Reference
Human Toxicity Data		
High Chronic/Repeat Dose Toxicity		
LOAEC	NDF	
LOAEL	NDF	
Animal Toxicity Data		
Acute Toxicity		
LD_{50}		
Rat, oral	LD_{50}: 10 000 mg/kg/bw	Cited by ECHA, 2019
Rabbit, dermal	LD_{50}: > 2 000 mg/kg/bw	Cited by ECHA, 2019
High Chronic/Repeat Dose Toxicity		
LOAEL	LOAEL (dermal, rats, local effects): 50 mg/kg bw/day	Cited by ECHA, 2019
NOAEL	NOAEL (oral, sub-acute, rats): > 750 mg/kg bw/day NOAEL (dermal, rats, systemic effects): 50 mg/kg bw/day NOAEL (oral, rat, developmental and parental toxicity): 1,000 mg/kg bw/day	Cited by ECHA, 2019

Footnotes:
LD_{50} – lethal dose for 50% of experimental population
LOAEL – Lowest Observed Adverse Effect Level
NOAEL – No Observed Adverse Effect Level
NDF – No data found within the limits of the search strategy

Human Health Toxicity Ranking		
	Hazard data	**Comment**
Hazard Band 4		
Carcinogenicity (IARC Group 1 or 2A)	No	
Mutagenicity/Genotoxicity (GHS Category 1A and 1B)	No	
Reproductive Toxicity/Developmental toxicity (GHS Category 1, 1A and 1B)	No	
Endocrine Disruption[1]	No	
Hazard Band 3		
Carcinogenicity (IARC Group 2B)	No	
Mutagenicity/Genotoxicity (GHS Category 2)	No	
Reproductive Toxicity/Developmental toxicity (GHS Category 2)	No	
Acute Toxicity (oral, dermal or inhalation) Very Toxic/Toxic • oral LD_{50} ≤ 300 mg/kg [2] • dermal LD_{50} ≤ 1000 mg/kg • inhalation LC_{50} ≤ 10 mg/L [3] (or mg/m^3) (vapour)	No	
High Chronic/repeat dose toxicity • oral LOAEL ≤ 10 mg/kg/d [2]; • dermal LOAEL ≤ 2 0 mg/kg/d; • inhalation LOAEC (6 h/d) ≤ 50 ppm/d for gases, ≤ 0.2 mg/L/d for vapours or ≤ 0.02 mg/L/d for dust/mists/fumes [3]	No	
Corrosive (irreversible effect)	No	
Respiratory sensitiser	-	
Hazard Band 2		

Human Health Toxicity Ranking		
	Hazard data	**Comment**
Harmful chronic/repeat dose toxicity • oral LOAEL > 10 mg/kg/d and ≤ 100 mg/kg/d • dermal LOAEL > 20 mg/kg/d and ≤ 200 mg/kg/d • inhalation (6-h/d) LOAEC > 50 mg/L ≤ 250 mg/L/d for gases, > 0.2 mg/L ≤ 1 .0 mg/L/d for vapours or > 0.02 mg/L ≤ 0.2 mg/L/d for dust/mists/fumes [3]	Yes	LOAEL (dermal): 50 mg/kg bw/day
Skin Sensitiser	No	
Hazard Band 1		
Acute Toxicity-Harmful • oral LD_{50} > 300 mg/kg ≤ 2000 mg/kg • dermal LD_{50} >1 000 mg/kg ≤ 2000 mg/kg; • inhalation LC_{50} (6 h/d) > 10 mg/L ≤ 20 mg/L for vapours) [3]	No	
Irritant (reversible effect)	Yes	Irritating to skin and eyes.
Hazard Band 0 **All indicators outside criteria listed in Hazards 1-4**	-	
Physical Hazards		
Flammable potential	No	
Explosive potential	No	
Hazard Evaluation (highest band) not including physical hazards	2	Based on chronic dermal toxicity.
Data confidence (available points out of 12 parameters)	11/12	92%

* Based on IMAP Framework [NICNAS (2013) Inventory Multi-tiered Assessment and Prioritisation (IMAP) Framework. National Industrial Chemicals Notification and Assessment Scheme. Department of Health and Aging, Canberra].

"[1]Based on list of endocrine disrupting chemicals from the European Commission's Endocrine Disrupters website.

[2] milligrams per kilogram body mass (mg/kg) or milligrams per kilogram body mass per day (mg/kg/d)

[3] Based on GHS cut-offs for hazard classification. For chronic/repeat dose toxicity, GHS cut-offs are provided as guidance values (i.e. the dose/concentration at or below which significant health effects are observed)". (p 18, NICNAS 2013).

Human Health Guidelines		
Media	**Concentration (mg/m^3; mg/L; mg/kg)**	**Reference**
Occupational Exposure Limits		
Air (OEL)		
8-h TWA	NDF	
STEL	NDF	
Peak Limitation	NDF	
Environmental Exposure		
Air, ambient, residential	NDF	
Air, commercial/industrial	NDF	
Water, potable	NDF	
Water, recreational	NDF	
Soil, residential	NDF	
Soil, commercial/industrial	NDF	
Soil, protection of groundwater	NDF	

Footnotes:

OEL = Occupational Exposure Limit

TWA = 8 h Time-Weighted Average

STEL = (15 min) Short-term Exposure Limit

NDF – No data found within the limits of the search strategy

Qualifying Summary Comments

Limited information was available for Amides, tall-oil fatty, N,N-bis(hydroxyethyl) (CAS RN: 68155-20-4). Therefore, a surrogate compound of amides, C18-unsatd., N,N-bis(hydroxyethyl) (CAS RN: 93-83-4) has been adopted for this assessment. The U.S. EPA's Analog Identification Methodology (AIM) Tool software program identified CAS RN: 93-83-4 as an exact chemical match to CAS RN: 68155-20-4 (U.S. EPA, 2019). Amides, C18-unsatd., N,N-bis(hydroxyethyl) is a brown liquid (at 20°C and 1013 hPa) with a density of 0.967 g/cm^3 (at 20°C). It has a freezing point of <-80°C and is reported to decomposes before boiling at > 300°C. Modelling suggests a water solubility between 0.12 mg/L and 2.17 mg/L at 25°C. Studies on a surrogate compound suggest that it will be absorbed readily via the oral route, then metabolised to polar metabolites and excreted principally in urine. Dermal absorption is likely low. Amides, C18-unsatd., N,N-bis(hydroxyethyl) has numerous industrial and consumer uses.

Amides, C18-unsatd., N,N-bis(hydroxyethyl) was ranked in Hazard Band 2, based on chronic dermal exposure and observed LOAEL (dermal) of 50 mg/kg bw/day. Amides, C18-unsatd., N,N-bis(hydroxyethyl) is an eye and skin irritant.

References

European Chemicals Agency (ECHA), 2019. *Registration Dossier for Amindes, C18-unsatd., N,N-bis(hydroxyethyl)*. Available at https://echa.europa.eu/registration-dossier/-/registered-dossier/13417/1. Last modified 9 December 2019, accessed December 2019.

European Commission (EC), 2000. Towards the establishment of a priority list of substances for further evaluation of their role in endocrine disruption, preparation of a candidate list of substances as a basis for priority setting, Final Report (Incorporating corrigenda to final report dated 21 June 2000).

International Agency for Research on Cancer (IARC), 2019. Agents Classified by the IARC Monographs, Volumes 1–125, last updated 29 November, 2019. Available at https://monographs.iarc.fr/agents-classified-by-the-iarc/, accessed December 2019.

U.S. Environmental Protection Agency (U.S. EPA), 2019. *Analog Identification Methodology (AIM) Tool software program*. Available at https://www.epa.gov/tsca-screening-tools/analog-identification-methodology-aim-tool, accessed December 2019.

Created by:	MGT	Date: 17/12/2019
Reviewed by:	CLB	Date and Revision: 21/01/20

Name	Ethanol
Synonyms	Ethyl alcohol; alcohol
CAS number	64-17-5
Molecular formula	C_2H_6O
Molecular structure	 (Source: ECHA, 2020)

Overview	References
Ethanol is a simple alcohol. It is a colourless liquid (at 20°C and 1013 hPa), with a mild but typical alcoholic odour. Ethanol is fully soluble in water (at relevant environmental temperature). The melting/freezing point of ethanol is approximately - 114°C and the boiling point is approximately 78°C. Ethanol is highly flammable, with auto flammability at 363 to 425°C. Ethanol is considered non-explosive. Ethanol has a variety of uses. It is found in alcoholic beverages, is a fuel source, is found in cosmetics and various household products, and it has various industrial uses including as a cleaning solvent, a processing aid and a chemical intermediate in industrial processes such as the protective coating of metal compartments of vehicles, rubber production/processing and chemical production. This review focuses on the use of and potential human exposure to ethanol in industrial uses such as hydraulic fracturing activities. Exposures via consumer products will not be considered further. When released to the environment, modelling indicates that at static equilibrium alcohols will likely be distributed mainly to water and air, with adsorption to soil and sediment being weak. Ethanol is not expected to undergo direct photolysis, but experimental data supported by modelling data predicts that it will likely undergo indirect photolysis through hydroxyl radical reactions at a slow to moderate rate. Based on indirect photolysis, the half-life of ethanol is estimated to be 38 hours. Ethanol is considered readily biodegradable, but resistant to hydrolysis. Ethanol is considered to have a low bioaccumulation potential. Upon human exposure, ethanol is absorbed across the surface of the gastrointestinal tract, the lungs and the skin, due to its low molecular weight and being highly soluble in both water and lipids. Greater than 90% of the ingested dose is absorbed by the GI tract, with absorption beginning immediately following ingestion. Following absorption into the bloodstream, irrespective of the route of exposure, ethanol is distributed throughout the body. Ethanol is metabolised primarily by the liver, in three steps, (i) oxidation of ethanol to acetaldehyde (AcH) (ii) conversion of AcH to acetate and (iii) oxidation of acetate to carbon dioxide and water. The maximum amount of ethanol that can be metabolised per	ECHA, 2020

hour has been estimated to be between 83 – 127 mg/kg bw/hr. Although elimination rates vary for between people, as the rates can be influenced by both environmental and genetic factors.	

Human Health Toxicity Summary	Reference
Carcinogenicity Ethanol in alcoholic beverages has been evaluated by the International Agency for Research on Cancer (IARC) as Group 1 indicating carcinogenic to humans, based on epidemiological data in humans and experimental animal studies. Ethanol when not as a component of alcoholic beverages has not been evaluated by IARC as to its carcinogenicity. ECHA summaries two studies considered relevant to the use of ethanol as a chemical substance (rather than consumption of alcoholic beverages). ECHA concludes that there is no significant evidence to warrant a classification of ethanol for cancer in the context of the relevant classification and labelling regulations for chemical substances.	IARC, 2020 ECHA, 2020
Mutagenicity/Genotoxicity Ethanol is not classified as genotoxic under criteria for classification and labelling purposes. Excluding data from studies assessing heavy consumption of alcoholic beverages and considering confounding toxicity due to other toxic effects associated with very high doses, there is no significant evidence for ethanol being a genotoxic hazard. ECHA summaries several *in vitro* and *in vivo* mutagenicity/ genotoxicity tests, with the results summarised as follows: *In vitro* Based on multiple bacterial reverse mutation studies, overall it was concluded that ethanol is not mutagenic to bacteria. There was little evidence for the clastogenicity of ethanol in a number of assays and using a number of different mammalian cell lines. Results of mammalian cell mutation studies were negative. *In vivo* Micronucleus tests showed overall that there was no convincing evidence that ethanol induces micronuclei in the bone marrow of rodents. Chromosome aberration tests in hamsters reported that ethanol had no effect on bone marrow chromosomes. Dominant lethal assay results indicate that ethanol is unlikely to produce a dominant lethal effect up to the maximum tolerated dose (< 1 g/kg/day). In test for the potential to case DNA damage. The no effect level was 2 g/kg, which was the maximum recommended does in the guidelines for a single dose experiment.	ECHA, 2020
Reproductive Toxicity Classification of ethanol for reproductive toxicity was considered not warranted in the context of a chemical substance, because adverse reproductive responses were only observed for repeat dose oral consumption of large amounts of ethanol, at doses normally only associated with problem drinking. ECHA notes that available studies on ethanol use extremely high doses.	ECHA, 2020

ECHA identifies the key reproductive studies as a two-generation drinking-water study in mice and an inhalation study on rats. The two-generation study in mice investigated the effects of 5%, 10% and 15% ethanol in drinking water in reproduction and fertility. This study reported a NOAEL of 13 800 mg/kg for effects on fertility. The inhalation study identifying a NOAEC of 30 400 mg/m^3 for effects on fertility (values close to or exceeding 50% of the lower explosive limit).	
Developmental Toxicity/Teratogenicity Classification of ethanol for developmental toxicity was considered not warranted in the context of a chemical substance, because adverse reproductive responses were only observed for repeat dose oral consumption of large amounts of ethanol, at doses normally only associated with problem drinking. Several toxicity studies are presented on the ECHA dossier, with the overall conclusion being that ethanol can clearly cause developmental toxicity. However, the doses required are exceedingly high compared to doses normally use to assess chemical substance hazards. These doses are also associated with maternal toxicity. *Oral* In an oral study, pregnant female mice were exposed to ethanol at several doses by gavage. No teratogenic effects were seen even at the highest dose tested (7 800 mg/kg bw/day). *Inhalation* An inhalation study assessing pregnant female rats exposed to ethanol reported a NOAEL for teratogenicity of 38 000 mg/m^3 ethanol. The study also reported clear maternal toxicity (nacrosis and food intake reduction) at the highest dose and a NOAEL for maternal toxicity of 30 400 mg/m^3 of ethanol was established.	ECHA, 2020
Endocrine Disruption Ethanol is not identified in the European Commission (EC)'s report, "*Towards the establishment of a priority list of substances for further evaluation of their role in endocrine disruption*" as a substance of interest.	EC, 2000
Acute Toxicity (oral, dermal, inhalation) Ethanol is not classified as acutely toxic by ECHA (based on LD_{50} and LC_{50} values being above thresholds for classification for acute toxicity). Numerous studies are provided for assessment of the acute oral, dermal and inhalation toxicity of ethanol. ECHA summarises the toxicity references values as: *Oral* Human: LD_{50} ~ 2000 mg/kg Rat: LD_{50} of 15 010 mg/kg (female), 10 600 mg/kg (male, young adult), 7 060 mg/kg (male, old adult), 11 500 mg/kg (old adult), 17 750 mg/kg (young adult), 6 160 mg/kg (immature animal), 10 470 mg/kg (male/female), >7 692 mg/kg (female). Mouse: 8 350 mg/kg. *Inhalation* Rat (4 hr): LC_{50} 51 mg/L (male) and 55 mg/L (female).	ECHA, 2020

Dermal No reliable data. Information indicates LD_{50} > 15 800 mg/kg.	
Chronic/repeat dose toxicity (oral, dermal, inhalation) Adverse effects in repeated dose toxicity studies were seen only at extremely high doses, which are well above the concentrations that would trigger classification for repeat dose effects. *Oral* Toxicity references values outlined for the oral route of exposure included the following: *Key study identified by ECHA* Rat NOAEL (90 day): 1 730 mg/kg bw/day Rat LOAEL (90 day): 3 160 mg/kg bw/day. The primary study referenced is a 90 day study in rats, fed a mixture containing 16.25% USP ethanol at 3 dose levels. The NOAEL was determined to be 10 mL/kg for the mixture for increased kidney weight and renal tubular epithelial hyperplasia in males (which is equivalent to 1 730 mg/kg bw). The LOAEL was determined to be 4 mL/kg of 100% USP ethanol for the same end points (equivalent to 3 160 mg/kg bw) *Other studies* Rat NOAEL (90 day): 3 250 mg/kg bw/day (male), 3900 mg/kg bw/day (male/female), <4 400 mg/kg bw/day (female) Mouse NOAEL (90 day): > 9 400 mg/kg bw/day (female), < 9 700 mg/kg bw/day (male) Monkey NOEL (chronic): < 6 200 mg/kg bw/day. *Dermal* Repeat dose toxicity data for the dermal route was not available. However, under non-occlusive conditions, there is sufficient evidence to conclude that dermal exposure would be negligible based on rapid evaporation of ethanol. In addition, skin absorption under practical conditions is considered negligible based on available data. *Inhalation* For the inhalation route, there is limited repeat dose toxicity data. The information that is available (sub-acute studies, supplemented by reproductive toxicity data by the inhalation route) indicate that toxicity by the inhalation route is not likely to be of concern.	ECHA, 2020
Sensitisation of the skin or respiratory system In an ear swelling study, ethanol was found to be not sensitising to the skin. No data is available for assessment of respiratory sensitisation. However, with lacking data on respiratory sensitisation, considering that there are no alerts for respiratory sensitisation and ethanol is not a skin sensitiser, ECHA outlines that no classification for respiratory sensitisation is warranted.	ECHA, 2020
Corrosion (irreversible)/irritation (reversible) effects on the skin or eye Ethanol is not classified as a skin irritant by ECHA (based on available data reviewed as a whole). This classification was based on slight responses seen in animal studies and the lack of response in a human study, indicating the substance had minimal acute skin irritation potential. In the human	ECHA, 2020

volunteer study, there was some evidence to suggest the potential for chronic irritation from repeated application under extreme occlusive conditions. Ethanol is considered an eye irritant by ECHA (based on available data), classified as reversible eye irritant (Category 2) under the EU regulation 1272/2008. Studies indicate that irritancy effect diminishes rapidly with dilution. Results of studies undertaken for ethanol concentrations of 50% or less do not warrant classification. Considering this and the fact that results at 100% only just trigger classification, dilutions up to 70-80% are unlikely to warrant classification.	

Physical Hazards	Reference
Flammable Potential Highly flammable.	ECHA, 2020
Explosive Potential Non explosive (based on the composition and no chemical structures being associated with explosive properties).	ECHA, 2020

Toxicity Values	Value	Reference
Human Toxicity Data		
Acute Toxicity		
LD_{50}	~ 2000 mg/kg	Cited by ECHA, 2020
High Chronic/Repeat Dose Toxicity		
LOAEC	NDF	
LOAEL	NDF	
Animal Toxicity Data		
Acute Toxicity		
LD_{50}		
Rat, oral	15 010 mg/kg (female) 10 600 mg/kg (male, young adult) 7 060 mg/kg (male, old adult) 11 500 mg/kg (old adult) 17 750 mg/kg (young adult) 6 160 mg/kg (immature animal) 10 470 mg/kg (male/female) >7 692 mg/kg (female).	Cited by ECHA, 2020
Mouse, oral	8 350 mg/kg	Cited by ECHA, 2020
LC_{50}		

Rat	51 mg/L (male, 4 hr) 55 mg/L (female, 4 hr)	Cited by ECHA, 2020
High Chronic/Repeat Dose Toxicity		
LOAEL	Oral (rat, male, increased kidney weight and renal tubular epithelial hyperplasia): 3 160 mg/kg bw/day	Cited by ECHA, 2020
NOAEL	Oral (rat, male, increased kidney weight and renal tubular epithelial hyperplasia): 1 730 mg/kg bw/day Oral (mice, 2-generation, fertility): 13 800 mg/kg	Cited by ECHA, 2020
NOAEC	Inhalation (rats, fertility): 30 400 mg/m^3 Inhalation (rats, teratogenicity): 38 000 mg/m^3	Cited by ECHA, 2020

Footnotes:
LD_{50} – lethal dose for 50% of experimental population
LC_{50} – lethal air concentration for 50% of experimental population
LOAEL – Lowest Observed Adverse Effect Level
LOAEC – Lowest Observed Adverse Effect Concentration
NDF – No data found within the limits of the search strategy
NOAEL – No Observed Adverse Effect Level
NOAEC – No Observed Adverse Effect Concentration

Human Health Toxicity Ranking		
	Hazard data	**Comment**
Hazard Band 4		
Carcinogenicity (IARC Group 1 or 2A)	No^	
Mutagenicity/Genotoxicity (GHS Category 1A and 1B)	No^	
Reproductive Toxicity/Developmental toxicity (GHS Category 1, 1A and 1B)	No^	
Endocrine Disruption[1]	No^	
Hazard Band 3		
Carcinogenicity (IARC Group 2B)	No^	
Mutagenicity/Genotoxicity (GHS Category 2)	No^	
Reproductive Toxicity/Developmental toxicity (GHS Category 2)	No^	
Acute Toxicity (oral, dermal or inhalation) Very Toxic/Toxic • oral LD_{50} ≤ 300 mg/kg [2] • dermal LD_{50} ≤ 1000 mg/kg • inhalation LC_{50} ≤ 10 mg/L [3] (or mg/m^3) (vapour)	No^	
High Chronic/repeat dose toxicity • oral LOAEL ≤ 10 mg/kg/d [2]; • dermal LOAEL ≤ 2 0 mg/kg/d; • inhalation LOAEC (6 h/d) ≤ 50 ppm/d for gases, ≤ 0.2 mg/L/d for vapours or ≤ 0.02 mg/L/d for dust/mists/fumes [3]	No^	
Corrosive (irreversible effect)	No	
Respiratory sensitiser	No	
Hazard Band 2		

Human Health Toxicity Ranking		
	Hazard data	**Comment**
Harmful chronic/repeat dose toxicity • oral LOAEL > 10 mg/kg/d and ≤ 100 mg/kg/d • dermal LOAEL > 20 mg/kg/d and ≤ 200 mg/kg/d • inhalation (6-h/d) LOAEC > 50 mg/L ≤ 250 mg/L/d for gases, > 0.2 mg/L ≤ 1 .0 mg/L/d for vapours or > 0.02 mg/L ≤ 0.2 mg/L/d for dust/mists/fumes [3]	No^	
Skin Sensitiser	No	
Hazard Band 1		
Acute Toxicity-Harmful • oral LD_{50} > 300 mg/kg ≤ 2000 mg/kg • dermal LD_{50} >1 000 mg/kg ≤ 2000 mg/kg; • inhalation LC_{50} (6 h/d) > 10 mg/L ≤ 20 mg/L for vapours) [3]	No^	Human, oral: LD_{50} ~ 2000 mg/kg Rat, inhalation: LD_{50} 51 mg/L
Irritant (reversible effect)	Yes	Eye irritant (Category 2)
Hazard Band 0 **All indicators outside criteria listed in Hazards 1-4**	-	
Physical Hazards		
Flammable potential	Yes	Highly flammable.
Explosive potential	No	
Hazard Evaluation (highest band) not including physical hazards	1	Based on eye irritancy
Data confidence (available points out of 12 parameters)	12/12	100%

^ Hazard Bank Ranking, when excluding data from human consumption of alcohol.

* Based on IMAP Framework [NICNAS (2013) Inventory Multi-tiered Assessment and Prioritisation (IMAP) Framework. National Industrial Chemicals Notification and Assessment Scheme. Department of Health and Aging, Canberra].

"[1]Based on list of endocrine disrupting chemicals from the European Commission's Endocrine Disrupters website.

[2] milligrams per kilogram body mass (mg/kg) or milligrams per kilogram body mass per day (mg/kg/d)

[3] Based on GHS cut-offs for hazard classification. For chronic/repeat dose toxicity, GHS cut-offs are provided as guidance values (i.e. the dose/concentration at or below which significant health effects are observed)". (p 18, NICNAS 2013).

Human Health Guidelines		
Media	**Concentration (mg/m^3; mg/L; mg/kg)**	**Reference**
Occupational Exposure Limits		
Air (OEL)		
8-h TWA	1880 mg/m^3	Safe Work Australia, 2020
STEL	NDF	-
Peak Limitation	NDF	-
Environmental Exposure		
Air, ambient, residential	NDF	
Air, commercial/industrial	NDF	
Water, potable	NDF	
Water, recreational	NDF	
Water, fresh waters	1 400 µg/L	NEPC, 2013
Soil, residential	NDF	
Soil, commercial/industrial	NDF	
Soil, protection of groundwater	NDF	

Footnotes:

OEL = Occupational Exposure Limit

TWA = 8 h Time-Weighted Average

STEL = (15 min) Short-term Exposure Limit

Qualifying Summary Comments

Ethanol is a simple alcohol, that is found as a highly flammable, colourless liquid (at 20°C and 1013 hPa) and is fully soluble in water. Ethanol is a component of alcoholic beverages, is used as a fuel source, is found in cosmetics and other household products, and has various industrial uses. Upon release to the environment, ethanol will likely distribute to water and air. Ethanol is considered readily biodegradable and has a low potential to bioaccumulate.

Ethanol has been ranked in Hazard Band 1, based on being an eye irritant. This ranking is based on the exclusion of data specific to extremely high exposure to ethanol, as observed for consumption of alcoholic beverages. Adverse effects for several endpoints (carcinogenicity, mutagenicity/genotoxicity, reproductive/developmental toxicity and chronic toxicity) were observed at high dose rate. However, these dose rates are not considered relevant when considering industrial uses and potential occupational exposure.

References

European Commission (EC), 2000. Towards the establishment of a priority list of substances for further evaluation of their role in endocrine disruption, preparation of a candidate list of substances as a basis for priority setting, Final Report (Incorporating corrigenda to final report dated 21 June 2000).

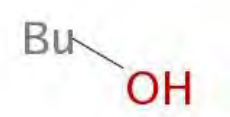
European Chemicals Agency (ECHA), 2020. Registration Dossier for ethanol. Available at https://echa.europa.eu/registration-dossier/-/registered-dossier/16105**.** Last modified 04 January 2020, accessed January 2020.

International Agency for Research on Cancer (IARC), 2019. Agents Classified by the IARC Monographs, Volumes 1–125, last updated 29 November, 2019. Available at https://monographs.iarc.fr/agents-classified-by-the-iarc/, accessed December 2019.

National Environment Protection Council (NEPC), 2013. National Environment Protection (Assessment of Site Contamination) Amended Measure 2013 (No.1). Schedule B1: Guidelines on Investigation Levels for soil and groundwater. National Environment Protection Council, Commonwealth Government of Australia.

Safe Work Australia, 2020. Hazardous Chemical Information System (HCIS): Exposure Standard Details for Ethyl alcohol. Available at: http://hcis.safeworkaustralia.gov.au/ExposureStandards/Details?exposureStandardID=259, accessed January 2020.

Created by:	MGT	Date: 08/01/2020
Reviewed by:	CLB	Date and Revision:14/01/20

Name	Butyl alcohol
Synonyms	Butan-1-ol, 1-butanol, butanol, n-butanol
CAS number	71-36-3
Molecular formula	$C_4H_{10}O$
Molecular structure	 (Source: ECHA, 2020)

Overview	References
Butyl alcohol is a liquid (at 20°C and 1012 hPa), that has a freezing point of -90°C and a boiling point of 119 °C. Its solubility in water is 66 g/L at 20°C, its relative density is 0.81 g/cm^3 at 20°C and it has a vapour pressure of <10 hPa at 20°C. Butyl alcohol is a flammable liquid, with a flash point of 35°C and an auto-flammability temperature of 355°C (at 1013 hPa). Butyl alcohol has many uses including in coatings (paints, inks, toners, adhesives), in lubricants, in metal working fluids and rolling oils, in cleaning agents and as a laboratory agent and a process chemical. Following human exposure, butyl alcohol is rapidly taken up and distributed throughout the body, followed by a fast and complete elimination. Studies have shown butyl alcohol is readily absorbed through the skin, intestinal tract and lungs. Once absorbed, it is distributed almost uniformly through the body. Following metabolism primarily by alcohol and aldehyde dehydrogenases, butyl alcohol is rapidly eliminated. The majority of butyl alcohol is excreted as carbon dioxide. Upon release to the environment, butyl alcohol is most likely to be found in water. It is unlikely to undergo hydrolysis and photochemical degradation in air will likely be slow. Butyl alcohol is readily biodegraded, resulting in a short retention time under natural conditions. Bioaccumulation is not expected.	ECHA, 2020

Human Health Toxicity Summary	Reference
Carcinogenicity Butyl alcohol has not been evaluated by the International Agency for Research on Cancer (IARC) as to its carcinogenicity.	IARC, 2019

Butyl alcohol is considered by ECHA to be not classified for carcinogenicity under CLP Regulation (EC) No 1272/2008, as amended for the ninth time in Regulation (EC) No 2016/1179. ECHA considered that there was no evidence of carcinogenic potential due to lack of mutagenicity, and because no structural fragments were found in a structure-activity-relationship model (CASE) indicating a carcinogenic potential.	ECHA, 2020
Mutagenicity/Genotoxicity Butyl alcohol is not considered classifiable for genetic toxicity by ECHA under CLP Regulation (EC) No 1272/2008, as amended for the eighth time in Regulation (EU) No. 2016/218, based on the available data. ECHA cites several *in vitro* studies including a gene mutation study in mammalian cells, a cytogenicity/micronucleus study and gene mutation studies in bacteria, and an *in vivo* mammalian somatic cell study. The results of these studies were all reported to be negative.	ECHA, 2020
Reproductive Toxicity Butyl alcohol is not considered classifiable for fertility or reproductive toxicity by ECHA under CLP Regulations (EC) No 1272/2008, as amended for the eighth time in Regulation (EU) No. 2016/218, based on the available data. They key **oral** studies cited by ECHA include: - A study on female fertility and prenatal development in rats. The NOAEL for maternal toxicity, including fertility was reported as 5 000 mg/kg bw/d. - A 90-day, repeated dose toxicity study (comparable to guideline study under GLP conditions) in rats reported a NOEL for reproductive organs of 500 mg/kg bw. The key **inhalation** study cited by ECHA was a behavioural peri-, postnatal developmental (neuro)toxicity rat study. The reported parental NOAEC, including fertility was 18.5 mg/L. An inhalation study for n-Butyl acetate is also provided, as this is considered a read across substance. The two-generation reproduction study in rats involved whole body exposure to vapours. The NOAEC for fertility was reported as 9.7 mg/L butyl acetate (converted to 6.189 mg/L for butyl alcohol). No studies were available to assess effects on fertility via the dermal route of exposure.	ECHA, 2020
Developmental Toxicity/Teratogenicity Butyl alcohol is not considered classifiable for teratogenicity or developmental toxicity by ECHA under CLP Regulations (EC) No 1272/2008, as amended for the eighth time in Regulation (EU) No. 2016/218, based on the available data. They key **oral** studies cited by ECHA include: - A prenatal developmental toxicity study in rats. The NOAEL for maternal and developmental toxicity was reported as 1 454 mg/kg bw/d. The study also reported no teratogenicity observed up to the highest dose tested, being 5 654 mg/kg bw/d. A study on female fertility and prenatal development in rats. The NOAEL for teratogenicity was reported as 5 000 mg/kg bw/d. A NOEL for developmental effects was not established by the study. The key **inhalation** studies cited by ECHA include: - A prenatal developmental toxicity study in rats. The NOAEC for developmental toxicity including	ECHA, 2020

morphological fetal alterations was 10.8 mg/L. - A behavioural peri-, postnatal developmental (neuro)toxicity rat study. The reported parental NOAEC, including behavioural or teratogenic effects was 18.5 mg/L. Inhalation studies for n-Butyl acetate are also provided, as this is considered a read across substance. - A prenatal developmental toxicity study in rabbits reported a NOAEC for developmental toxicity of 7.2 mg/L. - A prenatal developmental toxicity study in rats reported a LOAEC for maternal and developmental toxicity of 7.2 mg/L. However, it was noted that the developmental effects were associated with clear maternal toxicity and were not considered to be an independent effect. - A prenatal developmental study in rats reported a NOAEC for developmental toxicity of 9.6 mg/L.	
Endocrine Disruption Butyl alcohol is not identified in the European Commission (EC)'s report, "*Towards the establishment of a priority list of substances for further evaluation of their role in endocrine disruption*" as a substance of interest.	EC, 2000
Acute Toxicity (oral, dermal, inhalation) Butyl alcohol is classified for acute **oral** toxicity as Category 4 (H302: Harmful if swallowed). They key study references was a rat study, with a LD_{50} of approximately 2 290 mg/kg bw (study similar to OECD TG 401). Other Oral LD_{50} cited by ECHA include: - Rat 2 510 mg/kg bw - Rat (female) 4 360 mg/kg bw - Mouse 2 680 mg/kg bw - Rabbits 3 500 mg/kg bw - Golden hamsters 1 200 mg/kg bw - Dogs, minimum lethal dose 1 782 mg/kg bw Butyl alcohol was not classifiable for acute **dermal** toxicity under CLP Regulation (EC) No. 1272/2008, as amended for the ninth time in Regulation (EC) No 2016/1179, based on only slight dermal toxicity. The key study referenced was a rabbit study, with a LD_{50} of approximately 3 430 mg/kg bw (study similar to OECD TG 402). Butyl alcohol was not classifiable for acute **inhalation** toxicity under CLP Regulation (EC) No. 1272/2008, as amended for the ninth time in Regulation (EC) No 2016/1179, based on very low inhalation toxicity. The key study referenced was a rat study, with 4h exposure, and a LC_0 of > 17.76 mg/L (similar to OECD 403). Other toxicity reference doses cited by ECHA include: - Rats Inhalation Hazard Test (IHT), LT_0 21.48 mg/L: no mortality within 7 hrs (similar OECD 403). - Rats LC0 >24 mg/L, with 4 hr exposure; IHT: No mortality within 8 h (similar to OECD 403). Butyl alcohol is classified by ECHA for **inhalation** exposure as specific target organ toxicity (STOT) Single Exposure Category 3 (H335: May cause respiratory irritation/ H336: May cause drowsiness or dizziness) according to CLP Regulations (EC) 1272/2008 requirements. This classification was due to observed local irritant effects on the respiratory system in an inhalation hazard test and transient effects on the central nervous system (CNS) (drowsiness and dizziness). Studies cited by ECHA include:	ECHA, 2020

- Human study (3-5 minute exposure): sensory irritating effects on nose and throat. - Rat inhalation hazard test (7 hour exposure): irritating effects on the respiratory system. - Human study (10 year study on workers): No sign of irritation in human at concentrations <= 310 mg/m^3. The ECHA profile provides additional information as follows: The weight of evidence of all data indicated that there is no evidence that butyl alcohol has to be considered as neurotoxic or developmental neurotoxicant as it did not lead to adverse and/or persistent damage to the CNS or peripheral nervous system. Exposure to butyl alcohol led only to transient effects or impairment of neurological functions (drowsiness and dizziness) typical for short chain alcohols.	
Chronic/repeat dose toxicity (oral, dermal, inhalation) Butyl alcohol is not classified by ECHA for repeated dose systemic toxicity via oral, inhalation or dermal route under CLP Regulation (EC) No 1272/2008, as amended for the ninth time in Regulation (EU) No 2016/1179, based on the data available. ECHA does provide clarifying comments as follows: The CNS effects observed in the repeated dose studies were not centred on a specific organ but considered as general impairments of neurological and behavioural functions (Drowsiness and dizziness) which are classified accordingly (STOT SE 3, H336). Those observations typically occur for alcohols and there is currently no need for classification of butyl alcohol for repeated dose systemic toxicity. For **oral** exposure, the key study cited by ECHA is a sub-chronic 90-day rat study, which reports a NOEL of 125 mg/kg bw/d. Four groups of male and female rats (30/sex/group) were administered by gavage daily 0, 30, 125 or 500 mg/kg bw/d for either 6 or 13 weeks. General effects on neurological and behavioural functions as typically observed for alcohols were reported at the highest concentration, 500 mg/kg bw/d. For **dermal** exposure, the key study cited by ECHA is a short-term repeated dose rabbit study where butyl alcohol was applied occlusive to rabbit skin 12 times in 21 days for 5 hours (each exposure). Drying of the skin was observed and slight erythema but effects reversible. From continuous exposure, cracking, furrowing and exfoliation of the epidermis was observed but effects were reversible. No systemic toxicity observed. A NOAEL/LOAEL was not reported. For **inhalation**, the key study cited by ECHA was a sub-chronic 90-day rat study, with rats exposed to vapours 5 day/week for 5 h per day. The observed effect level was 320 mg/m^3, but the study was not considered suitable for NOAEL/LOAEL derivation.	ECHA, 2020
Sensitisation of the skin or respiratory system Butyl alcohol is not classified by ECHA as a skin sensitizer, under CLP Regulation (EC) No 1272/2008, as amended for the ninth time in Regulation (EU) No 2016/1179, based on the available data being suitable for classification purposes. The key study cited by ECHA is a mouse Local Lymph Node Assay study (in vivo) (undertaken similar to OECD guideline 429) that showed that the test item does not have a sensitising effect on the skin under the test conditions. No data is available to assess respiratory sensitisation.	ECHA, 2020
Corrosion (irreversible)/irritation (reversible) effects on the skin or eye	ECHA, 2020

Butyl alcohol is classified by ECHA as a **skin** irritant (Category 2, H315: Causes skin irritation), under Regulation (EC) No 1272/2008, as amended for the ninth time in CLP Regulation (EU) No. 2016/1179, based on studies undertaken with a typical mixture containing butyl alcohol.. It is noted that pure butyl alcohol reportedly causes only slight and reversible skin irritation. For typically produced mixtures, however, the effects on the skin are more distinct. The key study cited by ECHA is a rabbit study, where two rabbits were exposed to the butyl alcohol (purity unknown; taken directly from the production) for 5 minutes, 1 hour and 2 hours under occlusive conditions, and then observed for 8 days. The study concluded the substance with irritating to the skin. For the exposure duration of 5 minutes effects were completely reversible within 8 days, but for the exposure duration of 1 hour and 2 hours, the effects were not fully reversible within 8 d. Butyl alcohol is classified by ECHA as a risk for serious **eye** damage (Category 1, H318: “Causes serious eye irritation”) according to CLP Regulations (EC) 1272/2008 requirements, as amended for the ninth time in Regulation (EU) No 2016/21179. This classification was due to the irreversible and sever effects on corneal opacity, iritis, conjunctivae redness and chemosis within 7 days. The key study cited by ECHA is a rabbit study, where three rabbits were exposure for 24 h to 0.1 mL of the test substance (study in according to OECD guideline 405). This study reported observed corneal opacity, iritis, conjunctivae redness and chemosis, with effects not fully reversible within 7 days. An additional study was cited where the same effects were observed to be fully reversible within at least 21 days.	

Physical Hazards	Reference
Flammable Potential Flammable liquid	ECHA, 2020
Explosive Potential Non-explosive	ECHA, 2020

Toxicity Values	Value	Reference
Human Toxicity Data		
High Chronic/Repeat Dose Toxicity		
LOAEC	NDF	
LOAEL	NDF	
Animal Toxicity Data		
Acute Toxicity		
LD_{50}		
Rat, oral	LD_{50} ~ 2 290 mg/kg bw	Cited by ECHA, 2020
Rat, dermal	LD_{50} ~ 3 430 mg/kg bw	Cited by ECHA, 2020
LC_{50}		
Rat	LC_0 of > 17.76 mg/L	Cited by ECHA, 2020
High Chronic/Repeat Dose Toxicity		
LOAEL	NDF	
LOAEC	NDF	
NOAEL	Rat (oral, systemic effects): 125 mg/kg bw/d	Cited by ECHA, 2020

	Rat (oral, reproductive organs): 500 mg/kg bw Rat (oral, maternal and developmental toxicity): 1 454 mg/kg bw/d	
NOAEC	Rat (inhalation, fertility): 6.189 mg/L Rat (inhalation, developmental toxicity including morphological fetal alterations): 10.8 mg/L	Cited by ECHA, 2020

Footnotes:
LD_{50} – lethal dose for 50% of experimental population
LC_{50} – lethal air concentration for 50% of experimental population
LOAEL – Lowest Observed Adverse Effect Level
LOAEC – Lowest Observed Adverse Effect Concentration
NDF – No data found within the limits of the search strategy

Human Health Toxicity Ranking		
	Hazard data	**Comment**
Hazard Band 4		
Carcinogenicity (IARC Group 1 or 2A)	No	
Mutagenicity/Genotoxicity (GHS Category 1A and 1B)	No	
Reproductive Toxicity/Developmental toxicity (GHS Category 1, 1A and 1B)	No	
Endocrine Disruption[1]	No	
Hazard Band 3		
Carcinogenicity (IARC Group 2B)	No	
Mutagenicity/Genotoxicity (GHS Category 2)	No	
Reproductive Toxicity/Developmental toxicity (GHS Category 2)	No	
Acute Toxicity (oral, dermal or inhalation) Very Toxic/Toxic • oral LD_{50} ≤ 300 mg/kg [2] • dermal LD_{50} ≤ 1000 mg/kg • inhalation LC_{50} ≤ 10 mg/L [3] (or mg/m^3) (vapour)	No	
High Chronic/repeat dose toxicity • oral LOAEL ≤ 10 mg/kg/d [2]; • dermal LOAEL ≤ 2 0 mg/kg/d; • inhalation LOAEC (6 h/d) ≤ 50 ppm/d for gases, ≤ 0.2 mg/L/d for vapours or ≤ 0.02 mg/L/d for dust/mists/fumes [3]	No	
Corrosive (irreversible effect)	Yes	Irreversible and sever effects on the eyes
Respiratory sensitiser	NDF	
Hazard Band 2		

Human Health Toxicity Ranking		
	Hazard data	**Comment**
Harmful chronic/repeat dose toxicity • oral LOAEL > 10 mg/kg/d and ≤ 100 mg/kg/d • dermal LOAEL > 20 mg/kg/d and ≤ 200 mg/kg/d • inhalation (6-h/d) LOAEC > 50 mg/L ≤ 250 mg/L/d for gases, > 0.2 mg/L ≤ 1 .0 mg/L/d for vapours or > 0.02 mg/L ≤ 0.2 mg/L/d for dust/mists/fumes [3]	No	
Skin Sensitiser	No	
Hazard Band 1		
Acute Toxicity-Harmful • oral LD_{50} > 300 mg/kg ≤ 2000 mg/kg • dermal LD_{50} >1 000 mg/kg ≤ 2000 mg/kg; • inhalation LC_{50} (6 h/d) > 10 mg/L ≤ 20 mg/L for vapours) [3]	No	
Irritant (reversible effect)	Yes	Skin irritant
Hazard Band 0 **All indicators outside criteria listed in Hazards 1-4**		
Physical Hazards		
Flammable potential	Yes	
Explosive potential	No	
Hazard Evaluation (highest band) not including physical hazards	3	Corrosive to the eyes
Data confidence (available points out of 12 parameters)	11/12	92%

* Based on IMAP Framework [NICNAS (2013) Inventory Multi-tiered Assessment and Prioritisation (IMAP) Framework. National Industrial Chemicals Notification and Assessment Scheme. Department of Health and Aging, Canberra].

"[1]Based on list of endocrine disrupting chemicals from the European Commission's Endocrine Disrupters website.

[2] milligrams per kilogram body mass (mg/kg) or milligrams per kilogram body mass per day (mg/kg/d)

[3] Based on GHS cut-offs for hazard classification. For chronic/repeat dose toxicity, GHS cut-offs are provided as guidance values (i.e. the dose/concentration at or below which significant health effects are observed)". (p 18, NICNAS 2013).

Human Health Guidelines		
Media	**Concentration (mg/m^3; mg/L; mg/kg)**	**Reference**
Occupational Exposure Limits		
Air (OEL)		
8-h TWA	-	
STEL	-	
Peak Limitation	152 mg/m^3	Safe Work Australia, 2020
Environmental Exposure		
Air, ambient, residential	-	
Air, commercial/industrial	-	
Water, potable	2 mg/L	US EPA, 2019
Water, recreational	-	
Soil, residential	7 800 mg/kg	US EPA, 2019
Soil, commercial/industrial	120 000 mg/kg	US EPA, 2019
Soil, protection of groundwater	0.41 mg/kg	US EPA, 2019

Footnotes:

OEL = Occupational Exposure Limit

TWA = 8 h Time-Weighted Average

STEL = (15 min) Short-term Exposure Limit

Qualifying Summary Comments

Butyl alcohol is a flammable liquid (at 20°C and 1012 hPa), with a flash point of 35°C. It has many uses including in coatings (paints, inks, toners, adhesives), in lubricants, in metal working fluids and rolling oils, in cleaning agents and as a laboratory agent and a process chemical. Upon release to the environment, butyl alcohol is most likely to be found in water. Butyl alcohol is readily biodegraded, resulting in a short retention time under natural conditions. Bioaccumulation is not expected. Following human exposure, butyl alcohol is rapidly taken up and distributed throughout the body, followed by a fast and complete elimination.

Butyl alcohol has been ranking in Hazard Band 3 because it is corrosive to the eyes, causing serious and irreversible eye damage (classified as Category 1, H318: “Causes serious eye irritation”). It is also a skin irritant (classified as Category 2, H315: Causes skin irritation). As typical of alcohols, butyl alcohol can result in transient effects on the central nervous systems (CNS) consistent with general impairments of neurological and behavioural functions (drowsiness and dizziness). As such, butyl alcohol is also classified as specific target organ toxicity (STOT) Single Exposure Category 3 (H335: May cause respiratory irritation/ H336: May cause drowsiness or dizziness), and is also classified for acute oral toxicity as Category 4 (H302: Harmful if swallowed).

References

European Chemicals Agency (ECHA), 2019. Registration Dossier for Butan-1-ol. Available at https://echa.europa.eu/registration-dossier/-/registered-dossier/15322. Last modified 04/01/202., accessed January 2020.

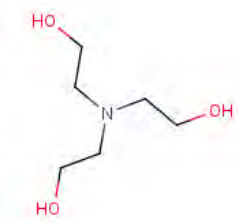
European Commission (EC), 2000. Towards the establishment of a priority list of substances for further evaluation of their role in endocrine disruption, preparation of a candidate list of substances as a basis for priority setting, Final Report (Incorporating corrigenda to final report dated 21 June 2000).

International Agency for Research on Cancer (IARC), 2019. Agents Classified by the IARC Monographs, Volumes 1–125, last updated 12 December 2019. Available at https://monographs.iarc.fr/agents-classified-by-the-iarc/, accessed January 2020.

Safe Work Australia, 2020. Hazardous Chemical Information System (HCIS): Exposure Standard Details for n-Butyl alcohol. Available at: http://hcis.safeworkaustralia.gov.au/ExposureStandards/Details?exposureStandardID=82, accessed January 2020.

U.S. Environmental Protection Agency (U.S. EPA), 2019. Regional Screening Levels (RSLs) – Generic Tables (Tables as of November 2019). Available at: https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables, accessed December 2019.

Created by:	MGT	Date: 10/01/2020
Reviewed by:	CLB	Date and Revision: 21/01/2020

Name	Triethanolamine
Synonyms	Trolamine, triethanolamine, sterolamide, nitrilotriethanol, 2,2`,2"-nitrilotriethanol
CAS number	102-71-6
Molecular formula	$C_6H_{15}NO_3$
Molecular structure	

Overview	References
Triethanolamineis a colourless to slightly liquid which is very hygroscopic and turns brown on exposure to air and light. It is a water-soluble strong base with a pH of 10.3 (concentration 1%) and emits a slight odour of ammonia. Triethanolamineis used commercially and industrially in the manufacture of surfactants and detergents, textiles, waxes, polishes, herbicides, petroleum demulsifiers, toilet goods, cement additives, cutting oils and other products. Kinetic studies in rats and mice using radioactive tracers indicate that triethanolamine identified that the compound distributes to the heart, kidney, liver, lung, and spleen with 40% of an intravenously administered dose excreted within 24 hours. Triethanolamine has a low order of acute and chronic toxicity. The principal route of exposure causing toxicity is through the skin, with some exposure occurring from inhalation of vapour and aerosols. Potential health effects in humans would be acute in nature and due to alkalinity rather than systemic toxicity. It is not genotoxic, carcinogenic, or toxic to development or the reproductive system.	HSDB (2009) ECHA (2020a)

Human Health Toxicity Summary	Reference
Carcinogenicity Not classifiable as to its carcinogenicity to humans (Group 3) based on inadequate evidence in experimental animals and humans. ECHA conclude from review of available data that triethanolamine is no considered carcinogenic for humans. Triethanolamine is not considered to be classified for carcinogenicity under Regulation (EC)	IARC (2000) ECHA (2020a)

No 1272/2008 and the available data are reliable and suitable for classification purposes under this regulation.	
Mutagenicity/Genotoxicity - Not classified as a mutagenic chemical. It is not genotoxic. - Triethanolamine did not induce mutations, DNA damage or other effects on genetic material in a number of non mammalian and mammalian tests both in vitro and in vivo. Based on available experimental information the test substance is not classified for genetic toxicity.	IARC (2000) ECHA (2020a)
Reproductive Toxicity - Not classified as a reproductive toxicant. - No reproductive or developmental effects were produced when rats and mice were exposed by topical administration. Other routes of exposure have not been studied. ECHA provide a summary of a screening reproduction/developmental toxicity study (OECD 421) with triethanolamine in rats, the NOAEL for systemic toxicity as well as for reproductive performance and fertility in parental animals was established at 1000 mg/kg bw/day, the highest dose tested. The NOAEL for postnatal toxicity in the offspring was 1000 mg/kg bw/day, whereas the NOAEL for prenatal developmental toxicity was determined to be 300 mg/kg bw/day based on decreased numbers of implants and delivered pups, and an increased postimplantation loss.	IARC (2000), ECHA (2020a)
Developmental Toxicity/Teratogenicity - Not classified as a developmental toxicant. Teratogenic at maternally toxic doses. - Maternal effects observed among rat dams given 225 mg/kg/day, however reproductive parameters in exposed rats were unaffected at this or lower dose levels (0-75 mg/kg/day). Maternal effects were observed in another rat study at 450 mg/kg/day. -	HSDB (2020) ECHA (2020a)
Endocrine Disruption Not listed as an endocrine disruptor on the European Commission List of Endocrine Disruptors.	EC, 2000
Acute Toxicity (oral, dermal, inhalation) - Large doses produced minimal toxicity when administered orally to laboratory animals. - When heated to decomposition it emits toxic and irritating fumes of nitrogen oxides and hydrogen cyanides. - The probably oral lethal dose in humans is 5-15 g/kg bw. Toxicity is low following single exposures.	HSDB (2020) OECD (2000)
Chronic/repeat dose toxicity (oral, dermal, inhalation) - Human data are limited. Based on data from animal studies, chemical is anticipated to have low chronic toxicity under typical human exposure conditions. - Skin irritation and ulceration have been reported following repeated, subchronic, and chronic topical exposure in laboratory animals. - Kidney toxicity is reported in a number of experimental animal studies. Aside from nephrotoxicity (the primary effect), side effects reported in laboratory animals following long-term oral administration include hepatic congestion, and demyelination of peripheral and sciatic nerve fibers. - Classified as causing potential organ damage. - Classified as a potential respiratory irritant.	HSDB (2020) ECHA (2020, b)
Sensitisation of the skin or respiratory system - A skin sensitiser. - Not sensitising in a guinea pig study. - Very low sensitisation potential in humans in a volunteer human study	Safe Work Australia (2020)

	ECHA (2020a) ECHA (2020b)
Corrosion (irreversible and reversible)/irritation of the skin or eye - Not irritating to skin in rabbit studies. - Not irritating to eyes in three rabbit studies. Irritating to eyes in two rabbit studies. Conclusive but not sufficient for classification	ECHA (2020a) ECHA (2020b)

Physical Hazards	Reference
Flammable Potential Non flammable. Combustible, when exposed to heat or flame.	ECHA (2020a)
Explosive Potential There are no chemical groups associated with explosive properties in the molecule.	ECHA (2020a)

Toxicity Values	Value	Reference
Human Toxicity Data		
Acute Toxicity		
	NDF	All proposed data sources
High Chronic/Repeat Dose Toxicity		
LOAEC	NDF	
LOAEL	NDF	
Animal Toxicity Data		
Acute Toxicity		
LD_{50}		
Guinea pig (oral)	2200 mg/kg	PubChem (2020)
Mouse (intraperitoneal)	1450 mg/kg	PubChem (2020)
Mouse (oral)	5846 mg/kg	PubChem (2020)
Rabbit (oral)	2200 mg/kg	PubChem (2020)
Rabbit (skin)	>20 mL/kg	PubChem (2020)
Rat (intraperitoneal)	1510 mg/kg	PubChem (2020)

Rat (oral)	4920 uL/kg	PubChem (2020)
Rat (skin)	> 16 mL/kg	PubChem (2020)
Rabbit (dermal)	> 2,000 mg/kg	ECHA (2020a)
Rats (oral)	6400 mg/kg	ECHA (2020a)
LC0		
Rat (inhalation, 8h)	Saturated atmosphere (approximately 1.8 mg/m^3)	ECHA (2020a)
High Chronic/Repeat Dose Toxicity		
NOAEL, rat , oral	1000 mg/kg bw	ECHA (2020a)
NOAEL (local effects), mouse	250 mg/kg bw/day	ECHA (2020a)
NOAEC (local effects), rat (inhalation)	0.02 mg/L air	ECHA (2020a)
NOAEL (local effects) male rat (dermal)	125 mg/kg bw/day	ECHA (2020a)
NOAEL (local effects) female rat (dermal)	250 mg/kg bw/day	ECHA (2020a)

Footnotes:
LD_{50} – lethal dose for 50% of experimental population
LC_{50} – lethal air concentration for 50% of experimental population
LOAEL – Lowest Observed Adverse Effect Level
LOAEC – Lowest Observed Adverse Effect Concentration
NDF – No data found within the limits of the search strategy

Human Health Toxicity Ranking*		
	Hazard data	**Comment**
Hazard Band 4		
Carcinogenicity (IARC Group 1 or 2A)	No	IARC (2000) Group 3 - Not classifiable based on inadequate evidence.
Mutagenicity/Genotoxicity (GHS Category 1A and 1B)	No	ECHA (2020a)
Reproductive Toxicity/Developmental toxicity (GHS Category 1, 1A and 1B)	No	ECHA (2020a); IARC (2000)
Endocrine Disruption[1]	No	Not listed as an endocrine disruptor by European Commission.
Hazard Band 3		
Carcinogenicity (IARC Group 2B)	No	IARC 2000
Mutagenicity/Genotoxicity (GHS Category 2)	No	Not classified as a germ cell mutagen by ECHA (2020a)
Reproductive Toxicity/Developmental toxicity (GHS Category 2)	No	
Acute Toxicity (oral, dermal or inhalation) Very Toxic/Toxic • oral LD_{50} ≤ 300 mg/kg[3] • dermal LD_{50} ≤ 1000 mg/kg inhalation LC_{50} ≤ 10 mg/L[4] (or mg/m^3) (vapour)	No	-
High Chronic/repeat dose toxicity • oral LOAEL ≤ 10 mg/kg/d[3]; • dermal LOAEL ≤ 2 0 mg/kg/d; • inhalation LOAEC (6 h/d) ≤ 50 ppm/d for gases, ≤ 0.2 mg/L/d for vapours or ≤ 0.02 mg/L/d for dust/mists/fumes[4]	No	-

Human Health Toxicity Ranking*		
	Hazard data	**Comment**
Corrosive (irreversible effect)	No	Not classified as corrosive to skin or eyes by ECHA (2020)
Respiratory sensitiser	No	Not classified as a respiratory system sensitiser by ECHA (2020)
Hazard Band 2		
Harmful chronic/repeat dose toxicity • oral LOAEL > 10 mg/kg and ≤ 100 mg/kg/d • dermal LOAEL > 20 mg/kg/d and ≤ 200 mg/kg/d • inhalation (6-h/d) LOAEC > 50 mg/L ≤ 250 mg/L/d for gases, > 0.2 mg/L ≤ 1 .0 mg/L/d for vapours or > 0.02 mg/L ≤ 0.2 mg/L/d for dust/mists/fumes [4]	Yes	Potential local effects (irritation) in the respiratory tract.
Skin Sensitiser	Yes	Safe Work Australia (2020) - Skin irritation – category 2
Hazard Band 1		
Acute Toxicity-Harmful • oral LD_{50} > 300 mg/kg ≤ 2000 mg/kg • dermal LD_{50} >1 000 mg/kg ≤ 2000 mg/kg; inhalation LC_{50} (6 h/d) > 10 mg/L ≤ 20 mg/L for vapours)[4]	No	-
Irritant (reversible effect)	Yes	Safe Work Australia (2020) - Eye irritation – category 2A
Hazard Band 0 **All indicators outside criteria listed in Hazards 1-4**		
Physical Hazards		
Flammable potential	No	-

Human Health Toxicity Ranking*		
	Hazard data	**Comment**
Explosive potential	No	-
Hazard Evaluation (highest band) not including physical hazards	**Band 2**	
Data confidence (available points out of 12 parameters)	12/12 = 100%	

* Based on IMAP Framework [NICNAS (2013) Inventory Multi-tiered Assessment and Prioritisation (IMAP) Framework. National Industrial Chemicals Notification and Assessment Scheme. Department of Health and Aging, Canberra].

"[1]*Based on list of endocrine disrupting chemicals from the European Commission's Endocrine Disrupters website.*

[2] *Based on list of neurotoxic chemicals from US Agency for Toxic Substances and Disease Registry (ATSDR).*

[3] *milligrams per kilogram body mass (mg/kg) or milligrams per kilogram body mass per day (mg/kg/d)*

[4] *Based on GHS cut-offs for hazard classification. For chronic/repeat dose toxicity, GHS cut-offs are provided as guidance values (i.e. the dose/concentration at or below which significant health effects are observed"). (p 18, NICNAS 2013).*

Human Health Guidelines		
Media	**Concentration (mg/m^3; mg/L; mg/kg)**	**Reference**
Occupational Exposure Limits		
Air		
8-h TWA	5 mg/m^3	Safe Work Australia (2020)
STEL	NDF	
Peak Limitation	NDF	
Environmental Exposure		
Air, ambient, residential	NDF	
Air, commercial/industrial	NDF	

Water, potable	NDF	
Water, recreational	NDF	
Soil, residential	NDF	
Soil, commercial/industrial	NDF	
Soil, protection of groundwater	NDF	

Footnotes:

OEL = Occupational Exposure Limit

TWA = 8 h Time-Weighted Average

STEL = (15 min) Short-term Exposure Limit

Qualifying Summary Comments

Triethanolamineis a colourless to slightly liquid which is very hygroscopic and turns brown on exposure to air and light. It is a water-soluble strong base with a pH of 10.3 (concentration 1%) and emits a slight odour of ammonia. Triethanolamine is used commercially and industrially in the manufacture of surfactants and detergents, textiles, waxes, polishes, herbicides, petroleum demulsifiers, toilet goods, cement additives, cutting oils and other products. Triethanolamine has a low order of acute and chronic toxicity. It is classified as a skin sensitiser and eye irritant. It is not genotoxic, carcinogenic, or toxic to development or the reproductive system. Given the relatively low to moderate hazard it is categorised in Hazard Band 2.

References

European Chemicals Agency. Registered Chemical Substances Search. Available at http://echa.europa.eu/web/guest/information-on-chemicals/registered-substances. [Accessed 6 January 2020] (ECHA 2020a)

European Chemicals Agency. Classification and Labelling Inventory database Search. Available at http://echa.europa.eu/web/guest/information-on-chemicals/cl-inventory-database. [Accessed 6 January 2020] (ECHA 2020b)

HSDB (Hazardous Substances Data Bank) 2020. National Center for Biotechnology Information. U.S. National Library of Medicine. *Compound Summary for Triethanolamine*. Toxicology Data Network (PUBCHEM). Available at https://pubchem.ncbi.nlm.nih.gov/compound/7618, [Accessed 6 January 2020].

International Agency for Research on Cancer (IARC), 2020. Agents Classified by the *IARC Monographs*, Volumes 1–125, last updated 12 December 2019. Available at http://monographs.iarc.fr/ENG/Classification/index.php. [Accessed 6 January 2020]

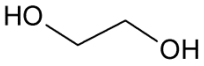
National Environment Protection (Assessment of Site Contamination) Amended Measure 2013 (No.1). *Schedule B1: Guidelines on Investigation Levels for soil and groundwater*. National Environment Protection Council, Commonwealth Government of Australia.

National Industrial Chemicals Notification and Assessment Scheme (NICNAS) (2020). Australian Inventory of Chemical Substances database search. Available at http://www.nicnas.gov.au/regulation-and-compliance/aics/aics-search-page. [Accessed 6 January 2020].

OECD (2000). Triethanolamine.: SIDS initial assessment report. From INCHEM. Available at http://www.inchem.org/documents/icsc/icsc/eics1034.htm

Safe Work Australia. Hazardous Chemical Information System (HCIS). Available at http://hcis.safeworkaustralia.gov.au/HazardousChemical. [Accessed 6 January 2020]

Created by:	LPA	Date: 18/12/2019
Reviewed by:	CLB	Date and Revision: 20/01/20

yesName	Ethylene glycol
Synonyms	Ethane-1,2-diol, 1,2-ethanediol, glycol, ethylene alcohol, hypo-dicarbonous acid, mono-ethylene glycol, 1,2-dihydroxyethane, ethylene dehydrate, MEG, Lutrol-9, Dowtherm Sr 1, Fridex, Norkool, Ramp, Tescol; Ucar 17
CAS number	107-21-1
Molecular formula	$C_2H_6O_2$
Molecular structure	

Overview	References
Ethylene glycol is a colourless, odourless, sweet tasting, relatively non-volatile liquid with high water solubility. It is a small molecular-weight alcohol which readily passes through biological membranes and is absorbed from the gastro-intestinal tract (GI) tract and in the lung. Ethylene glycol has numerous commercial and industrial applications such as in chemical manufacturing, natural gas processing and as an engine coolant. It is commonly used in antifreeze and hydraulic break fluids in both the automotive and aviation industry. It is also present in inks used in stamp pads, ballpoint pens and print shops. Ethylene glycol is considered highly toxic with multiple metabolites contributing to the toxic effects. The metabolites of ethylene glycol that have been typically detected are carbon dioxide, glycolic acid, and oxalic acid. Oxalic acid is converted to harmful calcium oxalate crystals, which are deposited in various tissues. Target organ cellular damage is seen in the kidney, brain, myocardium, pancreas, and blood vessel walls. Numerous human case studies and controlled experiments on animals are available to provide data on the toxic effects of ethylene glycol. Ethylene glycol is quickly and extensively absorbed through the GI tract of many species, but dermal absorption is slow in rodents and is slow and poorly absorbed through the skin in humans.	ATSDR 2010

Human Health Toxicity Summary	Reference
Carcinogenicity Ethylene glycol has not been evaluated by the International Agency for Research on Cancer. Ethylene glycol exhibited no evidence of carcinogenicity based on a two year bioassay with rats and mice. In several animal studies, there was no evidence of carcinogenicity in animals.	IARC 2019; ATSDR 2010

Mutagenicity/Genotoxicity Ethylene glycol is not classified as a mutagen by the European Chemicals Agency (ECHA). An ATSDR study reported that available *in vivo* and *in vitro* laboratory studies provided consistently negative genotoxicity results. No significant mutagenic activity was observed using the Ames test. *In vitro* mutagenicity studies in bacterial cells have consistently reported negative results.	ECHA 2020; ATSDR 2010
Reproductive Toxicity Ethylene glycol is not classified as reproductively toxic by ECHA on the basis that the data are sufficient and do not support classification under the GHS (Rev4)) thresholds. This fact contrasts with the ATSDR (2010) animal data on developmental toxicity (see section below). While the GHS classification includes both reproductive and developmental toxicity these data have been presented separately in this profile to differentiate the nature of the toxicological response. There have been equivocal studies of reproductive toxicity. There has been no evidence of an adverse impact on reproductive organs observed in repeated dose toxicity studies in animals while other contradictory reports suggest reproductive effects such as decreased number of litters per pair, number of live pups per pair, and live pup weight, pup facial deformities and abnormal skeletons following long-term exposure to high doses. While the latter was observed in mice the effect was not observed in rats or rabbits under the same conditions. A further study in rats reported embryotoxicity following administration of ethylene glycol.	ECHA 2020 ATSDR 2010
Developmental Toxicity/Teratogenicity While there are insufficient human data on developmental toxicity / teratogenicity of ethyl glycol. There are animal data as presented in ATSDR (2010) and summarized below. Several acute-durational studies have been undertaken to assess developmental toxicity of ethylene glycol in mice, rats and rabbits. The studies indicate that malformations occur in both mice and rats exposure during gestations. Skeletal malformations were most apparent and mice appeared more sensitive than the other animals. Reduction in foetal body weight was also observed in laboratory animals exposed to ethylene glycol. ATSDR (2010) consider ethylene glycol to be teratogenic, more so in mice than in rats, rabbits and chickens. It induces primarily skeletal and external malformations. Teratogenic effects in mice were seen at all dose levels (750-3000 mg/kg/day) and in rats at 2500 and 5000 mg/kg/day. Animals given less than the limit dose (1000 mg/kg/day) only by the oral route and only when rapidly ingested (bolus) exhibited developmental toxicity.	ATSDR 2010
Endocrine Disruption Ethylene glycol is listed on the European Commission Priority List for endocrine disruptors as Category 3C. A classification of 3 indicates that the review found no scientific basis for inclusion in the priority list. The classification of C indicates that data were available on wildlife/relevant and/or mammal relevant endocrine effects for assessment.	EC 2000

Acute Toxicity (oral, dermal, inhalation) **Oral** Ethyl glycol is classified as acutely toxic via the oral route by ECHA based on its classification thresholds. ATSDR reports that in humans, the lethal dose of ethylene glycol is estimated to be in the range of 1,400–1,600 mg/kg. However, there are difficulties in quantifying the amounts consumed by persons who have succumbed to the toxic effects, which has led to uncertainty in the human lethal dose estimates. In laboratory animals (rats, mice, monkeys), oral doses of ≥4,000 mg/kg were required to cause death. Available information on the effects of acute accidental or intentional ingestion of ethylene glycol in humans suggests that acute oral toxicity in humans occurs in three stages within 72 hours of ingestion. Initially central nervous system depression, metabolic changes (hyper-osmolality) and gastrointestinal upset occurs and lasts from 30 minutes to 12 hours. These effects are followed by a second stage of symptoms which includes metabolic acidosis and associated cardio-pulmonary symptoms (tachypnea, hyperpnea, tachycardia, cyanosis, pulmonary oedema, and/or cardiac failure). The second stage of effects has been observed to last 12 – 24 hours after ingestion. The third stage (24 – 72 hours after ingestion) is characterized by renal involvement (flank pain and oliguria/anuria). There is also limited information suggesting a fourth stage, where cranial nerves (evident through deafness, facial paralysis, and other sequelae) may occur 6 or more days after exposure. Renal effects in orally exposed animals are consistent with those observed in humans. In acute-duration studies, effects occurred in the kidneys of rats exposed to 1,250–2,500 mg/kg/day by gavage or 2, 615– 5,270 mg/kg/day in drinking water for 9–29 days, and rabbits exposed to 2,000 mg/kg/day by gavage for 13 days. **Inhalation** A human inhalation study of short-term, high-exposure periods found that ethylene glycol was tolerated for only 15 minutes at 188 mg/m^3; 2 minutes at 244 mg/m^3; and one or two breaths at 308 mg/m^3. The study reports that irritation of the respiratory tract became common at an ethylene glycol concentration of approximately 140 mg/m^3 (further data not provided), with concentration of ≥ 200 mg/m^3 being intolerable due to strong irritation of the upper respiratory tract. Reported effects included a burning sensation in the trachea and a burning cough. **Dermal** Information on the acute dermal toxicity of ethylene glycol is limited. ATSDR note one study in rabbits that found minimal skin and eye irritation following single applications and one negative developmental toxicity study in mice.	ECHA 2020; ATSDR 2010
Chronic/repeat dose toxicity (oral, dermal, inhalation) Ethylene glycol is classified as chronically toxic via the oral route by ECHA. Prolonged or repeat exposure may cause damage to the kidney (GHS Category 2). A 90-day study of rats exposed to ethylene glycol in drinking water found that renal effects were observed in males at > 947 mg/kg/day and females at 3, 087 mg/kg/day. The effects included renal tubular oxalate crystal deposition, dilation and degeneration of the kidney.	ECHA 2020; ATSDR 2010

Renal effects in rats and mice exposed to ethylene glycol in the diet for up to 2 years have also been studied. The studies showed males were more sensitive than females and rats were more sensitive than mice. At concentrations of ≥ 300 mg/kg/day, renal effects, including oxalate nephrosis, were observed in male rats. Oxalate crystal deposition and apparent tubular degenerative changes in male rats was observed at ≥ 375 mg/kg/day and in female rats at ≥ 750 mg/kg/day. A 30-day human study reported that inhalation exposure to ethylene glycol vapour was well tolerated at an average concentration of 30 mg/m^3 for 20-22 hours/day. The effects reported were essentially limited to the occasional complaint about mild irritation of the upper respiratory tract.	
Sensitisation of the skin or respiratory system Ethylene glycol is not classified as a skin or respiratory system sensitiser by ECHA (considered conclusive data for not classifying the substance by ECHA).	ECHA 2020
Corrosion (irreversible)/irritation (reversible) effects on the skin or eye Ethylene glycol is not reported as causing corrosion or irritation effects on the skin or eyes by ECHA.	ECHA 2020

Physical Hazards	Reference
Flammable Potential Not considered flammable by ECHA. Flashpoint of 127ºC, Auto-ignition temperature of 398ºC.	ECHA 2020; ATSDR 2010
Explosive Potential Not considered explosive by ECHA. Explosive limits are reported as 3.20 – 53%	ECHA 2020; ATSDR 2010

Toxicity Values	Value	Reference
Human Toxicity Data		
High Chronic/Repeat Dose Toxicity		
LD_{Lo} (lowest lethal dose), male, lethal dose 48 hrs after single ingestion	4071 mg/kg	ATSDR 2010
LD_{Lo}, lethal dose in 6/11 after single exposure	2379 mg/kg	ATSDR 2010
LOAEL, humans, inhalation, respiratory tract irritation	140 mg/m^3	ATSDR 2010
Animal Toxicity Data		
Acute Toxicity		
LD_{50}		
Rat, oral, female	4000 mg/kg /day	ATSDR 2010
Rat, oral	7712 mg/ kg	ECHA 2020
Mouse, dermal	> 3500 mg/kg	ECHA 2020
LC_{50}		

Rat, 6 hr exposure	> 2.5 mg/L air (> 2500 mg/m^3)	ECHA 2020
High Chronic/Repeat Dose Toxicity		
LOAEL, rats, 10 d, drinking water, renal toxicity	2615 mg/kg/day	ATSDR 2010
LOAEL, rats, male, 90 d drinking water, renal toxicity	947 mg/kg/day	ATSDR 2010
LOAEL, rats, female, 90 d drinking water, renal toxicity	3 087 mg/kg/day	ATSDR 2010
LOAEL, rats, male, 16 w dietary study, renal toxicity	180 mg/kg/day	ATSDR 2010
LOAEL, mice, oral, developmental toxicity	500 mg/kg/day	ATSDR 2010
LOAEL, rats, oral, developmental toxicity	750 mg/kg/day	ATSDR 2010
LOAEL, rabbit, 14 d GW, female, renal toxicity	2000 mg/kg/day	ATSDR 2010

Footnotes:
LD_{50} – lethal dose for 50% of experimental population
LC_{50} – lethal air concentration for 50% of experimental population
LOAEL – Lowest Observed Adverse Effect Level
LOAEC – Lowest Observed Adverse Effect Concentration
NDF – No data found within the limits of the search strategy

Human Health Toxicity Ranking		
	Hazard data	**Comment**
Hazard Band 4		
Carcinogenicity (IARC Group 1 or 2A)	No	ATSDR 2010, Not classified by IARC
Mutagenicity/Genotoxicity (GHS Category 1A and 1B)	No	ATSDR 2010
Reproductive Toxicity/Developmental toxicity (GHS Category 1, 1A and 1B)	No	See below
Endocrine Disruption[1]	No	Listed as Category 3C on priority by EC (EC 2000)
Hazard Band 3		
Carcinogenicity (IARC Group 2B)	No	ATSDR 2010
Mutagenicity/Genotoxicity (GHS Category 2)	No	ATSDR 2010
Reproductive Toxicity/Developmental toxicity (GHS Category 2)	Yes	Development toxicity observed in animal studies, ATSDR 2010.
Acute Toxicity (oral, dermal or inhalation) Very Toxic/Toxic • oral LD_{50} ≤ 300 mg/kg [2] • dermal LD_{50} ≤ 1000 mg/kg • inhalation LC_{50} ≤ 10 mg/L [3] (or mg/m^3) (vapour)	No	See below
High Chronic/repeat dose toxicity • oral LOAEL ≤ 10 mg/kg/d [2]; • dermal LOAEL ≤ 2 0 mg/kg/d; • inhalation LOAEC (6 h/d) ≤ 50 ppm/d for gases, ≤ 0.2 mg/L/d for vapours or ≤ 0.02 mg/L/d for dust/mists/fumes [3]	No	See below
Corrosive (irreversible effect)	No	ECHA 2020
Respiratory sensitiser	No	ECHA 2020

Human Health Toxicity Ranking		
	Hazard data	**Comment**
Hazard Band 2		
Harmful chronic/repeat dose toxicity • oral LOAEL > 10 mg/kg/d and ≤ 100 mg/kg/d • dermal LOAEL > 20 mg/kg/d and ≤ 200 mg/kg/d • inhalation (6-h/d) LOAEC > 50 mg/L ≤ 250 mg/L/d for gases, > 0.2 mg/L ≤ 1 .0 mg/L/d for vapours or > 0.02 mg/L ≤ 0.2 mg/L/d for dust/mists/fumes [3]	Yes	Prolonged or repeat does exposure may cause damage to the kidney (ATSDR 2010), GHS Category 2 (ECHA 2020)
Skin Sensitiser	No	ECHA 2020
Hazard Band 1		
Acute Toxicity-Harmful • oral LD_{50} > 300 mg/kg ≤ 2000 mg/kg • dermal LD_{50} >1 000 mg/kg ≤ 2000 mg/kg; • inhalation LC_{50} (6 h/d) > 10 mg/L ≤ 20 mg/L for vapours) [3]	No	LD_{50}, rat, oral – 4 000 mg/kg/day (ATSDR 2010)
Irritant (reversible effect)	Yes	Respiratory tract irritation (ATSDR 2010)
Hazard Band 0 **All indicators outside criteria listed in Hazards 1-4**	No	
Physical Hazards		
Flammable potential	No	
Explosive potential	No	
Hazard Evaluation (highest band) not including physical hazards	3	**Reproductive, developmental, teratogenic and neurological effects in animals.**
Data confidence (available points out of 12 parameters)	12/12	**100%**

* Based on IMAP Framework [NICNAS (2013) Inventory Multi-tiered Assessment and Prioritisation (IMAP) Framework. National Industrial Chemicals Notification and Assessment Scheme. Department of Health and Aging, Canberra].

"[1]Based on list of endocrine disrupting chemicals from the European Commission's Endocrine Disrupters website.

[2] *milligrams per kilogram body mass (mg/kg) or milligrams per kilogram body mass per day (mg/kg/d)*

[3] *Based on GHS cut-offs for hazard classification. For chronic/repeat dose toxicity, GHS cut-offs are provided as guidance values (i.e. the dose/concentration at or below which significant health effects are observed)". (p 18, NICNAS 2013).*

Human Health Guidelines		
Media	**Concentration (mg/m^3; mg/L; mg/kg)**	**Reference**
Occupational Exposure Limits		
Air (OEL)		
8-h TWA	52 mg/ m^3 (vapour) 10 mg/ m^3 (particulate)	Safe Work Australia 2020
STEL	104 mg/ m^3 (vapour)	Safe Work Australia 2020
Peak Limitation	NDF	
Minimal Risk Levels (MRLs)		
Inhalation (acute exposure, 14 days or less)	2 mg/m^3	ATSDR 2010
Oral (acute exposure, 14 days or less)	0.8 mg/kg/day	ATSDR 2010
Environmental Exposure		
Air, ambient, residential	0.42 mg/m^3	US EPA 2019
Air, commercial/industrial	1.8 mg/m^3	US EPA 2019
Water, potable	40 mg/L	USEPA 2019
Water, recreational	NDF	

Soil, residential	130 000 mg/kg	USEPA 2019
Soil, commercial/industrial	1 600 000*mg/kg	USEPA 2019
Soil, protection of groundwater		

Footnotes:

OEL = Occupational Exposure Limit

TWA = 8 h Time-Weighted Average

STEL = (15 min) Short-term Exposure Limit

* Above limit of practicality

Qualifying Summary Comments

Ethylene glycol exhibits a diverse range of adverse toxicological outcomes in animal studies including reproductive, developmental and teratogenic effects and renal effects after chronic exposure, although it is not considered highly acutely toxic via the oral, dermal and inhalation pathways. In humans it is considered to be acutely toxic. Furthermore, while ECHA has not classified ethylene glycol as a reproductive toxicant, ATSDR (2010) highlight the developmental toxicity of ethylene glycol in animals. Taking these concerns into account and subject to further evaluations of the animal data by regulatory agencies a Hazard Band 3 rating has been allocated. It is not flammable or explosive and burns with difficulty. While these properties warrant management for the occupational setting and where large scale emergency spills may result in local population exposure, data from river die-away tests suggest degradation is complete within 3 days at 20 deg C and 5-14 days at 8 deg C (HSDB, 2012). This implies rapid degradation of ethylene glycol in surface water. This limits its ability for accumulation and sustained environmental presence even though its mobility characteristics are high.

References

ATSDR (Agency for Toxic Substances and Disease Registry), 2010. *Toxicological Profile for Ethylene Glycol*., Division of Toxicology and Environmental Medicine/Applied Toxicology Branch, Public Health Service, US Department of Health and Human Services. Available at http://www.atsdr.cdc.gov/ToxProfiles/TP.asp?id=86&tid=21, Accessed January 2020.

EC (European Commission) 2000. *European Commission Towards the establishment of a priority list of substances for further evaluation of their role in endocrine disruption, preparation of a candidate list of substances as a basis for priority setting, Final Report (Incorporating corrigenda to final report dated 21 June 2000)*. BKH Consulting Engineers, Delft, The Netherlands in association with TNO Nutrition and Food Research, Zeist, The Netherlands Available at http://ec.europa.eu/environment/chemicals/endocrine/strategy/substances_en.htm#priority_list, Accessed January 2020.

ECHA (European Chemicals Agency Registered Chemical Substances Search) 2020. *Dossier of Ethane-1,2-diol*. Available at https://echa.europa.eu/registration-dossier/-/registered-dossier/15973/1, Accessed January 2020.

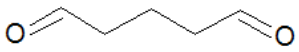
Safe work Australia (2020) HCIS (Hazardous Chemical Information System) 2020. *Hazardous Substances Information System for Ethylene glycol*. Safework Australia. Available at: http://hcis.safeworkaustralia.gov.au/ExposureStandards/Details?exposureStandardID=722, Accessed January 2020.

HSDB 2020. *Ethylene glycol*. Hazardous Substances Data Bank, PUBCHEM, US National Library of Medicine. Available at https://pubchem.ncbi.nlm.nih.gov/compound/174 . Accessed January 2020.

IARC (International Agency for Research on Cancer) 2019. *International Agency for Research on Cancer Agents classified by IARC Monographs*, Volumes 1- 125. Last updated: 12 December 2019, Available at http://monographs.iarc.fr/ENG/Classification/index.php., Accessed January 2020.

USEPA (United States Environmental Protection Authority) 2019. *Regional Screening Levels for Chemical Contaminants at Superfund Sites* Updated November 2019. Accessed 23 January 2020. https://www.epa.gov/risk/regional-screening-levels-rsls

Created by:	LPA	Date: 18/12/2019
Reviewed by:	CLB	Date and Revision: 23/01/2020

Name	Glutaraldehyde
Synonyms	Glutaral; 1,5-pentanedial Pentanedial; 1,5-pentanedione; 1,3-diformylpropane; Glutaric dialdehyde; Glutaral Glutardialdehyde; Potentiated Acid Glutaraldehyde
CAS number	111-30-8
Molecular formula	$C_5H_8O_2$
Molecular structure	

Overview	References
Glutaraldehyde is a colourless oily liquid which has a variety of uses. In Australia, it's primarily used as a cold disinfectant by the health care industry. Other uses include as a hardener in x-ray film processing, as a fixative in tanning, as a disinfectant of animal housing, aircraft and portable toilets, as a preservative in industrial oils and as a biocide in aquaculture. Glutaraldehyde is primarily used as an aqueous solution, ranging in concentration from 50% w/w to less than 1% w/w. It is not manufactured as a pure chemical in Australia (based on the National Industrial Chemicals Notification and Assessment Scheme (NICNAS) (1994) review) but is imported by a number of companies (usually as a 25, 45 or 50 % w/w aqueous solution). Glutaraldehyde was declared a Priority Existing Chemical (PEC) in 1993 under the *Industrial Chemicals (Notification and Assessment) Act, 1989* due to adverse health concerns, which could result from individuals being exposed through the production, handling, use and disposal of glutaraldehyde. Occupational exposure to glutaraldehyde has resulted in occupational asthma, significant skin, respirator and eye irritation, as well as skin sensitisation in some cases. The Hazardous Chemical Information System (HCIS) provided by Safe Work Australia, lists the following hazard statements glutaraldehyde: • H330 (Fatal if inhaled) • H301 (Toxic if swallowed) • H335 (May cause respiratory irritation) • H314 (Causes severe skin burns and eye damage) • H334 (May cause allergy or asthma symptoms or breathing difficulties if inhaled) • H317 (May cause an allergic skin reaction) • H400 (Very toxic to aquatic life) • H411 (Toxic to aquatic life with long-lasting effects)	NICNAS 1994

Human Health Toxicity Summary	Reference
Carcinogenicity Glutaraldehyde has not been evaluated by the International Agency for Research on Cancer (IARC) as to its carcinogenicity. Glutaraldehyde is not classified as carcinogenic by ECHA, as no carcinogenic potential was evident from its review of oral and inhalative long-term animal studies. . ECHA presents a 2 year oral feeding study of rats which reported that neoplastic findings were spontaneous in origin and showed no treatment-relationship. The animals were fed glutaraldehyde (in water) daily ranging from 6.1 mg/kg bw/day to 176.4 mg/kg bw/day. In a second 2 years drinking water study rats receiving daily glutaraldehyde in water (between 4 mg/kg bw/day and 86 mg/kg bw/day) reported that overall there was a statistically significant increased incidence of large granular lymphocytic leukaemia (LGLL) in the liver and spleen only in female rats in both dose groups The finding was not conclusive as the strain of rats used in the study has a high natural susceptibility to LGLL and variation in control data existed within the study laboratory.	IARC 2020 ECHA 2020 OECD SIDS 2017
Mutagenicity/Genotoxicity Glutaraldehyde is not classified as a mutagen by ECHA. From a review of available information, ECHA concluded that no classification is warranted according to EU Classification, Labelling and Packaging of Substances and Mixtures (CLP) Regulation (EC) No. 1272/2008. An in vivo cytogenicity study indicates that for rats who received 200 mg/kg bw or 400 mg/kg bw glutaraldehyde by oral gavage, the test was negative for genotoxicity. However, studies have indicated the glutaraldehyde is mutagenic in bacterial assays (in vitro studies).	ECHA 2020 ECHA 2020
Reproductive Toxicity Glutaraldehyde is not classified as reproductive toxicant by ECHA. From a review of available information, ECHA conclude that glutaraldehyde does not affect the reproductive performance and fertility, and neither possesses an embryo/fetotoxic nor a teratogenic potential. Therefore, no classification is warranted according to EU Classification, Labelling and Packaging of Substances and Mixtures (CLP) Regulation (EC) No. 1272/2008). A summary of a reproductive study states a NOAEL of 68 mg/kg bw/day for embryotoxicty. This was the highest dose group. Female rats were exposed to glutaraldehyde in their drinking water from day 6 to day 16 of gestation. Another similar study lists a LOAEL for maternal toxicity of 51 mg/kg bw/day (highest dose tested) based on reduction in food and water consumption and on the presence of foci in the glandular stomach of 2 animals.	ECHA 2020
Developmental Toxicity/Teratogenicity Glutaraldehyde is not classified as a developmental toxicant by ECHA (ECHA states conclusive data has been reviewed, indicating low toxicity which doesn't support classification under the GHS). Two studies cited by ECHA indicated there was no evidence of teratogenicity in female rats fed glutaraldehyde in water during gestation. The highest dose was 68 mg/kg bw/day.	ECHA 2020

Endocrine Disruption Glutaraldehyde is not identified in the European Commission (EC)'s report, "*Towards the establishment of a priority list of substances for further evaluation of their role in endocrine disruption*" as a substance of interest.	EC 2000
Acute Toxicity (oral, dermal, inhalation) Glutaraldehyde is classified as acutely toxic via the oral and inhalation route by ECHA based on its classification thresholds (Acute Tox 3: H301: Toxic if swallowed and Acute Tox 2: H330: Fatal if inhaled.). *Oral* ECHA reports an oral LD_{50} of 77 mg/kg bw for female rats (pure glutaraldehyde, based on a LD_{50} of 154 mg/kg bw of the test substance) from the key study. The glutaraldehyde was administered orally (by gavage) at doses of 100, 200, 400 mg/kg bw (test material) for male rats and 100, 141, 200 mg/kg bw (test material 50%) for female rats. Other clinical signs of toxicity were seen in all treated groups and included sluggishness, lacrimation, piloerection, diarrhea, trace amount of blood in the urine of two rats, a red crust on the perinasal fur and a brown stain on the perineal fur (of 1 rat). *Inhalation* ECHA cites a study which reports an inhalation LC_{50} of 0.48 mg/ L air (480 mg/m^3) for male and female rats. The test was conducted in general accordance with OECD Guidelines 403 (Acute Inhalation Toxicity). The exposure duration was 4 hours and the rats were exposed to the test substance as liquid aerosol at the following nominal concentrations: 0.35, 0.58 and 0.72 mg/L. ECHA reports an inhalation LC_{50} range between 0.28 and 0.39 mg/L air (50% glutaraldehyde). The test was conducted in general accordance with OECD Guidelines 403 (Acute Inhalation Toxicity). The exposure duration was 4 hours and the rats were exposed to the test substance as liquid aerosol. *Dermal* ECHA cites a study which reports a dermal LD_{50} of > 2000 mg/kg bw for male and female rabbits. Glutaraldehyde was applied semiocclusively at the one dose and the exposure period was 24 hours. Animals were observed for mortality, body weights, clinical signs or toxicity and local skin changes for 14 days after exposure. Limited clinical signs of mucoid faeces and wet brown urogenital staining were observed in the first 3 days of observation. Necropsy revealed thickening and scabbing of the application sites in all animals. No further treatment-related abnormalities were reported.	ECHA 2020
Chronic/repeat dose toxicity (oral, dermal, inhalation) Glutaraldehyde is not classified based on serious effects to organ systems following repeat dose exposure by the oral, dermal or inhalation route. ECHA presents summarise of a number of key studies including three **oral** studies where NOAELs determined ranged from 14.6 to 23.0 mg/kg bw pure glutaraldehyde. ECHA adopts a NOAEL for oral exposure of 15 mg/kg bw/day. Several **inhalation** studies indicate that glutaraldehyde affects primarily the respiratory tract. The NOAECs for local and systemic effects were determined to be 0.25 and 0.5 mg/m^3, respectively.	ECHA 2020

A **dermal** exposure study conducted in accordance with OECD Guideline 411 (Subchronic Dermal Toxicity: 90-Day Study) examined doses of 0, 50, 100 and 150 mg/kg bw/day (active ingredient) applied to rats for 5 days a week over a period of 13 weeks. The NOAEL for systemic toxicity was established at 150 mg/kg/day. ECHA conclude that systemic toxicity of glutaraldehyde under repeated oral or dermal exposure is not expected, Under repeated inhalation exposure conditions, the upper respiratory tract was identified as target for the toxicity of glutaraldehyde vapours. Therefore, according to Annex VI of EU Classification, Labelling and Packaging of Substances and Mixtures (CLP) Regulation (EC) No. 1272/2008 and based on the available data, glutaraldehyde does not have to be classified.	
Sensitisation of the skin or respiratory system Glutaraldehyde is classified as potentially causing an allergic **skin** reaction by ECHA based on its classification thresholds. According to Annex VI of EU Classification, Labelling and Packaging of Substances and Mixtures (CLP) Regulation (EC) No. 1272/2008) and based on the available data, glutaraldehyde has to be classified as Skin Sens. 1A: H317 and Resp. Sens. 1: H334. ECHA based the above conclusion on a number of key studies, including tested with an open cutaneous test, LLNA, Guinea Pig Maximisation Test, Buehler test, and the mouse ear swelling test and human sensitising studies. Besides a Buehler test and one guinea pig maximisation test, all animal studies indicate that glutaraldehyde is sensitising to skin. Human sensitisation was reported in studies using patch tests on volunteers, and in clinical case reports of contact dermatitis, particularly in occupation settings. Animal studies of **respiratory sensitisation** are not available. However, several studies have indicated occupational asthma and/or rhinitis have been linked with exposure to glutaraldehyde in the workplace. Glutaraldehyde is classified by Safe Work Australia (2020) as potentially causing allergy or asthma symptoms or breathing difficulties if inhaled.	ECHA 2020 Safe Work Australia 2020
Corrosion (irreversible)/irritation (reversible) effects on the skin or eye Glutaraldehyde is classified as causing severe skin burns and eye damage by EHCA based on its classification thresholds. According to Annex VI of EU Classification, Labelling and Packaging of Substances and Mixtures (CLP) Regulation (EC) No. 1272/2008 and based on the available data, glutaraldehyde has to be classified as Skin Corr. 1B: H314; Causes severe skin burns and eye damage and STOT SE 3: H335: May cause respiratory irritation. A skin corrosion/irritation study of white rabbits was presented by ECHA, which reported erythema and edema were observed after occlusive application of undiluted glutaraldehyde. The effects were observed to not be reversible after 4-hour exposure. ECHA provides a study which found that glutaraldehyde was found to cause eye damage which was not reversible. 0.1 mL of the test substance (~50% glutaraldehyde) was applied into the conjunctival sac of the right eye and the rabbits were observed for 8 days.	ECHA 2020

Physical Hazards	Reference
Flammable Potential Non flammable liquid	ECHA 2020
Explosive Potential Non explosive	ECHA 2020

Toxicity Values	Value	Reference
Human Toxicity Data		
High Chronic/Repeat Dose Toxicity		
LOAEC	NDF	
LOAEL	NDF	
Animal Toxicity Data		
Acute Toxicity		
LD_{50}		
Rat, oral	77 mg/kg bw (pure GA)	ECHA 2020
Mouse, oral	27 mg/kg bw (pure GA)	ECHA 2020
Rabbit, oral	133 mg/kg bw (pure GA)	ECHA 2020
Rat, dermal	> 2000 mg/kg bw (50% GA)	ECHA 2020
Rabbit, dermal	> 2000 mg/kg bw (50% GA)	ECHA 2020
Mouse, dermal	> 2000 mg/kg bw (50% GA)	ECHA 2020
LC_{50}		
Rat	0.28 mg/L (280 mg/m^3) (50% GA)	ECHA 2020
High Chronic/Repeat Dose Toxicity		

LOAEL (rats, oral, maternal toxicity, 50% GA)	51 mg/ kg bw/day	ECHA 2020
NOAEL (rats, oral, non-neoplastic effects, pure GA)	15 mg/kg bw/day	ECHA 2020
NOAEL (rats, oral, reproductive toxicity, embryotoxicty, 50% GA)	68 mg/kg bw/day	ECHA 2020

Footnotes:
LD_{50} – lethal dose for 50% of experimental population
LC_{50} – lethal air concentration for 50% of experimental population
LOAEL – Lowest Observed Adverse Effect Level
LOAEC – Lowest Observed Adverse Effect Concentration
NDF – No data found within the limits of the search strategy

Human Health Toxicity Ranking		
	Hazard data	**Comment**
Hazard Band 4		
Carcinogenicity (IARC Group 1 or 2A)	No	IARC 2020 ECHA 2020
Mutagenicity/Genotoxicity (GHS Category 1A and 1B)	No	ECHA 2020
Reproductive Toxicity/Developmental toxicity (GHS Category 1, 1A and 1B)	No	ECHA 2020
Endocrine Disruption[1]	No	EC 2000
Hazard Band 3		
Carcinogenicity (IARC Group 2B)	No	IARC 2020 ECHA 2020
Mutagenicity/Genotoxicity (GHS Category 2)	No	ECHA 2020
Reproductive Toxicity/Developmental toxicity (GHS Category 2)	No	ECHA 2020
Acute Toxicity (oral, dermal or inhalation) Very Toxic/Toxic • oral LD_{50} ≤ 300 mg/kg [2] • dermal LD_{50} ≤ 1000 mg/kg • inhalation LC_{50} ≤ 10 mg/L [3] (or mg/m^3) (vapour)	Yes	Oral LD_{50}: 77 mg/kg bw (pure GA) ECHA 2020, see below
High Chronic/repeat dose toxicity • oral LOAEL ≤ 10 mg/kg/d [2]; • dermal LOAEL ≤ 2 0 mg/kg/d; • inhalation LOAEC (6 h/d) ≤ 50 ppm/d for gases, ≤ 0.2 mg/L/d for vapours or ≤ 0.02 mg/L/d for dust/mists/fumes [3]	No	ECHA 2020, see below
Corrosive (irreversible effect)	Yes	ECHA 2020
Respiratory sensitiser	Yes	ECHA 2020

Human Health Toxicity Ranking		
	Hazard data	**Comment**
Hazard Band 2		
Harmful chronic/repeat dose toxicity • oral LOAEL > 10 mg/kg/d and ≤ 100 mg/kg/d • dermal LOAEL > 20 mg/kg/d and ≤ 200 mg/kg/d • inhalation (6-h/d) LOAEC > 50 mg/L ≤ 250 mg/L/d for gases, > 0.2 mg/L ≤ 1 .0 mg/L/d for vapours or > 0.02 mg/L ≤ 0.2 mg/L/d for dust/mists/fumes [3]	Yes	Oral LOAEL, rats, of 51 mg/kg bw/day (50% GA) ECHA 2020
Skin Sensitiser	Yes	ECHA 2020
Hazard Band 1		
Acute Toxicity-Harmful • oral LD_{50} > 300 mg/kg ≤ 2000 mg/kg • dermal LD_{50} >1 000 mg/kg ≤ 2000 mg/kg; • inhalation LC_{50} (6 h/d) > 10 mg/L ≤ 20 mg/L for vapours) [3]	Yes	oral LD_{50}, rat, of 316 mg/kg bw, ECHA 2020
Irritant (reversible effect)	Yes	
Hazard Band 0 **All indicators outside criteria listed in Hazards 1-4**		
Physical Hazards		
Flammable potential	No	
Explosive potential	No	
Hazard Evaluation (highest band) not including physical hazards	Hazard Band 3	**Corrosive to skin and respiratory sensitiser, and acute oral toxicity**
Data confidence (available points out of 12 parameters)	12/12	**100%**

* Based on IMAP Framework [NICNAS (2013) Inventory Multi-tiered Assessment and Prioritisation (IMAP) Framework. National Industrial Chemicals Notification and Assessment Scheme. Department of Health and Aging, Canberra].

"[1]Based on list of endocrine disrupting chemicals from the European Commission's Endocrine Disrupters website.

[2] milligrams per kilogram body mass (mg/kg) or milligrams per kilogram body mass per day (mg/kg/d)

[3] Based on GHS cut-offs for hazard classification. For chronic/repeat dose toxicity, GHS cut-offs are provided as guidance values (i.e. the dose/concentration at or below which significant health effects are observed)". (p 18, NICNAS 2013).

Human Health Guidelines		
Media	**Concentration (mg/m^3; mg/L; mg/kg)**	**Reference**
Occupational Exposure Limits		
Air (OEL)		
8-h TWA	NDF	
STEL	NDF	
Peak Limitation	0.41 mg/m^3 (0.1 ppm)	Safe Work Australia 2020
Environmental Exposure		
Air, ambient, residential	NDF	
Air, commercial/industrial	NDF	
Water, potable	NDF	
Water, recreational	NDF	
Soil, residential	NDF	
Soil, commercial/industrial	NDF	
Soil, protection of groundwater		

Footnotes:

OEL = Occupational Exposure Limit

TWA = 8 h Time-Weighted Average

STEL = (15 min) Short-term Exposure Limit

Qualifying Summary Comments

Glutaraldehyde is a colourless oily liquid which has a variety of uses. In Australia, it's primarily used as a cold disinfectant by the health care industry. Glutaraldehyde was declared a Priority Existing Chemical (PEC) in 1993 under the *Industrial Chemicals (Notification and Assessment) Act, 1989* due to adverse health concerns, which could result from individuals being exposed through the production, handling, use and disposal of glutaraldehyde. Glutaraldehyde is considered acutely toxic via the oral and inhalation route and is corrosive to the skin and eyes. Occupational exposure to glutaraldehyde has resulted in occupational asthma from inhalation, significant skin, respiratory system and eye irritation, as well as skin sensitisation in some cases from skin exposure. The inhalation hazards associated with use of glutaraldehyde need to be managed in an occupational setting as it can cause asthma. Glutaraldehyde has been ranked in Hazard Band 3, based on the potential for it to be corrosive to the skin and eyes, a respiratory sensitiser and acutely toxic via the oral route of exposure. These effects were observed for both undiluted and diluted solutions of glutaraldehyde. It is noted that the rapid metabolism of glutaraldehyde in soil and the rapid biodegradation of glutaraldehyde in the aquatic environment, along with the fact that it is not expected to bioaccumulate (see the Ecotoxicology section of the cover addendum), limits the potential for glutaraldehyde to persist under general environmental conditions.

References

EC (European Commission) 2000. *European Commission Towards the establishment of a priority list of substances for further evaluation of their role in endocrine disruption, preparation of a candidate list of substances as a basis for priority setting, Final Report (Incorporating corrigenda to final report dated 21 June 2000)*. BKH Consulting Engineers, Delft, The Netherlands in association with TNO Nutrition and Food Research, Zeist, The Netherlands Available at http://ec.europa.eu/environment/chemicals/endocrine/strategy/substances_en.htm#priority_list, Accessed January 2020

ECHA (European Chemicals Agency) 2020. Registered Chemical Substances Search: *Dossier of Glutaral.* Available at https://echa.europa.eu/registration-dossier/-/registered-dossier/1930/1, Accessed January 2020

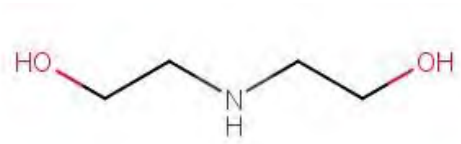
IARC (International Agency for Research on Cancer) 2020. *International Agency for Research on Cancer Agents classified by IARC Monographs*, Volumes 1- 125. Last updated: 12 December 2019, Available at http://monographs.iarc.fr/ENG/Classification/index.php., Accessed January 2020

NICNAS (National Industrial Chemicals Notification and Assessment Scheme) 1994, *Priority Existing Chemical Assessment Report No.3 – Glutaraldehyde.* Available at https://www.nicnas.gov.au/chemical-information/factsheets/chemical-name/glutaraldehyde

OECD SIDS (2017). Screening Information Data Set, initial assessment report for glutaraldehyde. Inchem Database available at http://www.inchem.org/documents/icsc/icsc/eics0158.htm, Date accessed January 2020

Safe Work Australia 2020. Hazardous Chemical Information System (HCIS): *Dossier for Glutaraldehyde*. Available at http://hcis.safeworkaustralia.gov.au/ExposureStandards/Document?exposureStandardID=297, Accessed January 2020.

Created by:	LP	Date: 18/12/2019
Reviewed by:	CLB	Date of Revision: 13/02/2020

Name	Diethanolamine
Synonyms	2,2'-iminodiethanol 2-[(2-hydroxyethyl)amino]ethan-1-ol DEA
CAS number	111-42-2
Molecular formula	$C_4H_{11}NO_2$
Molecular Structure	 (Source: ECHA, 2019)

Overview	References
Diethanolamine is a colourless solid, sometimes found as a syrupy liquid (at 20°C and 1013 hPa), with an ammonia-like odour. It has a molecular weight of 105.136. It has melting point of 27-28°C and a boiling point of 269.9°C at 1013.25 hPa, with decomposing likely at temperatures over 200°C. It has a density of 1.1 g/cm3 and is considered miscible with water (solubility of 1000 g/L) at 20°C. Diethanolamine has numerous industrial uses, including as a chemical intermediate and as a corrosive inhibitor and surface-active agent in metal working fluids, leather, fuels, cosmetic formulations, papers and textiles, paints and inks, as well as a dispensing agent for agricultural chemicals and in gas treatment. Once in the environment, diethanolamine is considered readily biodegrade according to OECD criteria. Diethanolamine will rapidly degrade by photochemical processes (half-life of 4.2 hours) following evaporation or exposure to air. However, based on Henry's Law Constant, diethanolamine is not expected to evaporate into the atmosphere. Hydrolysis is also not expected based on structural properties. Diethanolamine has a low potential for bioaccumulation (a log kow <= 3) or bioconcentration, and adsorption to solid soil phase is not expected.	ECHA, 2019 U.S. EPA, 2012

Human Health Toxicity Summary	Reference
Carcinogenicity Diethanolamine has been evaluated by the International Agency for Research on Cancer (IARC) as to its carcinogenicity. Diethanolamine was assigned Group 2B (assessment in 2013) indicating it is possibly carcinogenic to humans.	IARC, 2019

Mutagenicity/Genotoxicity The ECHA dossier, based on the available data, considered that diethanolamine does not need to be classified for genotoxicity. The ECHA dossier cites several in vitro tests and an in vivo test observing no mutagenic, clastogenic or genotoxic effects. Diethanolamine did not induce reverse mutations in Salmonella typhimurium or Escherichia coli. Diethanolamine did not induce chromosomal aberrations in rat hepatocytes, sister chromatid exchange or chromosomal aberrations in Chinese hamster ovary cells or gene mutation in mouse lymphoma cells. Diethanolamine (formulated in ethanol) did not induce micronuclei in vivo peripheral blood erythrocytes of mice after repeated unoccluded dermal application for 13 weeks at doses clearly showing systemic availability.	ECHA, 2019
Reproductive Toxicity The ECHA dossier, based on the available data, classified diethanolamine for effects on fertility and developmental toxicity. ECHA states that "classification with category 2 for reproductive toxicity (H361) is considered the most appropriate in line with the criteria laid down in Regulation EC 1272/2008 (CLP)". The ECHA dossier describes several reproductive toxicity tests. Details are provided for a key extended one-generation reproductive toxicity study in rats exposed to diethanolamine in drinking water. The LOAEL for general toxicity was 300 ppm based on evidence for distinct kidney toxicity and stomach irritation, as well as corresponding effects on water consumption, food consumption, body weights and clinical pathological parameters. The LOEAL for fertility and reproductive performance was 1000 ppm based on a lower number of implants, prolonged/irregular estrous cycles as well as pathological changes in sexual organs, pituitary and mammary glands of both genders. Alhough eosinophilic cysts in the pituitary gland were present in the F1 animals down to the 100 ppm dose level, but no assessment on adversity of this finding was possible. In summary, ECHA states that reproductive toxicity was substance- and dose relate but occurred in the presence of distinct general systemic toxicity in the mothers and in the offspring.	ECHA, 2019
Developmental Toxicity/Teratogenicity The ECHA dossier, based on the available data, classified diethanolamine for effects on fertility and developmental toxicity. ECHA states that "classification with category 2 for reproductive toxicity (H361) is considered the most appropriate in line with the criteria laid down in Regulation EC 1272/2008 (CLP)". The ECHA dossier concluded that diethanolamine only caused developmental toxicity in the presence of clear maternal toxicity and at dose levels considered as high, based on the available studies with rats and rabbits for the inhalation, dermal and oral route of exposure. ECHA also noted that maternal toxicity was observed at levels higher/comparable to general toxic effects in the repeated dose toxicity studies.	ECHA, 2019
Endocrine Disruption Diethanolamine is not identified in the European Commission (EC)'s report, "*Towards the establishment of a priority list of substances for further evaluation of their role in endocrine disruption*" as a substance of interest.	EC, 2000

Acute Toxicity (oral, dermal, inhalation) The ECHA dossier, based on the available data, classified diethanolamine for acute oral toxicity (classification Xn; R22). Diethanolamine is considered to have moderate acute oral toxicity and low toxicity following inhalation exposure. In the key study for **oral** exposure, the LD50 for males and females combine was 1 600 mg/kg bw. This study was performed to a comparable protocol as OECD guideline 401. Five rats per sex were dosed with 200 – 3200 mg/kg bw and observed up to 14 days. In their summary, ECHA reported that no deaths occurred up to 1000 mg/kg bw dosing group. Reported clinical signs were tumbling, staggering gait, twitches, convulsions, dyspnoea, abdominal lateral position and scrubby coat. Gross pathology revealed hydrothorax, local adhesions of the gut and signs of irritation on the gastro-intestinal track. Two additional acute oral studies were considered by EHCA as supporting studies. One study reported an LD_{50} of 1 820 mg/kg bw in female Winstar rats. The second study reported that for male rats receiving a single oral dose of aqueous diethanolamine solutions in the range of 100 – 6400 mg/kg bw, at the top dose 7/8 rats died. At > 100 mg/kg bw onwards increased liver weight was reported, and an increased in the relative kidney weight was reported at >1600 mg/kg. Acute **inhalation** tests showed no mortality in rats after 8-hour exposure to an atmosphere enriched with diethanolamine vapour. The highest concentration attainable was approximately 1.9 mg/m^3. Another study reported that after exposure of 3.35 mg/L for up to 4 hours no rats died. Toxicological signs consisted predominantly of lethargy and irregular respiration. For the **dermal** route of exposure, no reliable data was available.	ECHA, 2019
Chronic/repeat dose toxicity (oral, dermal, inhalation) The ECHA dossier, based on the available data, classified diethanolamine for chronic (repeated dose) oral toxicity, Classified as Xn, R48/22). The ECHA dossier cites two sub-chronic **oral** studies, with diethanolamine administered via drinking water (protocols similar to OECD TG 408). Mortality was observed in males at ≥ 5000 ppm and in females at ≥ 2 500 ppm. In the first study on rats, impaired body weight gains were observed at concentrations ≥ 320 ppm in females and 630 ppm in males. Systemic effects observed included anaemia, nephrotoxicity, cortical vacuolization of adrenal glands and demyelinization of brain/spinal cord without any neurofunctional finding. Based on anaemia, a LOAEL of 25 mg/kg bw/day (equal to 320 ppm) male and of 14 mg/kg bw/day (equal to 160 ppm) for females was reported. In the second study on mice, body weight gain was decreased in both species at concentrations of 1250 ppm for females and 2500 ppm for males. Systematic effects consisted of hepato- and nephrotoxicity and myocardial degeneration. Based on necrotic liver damages, a LOAEL of 104 mg/kg bw/day (equal to 630 ppm) for males and a LOAEL of 142 mg/kg bw/day for females was reported (equal to 630 ppm). **Dermal** exposure of rats and mice lead to mortality at high dose levels (> 500 mg/kg bw in rats and > 1000 mg/kg bw in mice). The study involved repeated unoccluded dermal application of ethanolic diethanolamine solution in subacute (14 days) and subchronic (13 weeks, protocol similar to OECD TP 411). Systemic effects observed in rats included signs of toxicity predominantly of anaemia and nephropathy. In mice, these effects were mainly in the form of liver and kidney damage. The study reported a LOAEL of 32 mg/kg bw/day in rats and a LOAEL of 80 mg/kg bw/day in mice. In a 2-year dermal study with rats and mice, non-carcinogenic effects were also observed. Critical effects were reported to be kidney (nephropathy) and liver toxicity, anaemia and dermal hyperkeratosis/acanthosis, with effects observed at the lowest tested dermal dose. The dermal LOAEL from this study was 8 mg/kg bw/day. Following **inhalation** (nose-only) exposure of rats to diethanolamine aerosols for 3 months, systemic and local effects were observed. Studies followed OECD TG 413. Systemic effects included kidney effects, adaptive liver effects and mild normochromic microcytic anaemia and some influences on the male reproductive system. Local effects observed included respiratory tract irritation, squamous	ECHA, 2019

metaplasia of the laryngeal epithelium and inflammatory responses. The NOAEC for systematic effects was 15 mg/m³ and the NOAEC for local respiratory tract effects was 3 mg/m³.	
Sensitisation of the skin or respiratory system The ECHA dossier lists diethanolamine as not sensitising to the skin and states that based on the available data, diethanolamine does not need to be classified for skin sensitisation. In a Guinea pig Maximisation test according to OECD TG 406, no skin sensitising potential of Diethanolamine was noted. The test involved 40 female Himalayan Guinea pigs. The ECHA dossier identifies occupational sensitisation in the industrial use of diethanolamine in water-based metalworking fluids. However sensitisation was considered likely due to regular exposure to these fluids and secondary skin conditions not attributable to diethanolamine. .	ECHA, 2019
Corrosion (irreversible)/irritation (reversible) effects on the skin or eye The ECHA dossier lists diethanolamine as irritating to the skin and highly irritating to the eyes. Based on this, ECHA classifies diethanolamine as Xi; R38 (irritating to the skin) and R41 (risk of serious damage to eyes). The key experimental study cited by ECHA reported both pure and technical diethanolamine (concentration reported as undiluted) applied via a patch test induced slight skin irritation after 1 – 15 minutes, while distinct irritation was noted after 20 hours. The test was undertaken in either equivalent or similar to OECD Guideline 404. The mean erythema and edema scores for 24, 48 and 72 hours in case of 20 h exposure were 2 and 1.33, respectively (noting that erythema was present at 72 hours, while edema was absent at 72 hours). Comparable results were observed in another study.	ECHA, 2019

Physical Hazards	Reference
Flammable Potential The ECHA dossier lists diethanolamine as non-flammable upon ignition. Diethanolamine has no pyrophoric properties and does not liberate flammable gases in contract with water and the substance is not a self-heating substance or mixture.	ECHA, 2019.
Explosive Potential The ECHA dossier lists diethanolamine as non-explosive.	ECHA, 2019.

Toxicity Values	Value	Reference
Human Toxicity Data		
High Chronic/Repeat Dose Toxicity		
LOAEC	NDF	
LOAEL	NDF	
Animal Toxicity Data		
Acute Toxicity		
LD_{50}		
Rat, oral	LD_{50}: 1 820 mg/kg bw	ECHA, 2019
LC_{50}		
Rat	LC_0 (8 h, rat, male/female): 200 mg/m³ LC_0 (4 h, rat, male) 3 350 mg/m³	ECHA, 2019
High Chronic/Repeat Dose Toxicity		
NOAEL/ LOAEL	LOAEL (rat, oral (drinking water), male): 25 mg/kg bw/day LOAEL (rat, oral (drinking water), female): 14 mg/kg bw/day LOAEL (mouse, oral (drinking water), male): 104 mg/kg bw/day LOAEL (mouse, oral (drinking water), female): 142 mg/kg bw/day LOAEL (rat and mouse, dermal): 8 mg/kg bw/day	ECHA, 2019

NOAEC/ LOAEC	NOAEC (rat, inhalation (nose-only), systemic): 15 mg/m³ NOAEC (rat, inhalation (nose-only), local respiratory tract): 3 mg/m³	ECHA, 2019

Footnotes:
LD_{50} – lethal dose for 50% of experimental population
LC_{50} – lethal air concentration for 50% of experimental population
LOAEL – Lowest Observed Adverse Effect Level
LOAEC – Lowest Observed Adverse Effect Concentration
NOAEL – No Observed Adverse Effect Level
NOAEC – No Observed Adverse Effect Concentration
NDF – No data found within the limits of the search strategy

Human Health Toxicity Ranking		
	Hazard data	**Comment**
Hazard Band 4		
Carcinogenicity (IARC Group 1 or 2A)	No	
Mutagenicity/Genotoxicity (GHS Category 1A and 1B)	No	
Reproductive Toxicity/Developmental toxicity (GHS Category 1, 1A and 1B)	No	
Endocrine Disruption[1]	No	Not listed by EC.
Hazard Band 3		
Carcinogenicity (IARC Group 2B)	Yes	IARC classification
Mutagenicity/Genotoxicity (GHS Category 2)	No	Not classifiable according to ECHA.
Reproductive Toxicity/Developmental toxicity (GHS Category 2)	Yes	ECHA classification
Acute Toxicity (oral, dermal or inhalation) Very Toxic/Toxic • oral LD_{50} ≤ 300 mg/kg [2] • dermal LD_{50} ≤ 1000 mg/kg • inhalation LC_{50} ≤ 10 mg/L [3] (or mg/m^3) (vapour)	No	Oral LD_{50} of 1820 mg/kg bw
High Chronic/repeat dose toxicity • oral LOAEL ≤ 10 mg/kg/d [2]; • dermal LOAEL ≤ 20 mg/kg/d; • inhalation LOAEC (6 h/d) ≤ 50 ppm/d for gases, ≤ 0.2 mg/L/d for vapours or ≤ 0.02 mg/L/d for dust/mists/fumes [3]	Yes	Dermal LOAEL of 8 mg/kg/d
Corrosive (irreversible effect)	No	
Respiratory sensitiser	No	
Hazard Band 2		

Human Health Toxicity Ranking		
	Hazard data	**Comment**
Harmful chronic/repeat dose toxicity • oral LOAEL > 10 mg/kg/d and ≤ 100 mg/kg/d • dermal LOAEL > 20 mg/kg/d and ≤ 200 mg/kg/d • inhalation (6-h/d) LOAEC > 50 mg/L ≤ 250 mg/L/d for gases, > 0.2 mg/L ≤ 1 .0 mg/L/d for vapours or > 0.02 mg/L ≤ 0.2 mg/L/d for dust/mists/fumes [3]	Yes	Oral LOAEL of 14 mg/kg/d
Skin Sensitiser	No	
Hazard Band 1		
Acute Toxicity-Harmful • oral LD_{50} > 300 mg/kg ≤ 2000 mg/kg • dermal LD_{50} >1 000 mg/kg ≤ 2000 mg/kg; • inhalation LC_{50} (6 h/d) > 10 mg/L ≤ 20 mg/L for vapours) [3]	Yes	Oral LD_{50} of 1820 mg/kg bw
Irritant (reversible effect)	Yes	
Hazard Band 0 **All indicators outside criteria listed in Hazards 1-4**	No	
Physical Hazards		
Flammable potential	No	
Explosive potential	No	
Hazard Evaluation (highest band) not including physical hazards	3	Based on carcinogenic and reproductive toxicity potential.
Data confidence (available points out of 12 parameters)	12/12	100%

* Based on IMAP Framework [NICNAS (2013) Inventory Multi-tiered Assessment and Prioritisation (IMAP) Framework. National Industrial Chemicals Notification and Assessment Scheme. Department of Health and Aging, Canberra].

"[1]Based on list of endocrine disrupting chemicals from the European Commission's Endocrine Disrupters website.

[2] milligrams per kilogram body mass (mg/kg) or milligrams per kilogram body mass per day (mg/kg/d)

[3] Based on GHS cut-offs for hazard classification. For chronic/repeat dose toxicity, GHS cut-offs are provided as guidance values (i.e. the dose/concentration at or below which significant health effects are observed)". (p 18, NICNAS 2013).

Human Health Guidelines		
Media	**Concentration (mg/m^3; mg/L; mg/kg)**	**Reference**
Occupational Exposure Limits		
Air (OEL)		
8-h TWA	13 mg/m^3	Safe Work Australia, 2019
STEL	NDF	
Peak Limitation	NDF	
Environmental Exposure		
Air, ambient, residential	0.21 µg/m^3	U.S. EPA, 2019
Air, commercial/industrial	0.88 µg/m^3	U.S. EPA, 2019
Water, potable	40 µg/L	U.S. EPA, 2019
Soil, residential	130 mg/kg	U.S. EPA, 2019
Soil, commercial/industrial	1600 mg/kg	U.S. EPA, 2019
Soil, protection of groundwater	0.0081 mg/kg	U.S. EPA, 2019

Footnotes:

OEL = Occupational Exposure Limit

TWA = 8 h Time-Weighted Average

STEL = (15 min) Short-term Exposure Limit

Qualifying Summary Comments

Diethanolamine is a colourless solid, with an ammonia-like odour. It has numerous industrial uses, including as a chemical intermediate and as a corrosive inhibitor and surface-active agent in metal working fluids, leather, fuels, cosmetic formulations, papers and textiles, paints and inks, as well as a dispensing agent for agricultural chemicals and in gas treatment. Once in the environment, diethanolamine will likely breakdown as it is readily biodegradable.

Diethanolamine was ranked in Hazard Band 3, based on carcinogenic and reproductive toxicity potential. Diethanolamine was assigned Group 2B by IARC indicating it is possibly carcinogenic to humans and it is classified by the ECHA dossier as Category 2 for reproductive toxicity (H361). The ECHA dossier also classifies diethanolamine for chronic (repeated dose) oral toxicity and as irritating to the skin and highly irritating to the eyes. Diethanolamine is considered to have moderate acute oral toxicity and low toxicity following inhalation exposure. It is considered to be not sensitising to the skin.

References

European Commission (EC), 2000. *Towards the establishment of a priority list of substances for further evaluation of their role in endocrine disruption, preparation of a candidate list of substances as a basis for priority setting*, *Final Report* (Incorporating corrigenda to final report dated 21 June 2000).

European Chemicals Agency (ECHA), 2019. *Registration Dossier for 2,2'-imminodiethanol*. Available at https://echa.europa.eu/registration-dossier/-/registered-dossier/15770/7/4/2. Last modified 09/10/2019, accessed December 2019.

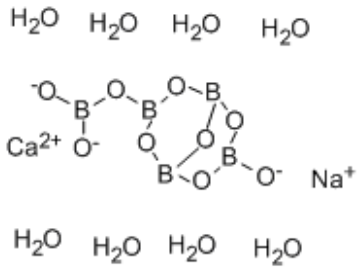
International Agency for Research on Cancer (IARC), 2019. Agents Classified by the *IARC Monographs*, Volumes 1–125, last updated 29 November, 2019. Available at https://monographs.iarc.fr/agents-classified-by-the-iarc/, accessed December 2019.

Safe Work Australia, 2019. *Hazardous Chemical Information System (HCIS): Exposure Standard Details for Diethanolamine.* Available at: http://hcis.safeworkaustralia.gov.au/ExposureStandards/Details?exposureStandardID=210, accessed December 2019.

U.S. Environmental Protection Agency (U.S. EPA), 2012. *Provisional Peer-Reviewed Toxicity Values for Diethanolamine (CASRN 111-42-2)*. Available at: https://cfpub.epa.gov/ncea/pprtv/documents/Diethanolamine.pdf, accessed December 2019.

U.S. Environmental Protection Agency (U.S. EPA), 2019. *Regional Screening Levels (RSLs) – Generic Tables (Tables as of November 2019)*. Available at: https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables, accessed December 2019.

Created by:	MGT	Date: 12/12/2019
Reviewed by:	CLB	Date and Revision: 14/01/20

Name	Ulexite
Synonyms	Boronatrocalcite, sodium calcium borate
CAS number	1319-33-1
Molecular formula	$(NaCaB_5O_6(OH)_6 \bullet 5(H_2O))$
Molecular structure	

Overview	References
Boronatrocalcite is the mineral ulexite. Ulexite is a hydrated sodium calcium borate hydroxide mineral. Ulexite is slightly soluble, decomposes and contains approximately 13% boron. Ulexite is mined to produce borate products for uses such as insulation, textile grade fiberglass, bleach, fire retardants, agricultural fertilisers and herbicides (as a trace element), and enamels. A study of the thermal degradation of ulexite has shown under increased temperature (around 600°C) the crystalline structure will break down to eventually release NaB_3O_5 and $NaCaBO_3$. Limited toxicology data are available for ulexite; however, the assessment of boron salts was undertaken by WHO (1998) and ECHA (2015). Disodium octaborate tetrahydrate is converted to boric acid ($B(OH)_3$) and disodium borate ($2NaB(OH)_4$) upon dissolution in water. Low concentrations of simple inorganic borates (e.g. boric acid, disodium tetraborate pentahydrate, boric oxide and disodium octaborate tetrahydrate) will predominately exist as undissociated boric acid in aqueous solutions at physiological and acidic pH. At about pH 11 the metaborate anion ($B(OH)_4^-$) becomes the main species in solution. In between pH 7 and 11, both un-dissociated boric acid and metaborate ions will be present. This leads to the conclusion that the main species in the plasma of mammals and in the environment is un-dissociated boric acid. Since other borates (such as potassium borate) dissociate to form boric acid in aqueous solutions, they too can be considered to exist as un-dissociated boric acid under the same conditions. Boron oxide /boric acid salts are used in this profile to describe the toxicity of ulexite. Boric acid and borax are absorbed from the gastrointestinal tract and the respiratory tract, as indicated by increased levels of boron in the blood, tissues, or urine or by systemic toxic effects of exposed individuals or laboratory animals. Clearance of boron compounds is similar in humans and animals. Elimination of borates from the blood is largely by excretion; 90% or more of the administered dose is eliminated via the urine, regardless of the route of administration. Excretion is relatively rapid, occurring over a period of a few, or possibly several, days.	WHO 1998; ECHA 2020; Stoch & Waclawska, 1990 WHO, 1998; ECHA, 2020

Human Health Toxicity Summary	Reference
Carcinogenicity Ulexite has not been classified as carcinogenic. The data that the classification is based on is categorised as 'conclusive'. No treatment related increase in tumour incidence was reported for a dietary, lifetime carcinogenicity study in B6C3F1 mice (test conducted according to OECD guidelines 451) with concentrations of boric acid up to 5000 ppm. Ulexite has not been evaluated by the International Agency for Research on Cancer (IARC) as to its carcinogenicity.	ECHA, 2020 IARC, 2016
Mutagenicity/Genotoxicity Ulexite is not classified as a germ cell mutagen (the data that the classification is based on is categorised as 'conclusive').	ECHA, 2020
Reproductive Toxicity Suspected of damaging fertility or the unborn child (via oral route). ECHA lists disodium octaborate as having a GHS group of 1B and a class of H360FD. ECHA note that the classification and labelling of disodium octaborate tetrahydrate for reproductive toxicity is based on read-across from other tested borates (e.g. boric acid) and borate salts (borax or disodium tetraborate decahydrate) because its hydrolysis results in the formation of the same substances. In a multigenerational study with rats, boric acid was administered via the oral route at four doses, with a maximum of 336 mg/kg/d (boron equivalent of 58.5 mg/kg/d). The authors reported that male rats were sterile and evidence of decreased ovulation in about half of the ovaries examined from the females exposed to boric acid at 336 mg/kg/d. In addition, 1/16 high dose females produced a litter when mated with control male animals. The authors concluded that the boric acid LOAEL for reproductive effects was 336 mg/kg/d. Short- and long-term oral exposures to boric acid or borax in laboratory animals have demonstrated that the male reproductive tract is a consistent target of toxicity. Testicular lesions have been observed in rats, mice, and dogs given boric acid or borax in food or drinking-water.	ECHA, 2020 WHO, 1998
Developmental Toxicity/Teratogenicity Evidence of developmental toxicity in offspring of rats fed boric acid (dose of 76 mg/kg bw/d) in their diet throughout gestation. The clinical observations included reduced foetal body mass, short and wavy ribs. These effects disappeared during the postnatal period. Similar but more marked effects were observed at the highest dose of 143 mg/kg and apart from a short 13th rib, they also disappeared during the postnatal period. The boric acid NOAEL for developmental effects was 55 mg/kg bw/d.	ECHA, 2020
Endocrine Disruption	

Ulexite is not identified in the European Commission (EC)'s report, "*Towards the establishment of a priority list of substances for further evaluation of their role in endocrine disruption*" as a substance of interest.	EC, 2000
Acute Toxicity (oral, dermal, inhalation) Not classified as acutely toxic via oral, dermal or inhalation exposure. The data that the classification is based on is categorised as 'conclusive' *Oral* The oral LD_{50} of boric acid in male albino rats was 3690 mg/kg with 95 % confidence limits of 2710 - 5010 mg/kg (exposure by gavage). There were no control subjects in this experiment. ECHA summarises a number of key study findings: - The oral LD_{50} of boric acid in male albino rats was 3450 mg/kg (Boron equivalent of 604 mg B/kg bw). In female albino rats the oral LD_{50} of boric acid was 4080 mg/kg (Boron equivalent of 714 mg B/kg bw). - The oral LD_{50} of boric acid in rats ranged from 2 660 mg/kg to 5140 mg/kg (Boron equivalent of 465 mg/kg to 899 mg/kg). - The oral LD_{50} of disodium octaborate in rats was 2550 mg/kg bw. - The oral LD_{50} of anhydrous boric acid was >2000 mg/kg bw as single oral administration of boric acid at dose levels 1540 or 2600 mg/kg/ bw resulted in no deaths. - The oral LD_{50} for male rats was >2500 mg/kg/bw. *Dermal* Acute dermal limit study of sodium tetraborate pentahydrate was carried out on New Zealand White rabbits (US EPA-FIFRA guidelines at the time, 1985). The exposure duration was 24 h. There were no control animals. The LD_{50} was > 2 000 mg/kg. Clinical changes included anorexia and decreased activity in four rabbits, diarrhoea and soft stools in 3 rabbits and nasal discharge in three rabbits, indicating low acute dermal toxicity. *Inhalation* The inhalation LC_{50} of disodium tetraborate pentahydrate in rats was > 2.04 mg/L (2.04 g/m^3) after exposure to dust for 4 h. During the first hour of exposure, ocular discharge, hypoactivity and hunched posture were noted. A few animals exhibited nasal discharge and/or hunched position. All animals recovered by day six after removal from chamber. ECHA also summarises other key study findings: The inhalation LC_{50} of disodium octoborate tetrahydrate in rats was 2.01 mg/L after exposure for 4 h. The inhalation LC_{50} of boric acid in rats was 2.12 mg/L after exposure to dust for 4 h. The inhalation LC_{50} of boric acid in rats was > 2.03 mg/L after exposure to aerosol for 4 h.	ECHA, 2020 WHO, 1998 ECHA, 2020
Chronic/repeat dose toxicity (oral, dermal, inhalation) *Oral* The ECHA dossier for disodium octaborate notes a number of sub-chronic and chronic studies on boric acid and disodium tetraborate decahydrate were carried out in rats, mice and dogs. Most support	ECHA, 2020

that boron can cause adverse haematological effects and that the main target organ of boron toxicity is the testis. Male and female rats were exposed to oral doses to boric acid of 5.9 mg/kg/d, 17.5 mg/kg/d and 58.5 mg/kg/d in a two year dietary study. The NOAEL for boron was 17.5 mg/kg/d and the LOAEL 58.5 mg/kg/d. Testicular atrophy and seminiferous tubule degeneration were observed at (6, 12 and 24) months at the high boron dose of 58.5 mg/kg/d (body weight) *Inhalation* Albino rats and dogs were exposed to aerosols of boron oxide, showing no evident toxic signs. NOAEC for systemic toxicity in rats was 470 mg/m^3. NOAEC for local effects due to irritation of noses of rats is 175 mg/m^3. NOAEC for dogs is 57 mg/m^3.	
Sensitisation of the skin or respiratory system Not classified as a skin or respiratory system sensitiser by ECHA. The data that the classification is based on is categorised as 'conclusive'. The exposure period was 0, 7 and 21 days. No irritation was observed in guinea pigs exposed to 95 % w/w (0.4 g) disodium tetraborate pentahydrate moistened with distilled water to enhance skin contact (OECD Guideline 406 "Skin Sensitisation" method [Buehler] test). ECHA interpretation of the results was not sensitising. Disodium octaborate tetrahydrate was determined to be not sensitising in guinea pigs according to OECD Guideline 406. Boric acid moistened with distilled water to enhance skin contact is considered a non-sensitiser for guinea pig according to OECD Guideline 406.	ECHA, 2020
Corrosion (irreversible)/irritation (reversible) effects on the skin or eye Not classified as corrosive to skin or eyes. The data that the classification is based on is categorised as 'conclusive'. Disodium octaborate tetrahydrate was not classified for skin irritation under criteria defined in directive 67/548/EEC, based on no irritating effects observed on application to the skin of test animals. It is also not considered an eye or respiratory irritant. Several studies are presented on the ECHA dossier, as follows: An in vivo skin corrosion test was carried out on rabbits exposed to potassium tetraborate powder for 4 h. No control animals were included. Potassium tetraborate was not corrosive. Potassium tetraborate was not irritating to the eyes of New Zealand White Rabbits in an OECD compliant study. Disodium tetraborate pentahydrate showed no irritancy for New Zealand White rabbit in compliance with US EPA-FIFRA guidelines.	ECHA, 2020

Disodium octaborate tetrahydrate produced iritis and conjunctival irritation persisting for less than 72 h when applied without rinsing to the eyes of six New Zealand white rabbits. However, no animals met irritation criteria based on average scores. No evidence of corrosion was noted. Boric acid was classified as not irritant under US CPS (16 CFR 15000.42) with minor effects on the iris and conjunctivae in New Zealand White rabbit.	

Physical Hazards	Reference
Flammable Potential Not classified as flammable. The data that the classification is based on is categorised as 'conclusive'.	ECHA, 2020
Explosive Potential Not classified as explosive. The data that the classification is based on is categorised as 'conclusive'.	ECHA, 2020

Toxicity Values	Value	Reference
Human Toxicity Data		
High Chronic/Repeat Dose Toxicity		
LOAEC	NDF	
LOAEL	NDF	
Animal Toxicity Data		
Acute Toxicity		
LD_{50}		
Rat, oral	2 550 to 5 140 mg/kg	WHO, 1998 & ECHA, 2020
Rabbit, dermal	> 2 000 mg/kg	ECHA, 2020
LC_{50}		
Rat	> 2040 mg/m^3	ECHA, 2020

Toxicity Values	Value	Reference
High Chronic/Repeat Dose Toxicity		
LOAEL, rat, oral	58.5 mg B/kg/d	ECHA, 2020
NOAEL, rat, oral	17.5 mg B/kg/d	ECHA, 2020
NOEAC, rat, inhalation	470 mg/m^3	ECHA, 2020
NOAEC, dog,inhalation	57 mg/m^3	ECHA, 2020

Footnotes:
LD_{50} – lethal dose for 50% of experimental population
LC_{50} – lethal air concentration for 50% of experimental population
LOAEL – Lowest Observed Adverse Effect Level
LOAEC – Lowest Observed Adverse Effect Concentration
NDF – No data found within the limits of the search strategy

Human Health Toxicity Ranking*		
	Hazard data	**Comment**
Hazard Band 4		
Carcinogenicity (IARC Group 1 or 2A)	No	IARC 2016
Mutagenicity/Genotoxicity (GHS Category 1A and 1B)	No	Not classified as a germ cell mutagen by ECHA 2020
Reproductive Toxicity/Developmental toxicity (GHS Category 1, 1A and 1B)	Yes	ECHA 2020. May damage fertility or the unborn child - GHS Category 1B
Endocrine Disruption[1]	No	Not listed as an endocrine disruptor by European Commission.
Hazard Band 3		
Carcinogenicity (IARC Group 2B)	No	IARC 2016
Mutagenicity/Genotoxicity (GHS Category 2)	No	Not classified as a germ cell mutagen by ECHA 2020
Reproductive Toxicity/Developmental toxicity (GHS Category 2)	No	GHS Category 1B
Acute Toxicity (oral, dermal or inhalation) Very Toxic/Toxic • oral LD_{50} ≤ 300 mg/kg [2] • dermal LD_{50} ≤ 1000 mg/kg • inhalation LC_{50} ≤ 10 mg/L [3] (or mg/m^3) (vapour)	No	See below.
High Chronic/repeat dose toxicity • oral LOAEL ≤ 10 mg/kg/d [2]; • dermal LOAEL ≤ 2 0 mg/kg/d; • inhalation LOAEC (6 h/d) ≤ 50 ppm/d for gases, ≤ 0.2 mg/L/d for vapours or ≤ 0.02 mg/L/d for dust/mists/fumes [3]	No	See below.

Human Health Toxicity Ranking*		
	Hazard data	**Comment**
Corrosive (irreversible effect)	No	Not classified as corrosive to skin or eyes by ECHA (2020)
Respiratory sensitiser	No	Not classified as a respiratory system sensitiser by ECHA (2020)
Hazard Band 2		
Harmful chronic/repeat dose toxicity • oral LOAEL > 10 mg/kg/d and ≤ 100 mg/kg/d • dermal LOAEL > 20 mg/kg/d and ≤ 200 mg/kg/d • inhalation (6-h/d) LOAEC > 50 mg/L ≤ 250 mg/L/d for gases, > 0.2 mg/L ≤ 1 .0 mg/L/d for vapours or > 0.02 mg/L ≤ 0.2 mg/L/d for dust/mists/fumes [3]	Yes	LOAEL, rat, oral of 58.5 mg/kg/d
Skin Sensitiser	No	Not classified as a skin sensitiser by ECHA (2020)
Hazard Band 1		
Acute Toxicity-Harmful • oral LD_{50} > 300 mg/kg ≤ 2000 mg/kg • dermal LD_{50} >1 000 mg/kg ≤ 2000 mg/kg; • inhalation LC_{50} (6 h/d) > 10 mg/L ≤ 20 mg/L for vapours) [3]	No	LD50, Rat oral of 2550 to 5 140 mg/kg ECHA (2020)
Irritant (reversible effect)	No	Potassium tetraborate is classified as a non-irritant to the eyes of New Zealand White rabbits ECHA (2020)
Hazard Band 0 **All indicators outside criteria listed in Hazards 1-4**		
Physical Hazards		
Flammable potential	No	

Human Health Toxicity Ranking*		
	Hazard data	**Comment**
Explosive potential	No	
Hazard Evaluation (highest band) not including physical hazards	4	Based on Reproductive Toxicity/Developmental toxicity
Data confidence (available points out of 12 parameters)	12/12 = 100 %	

* Based on IMAP Framework [NICNAS (2013) Inventory Multi-tiered Assessment and Prioritisation (IMAP) Framework. National Industrial Chemicals Notification and Assessment Scheme. Department of Health and Aging, Canberra].

"[1]Based on list of endocrine disrupting chemicals from the European Commission's Endocrine Disrupters website.

[2] milligrams per kilogram body mass (mg/kg) or milligrams per kilogram body mass per day (mg/kg/d)

[3] Based on GHS cut-offs for hazard classification. For chronic/repeat dose toxicity, GHS cut-offs are provided as guidance values (i.e. the dose/concentration at or below which significant health effects are observed)". (p 18, NICNAS 2013).

Human Health Guidelines		
Media	**Concentration (mg/m^3; mg/L; mg/kg)**	**Reference**
Occupational Exposure Limits		
Air		
8-h TWA	1 mg/m^3	Exposure Standard for Disodium tetraborate pentahydrate, Safe Work Australia (2020)
STEL	NDF	
Peak Limitation	NDF	
Environmental Exposure		
Air, ambient, residential	NDF	
Air, commercial/industrial	NDF	

Water, potable	4 mg /L (boron)	NHMRC, 2011
Soil, residential	4 500 mg/kg (boron)	NEPM, 2013
Soil, commercial/industrial	300 000 mg/kg (boron)	NEPM, 2013
Soil, protection of groundwater	13 mg/kg	US EPA (2019)

Footnotes:

OEL = Occupational Exposure Limit

TWA = 8 h Time-Weighted Average

STEL = (15 min) Short-term Exposure Limit
NDF – No data found within the limits of the search strategy

Qualifying Summary Comments

Ulexite has been assigned to Hazard Band 4 because of its potential to cause reproductive toxicity (infertility) and its potential for damaging the unborn child.

Ulexite is a hydrated sodium calcium borate hydroxide mineral. Ulexite is slightly soluble, decomposes and contains approximately 13% boron. Ulexite is mined to produce borate products. A study of the thermal degradation of ulexite has shown under increased temperature (around 600°C) the crystalline structure will break down to eventually release NaB_3O_5 and $NaCaBO_3$. In aqueous solutions sodium borates are likely to convert to boric acid/borate and at physiological and acidic pH, predominately exist as un-dissociated boric acid. Based on this, the potential human toxicity of ulexite can be based on boric acid.

The reproductive toxicity of boric acid and its salts occurs at high doses via the oral route. It is unlikely to present a reproductive toxicity hazard via skin contact and when inhaled as dust below the occupational exposure limit.

References

European Chemicals Agency (ECHA), 2020. *Registered Substances List Dossier for Disodium Octaborate*. Available at http://echa.europa.eu/registration-dossier/-/registered-dossier/14136/1, last updated 04 January 2020, Accessed January 2020.

European Commission (EC), 2000. Towards the establishment of a priority list of substances for further evaluation of their role in endocrine disruption, preparation of a candidate list of substances as a basis for priority setting, *Final Report* (Incorporating corrigenda to final report dated 21 June 2000).

Safe Work Australia (2020)Hazardous Chemical Information System (HCIS), 2020. *Exposure Standard Documentation: Borates, tetra, sodium salts (pentahydrates)*. Safe Work Australia. Available at http://hcis.safeworkaustralia.gov.au/HazardousChemical/Details?chemicalID=5359, Accessed January 2020.

International Agency for Research on Cancer (IARC), 2020. Agents Classified by the *IARC Monographs*, Volumes 1–125, last updated 12 December 2019. Available at http://monographs.iarc.fr/ENG/Classification/index.php, accessed January 2020.

National Environment Protection (Assessment of Site Contamination) Amended Measure 2013 (No.1). *Schedule B1: Guidelines on Investigation Levels for soil and groundwater*. National Environment Protection Council, Commonwealth Government of Australia.

NHMRC (2011). *Australian Drinking Water Guidelines 6*. Natural Resource Management Ministerial Council and National Health and Medical Research Council, Australian Government. National Water Quality Management Strategy, Version 3.5, updated August 2018.

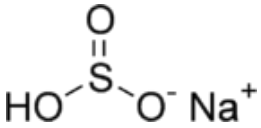
Stoch L and I Waclawska, 1990. *Thermal decomposition of Ulexite*. Journal of Thermal Analysis, September/October 1990, Volume 36, Issue 6, pp. 2045-2054.

U.S. Environmental Protection Agency (U.S. EPA), 2019. *Regional Screening Levels (RSLs) – Generic Tables (Tables as of November 2019)*. Available at: https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables, accessed January 2020.

World Health Organization (WHO) – International Program on Chemical Safety (IPCS), 1998. *Environmental Health Criteria 204: Borate Salt (1998)*. Available at www.inchem.org/documents/ehc/ehc/ehc204.htm. Accessed January 2020.

Created by:	LPA	Date: 18/12/2019
Reviewed by:	CLB	Date: 17/01/2020

https://golderassociates.sharepoint.com/sites/117999/project files/6 deliverables/report 014/appendix e - human health summaries/19133367_hh_1319-33-1_ulexite_dec2019.docx

Name	Sodium Bisulphite
Synonyms	Sodium hydrogensulphite, E222 (food additive)
CAS number	7631-90-5
Molecular formula	$NaHSO_3$
Molecular structure	

Overview	References
Sodium bisulphite occurs as a white crystal or crystalline powder. In many cases it is presented as an aqueous solution of varying strength. It has a disagreeable taste and slightly sulphurous odour. It is very soluble in water (> 10 000 mg/L). The commercial uses of sodium bisulphite include as a disinfectant and bleach, in dyeing and paper-making, as a stripper (reducer) in laundering, and as a preservative and antiseptic. It is present as an antioxidant in some eye drops. It is “generally recognized as safe” (GRAS) and used as a food additive by the United States Food and Drug Administration (US FDA), with a few exceptions (for example, it is not used in meats or in food recognized as a source of vitamin B1).	HSDB, 2020; ECHA, 2020 U.S. FDA, 2019

Human Health Toxicity Summary	Reference
Carcinogenicity Bisulphites have been evaluated by the International Agency for Research on Cancer (IARC) as to its carcinogenicity and were assigned Group 3 (not classifiable as to its carcinogenicity to humans based on inadequate evidence for the carcinogenicity in experimental animals).	IARC, 2019
Mutagenicity/Genotoxicity Sodium bisulphite is not classifiable as a mutagen according to GHS classification criteria (as listed by ECHA).	ECHA, 2020

ECHA provides two genetic toxicity in vitro studies which were used to determine the classification listed above. Both studies assessed disodium disulphite ($S_2O_5Na_2$) and concluded that the test substance did not appear to be mutagenic under the given test conditions.	
Reproductive Toxicity Sodium bisulphite is not classified by ECHA as a reproductive toxicant according to GHS classification criteria. ECHA cites a three-generation feeding study, where groups of 20 male and 20 female Wistar rats received 0, 0.125, 0.25, 0.5, 1.0 and 2.0% $S_2O_5Na_2$ (which was calculated to be equivalent to 49, 108, 220, 460, and 955 milligram/kilogram body weight/day (mg/kg bw/day) as actual dose) in a thiamine-containing diet over periods of 2 years. Rats in the F0 generation were mated at about 21 weeks and half also at 34 weeks, the F1a generation were mated at wk 12 and wk 30 to produce the F2a and F2b litters, and then 10 males and 15 females were mated at wk 14 and wk 22 to produce the F3 generation. Based on the results of this study, no evidence of a treatment-related effect on reproduction and fertility was seen. Thus, the No Observed Adverse Effect Level (NOAEL) for fertility can be expected above a dose level of 2% disodium disulphite, corresponding to a dose of 955 mg/kg bw/d $Na_2S_2O_5$ or 640 mg SO_2/kg bw/day. However, ECHA noted that there was a slight growth retardation during lactation in offspring of the 2% group. A drinking study is also provided which reported that continuous treatment of rats with $S_2O_5Na_2$ (up to 750 ppm as SO_2) in drinking water for 2 years and in 3 successive generations was very well tolerated, with no signs of systematic toxicity observed. ECHA reports that there was no significant different in the number of offspring for each generation and the proportion surviving the end of lactation did not differ. Based on these results, the NOAEL for systemic toxicity and effects on reproduction was expected to be above the highest dose level investigated, corresponding to 53 mg/kg bw/day.	ECHA, 2020
Developmental Toxicity/Teratogenicity Sodium bisulphite is not classified by ECHA as a developmental toxicant according to GHS classification criteria. Several developmental toxicity studies are listed by ECHA, with the following oral exposures: - Up to 100 mg/kg bw/d of sodium bisulphite to pregnant rabbits for 13 consecutive days - Up to 120 mg/kg bw/d of sodium bisulfphite to pregnant hamsters for 5 consecutive days - Up to 150 mg/kg bw/d of sodium bisulfphite to pregnant mice for 10 consecutive days - Up to 110 mg/kg bw/d of sodium bisulfphite to pregnant rats for 10 consecutive days. In all cases the studies reported no clearly discernible effects on nidation or on maternal or foetal survival. There was no difference in the number of abnormalities seen in either soft or skeletal tissues of the test groups compared to the number occurring spontaneously in the sham-treated controls. Therefore, the NOAELs for maternal and developmental toxicity are expected to be above the exposure dose for each of the experiments listed above.	ECHA, 2020

Endocrine Disruption Sodium bisulphite (or bisulphites) is not identified in the European Commission (EC)'s report, "*Towards the establishment of a priority list of substances for further evaluation of their role in endocrine disruption*" as a substance of interest.	EC, 2000
Acute Toxicity (oral, dermal, inhalation) Based on the GHS classification, sodium bisulphite is classified as having acute oral effects and has been assigned an 'Acute Tox. 4 H302: Harmful if swallowed' classification. It is not classified as having acute dermal or inhalation effects. The classification appears at odds with the LD_{50} data and the reason for this is unknown although it is likely due to the production of sulphur dioxide and the low pH when administered in a non-aqueous form. When tested as an aqueous solution (38%) the oral LD_{50} was greater than 2000 mg/kg. The Safe Work Australia Hazardous Chemical Information System (HCIS) also classifies sodium bisulphite (sodium hydrogensulphite) as Category 4 for acute toxicity (H302 - Harmful if swallowed) ECHA provides summaries of a number of studies including the following key results: **Oral** Sodium sulphite (SO_3Na_2) was administered orally to male and female rats at doses of 2150 mg/kg, 2610 mg/kg and 3160 mg/kg. The rats were observed during the 14 days following administration. A Lethal Dose $(LD)_{50}$ of approximately 2610 mg/kg bw was reported. **Dermal** In a rat study the LD_{50} for the dermal route was reported to be > 2,000 mg/kg bw for SO_3Na_2 in male and female rats. ECHA reports the test item is not classified as acute toxic via the dermal route. **Inhalation** In a rat study the LC_{50} for the inhalation route was > 5.5 mg/L after 4 hours of exposure to SO_3Na_2, the maximum aerosol concentration tested. The animals were observed for a 14 day period following exposure and no mortality occurred. ECHA reports the test item is not classified as acute toxic via the inhalation route. The substance can be absorbed into the body by ingestion. Ingestion could cause asthma-like reactions or urticaria in sensitive persons.	ECHA, 2020 Safe Work Australia, 2020 ECHA, 2020 IPCS, 2018
Chronic/repeat dose toxicity (oral, dermal, inhalation) Based on the GHS classification criteria sodium bisulphite is not classified by ECHA as causing repeat dose toxicity. ECHA cites three repeat dose studies where a NOAEL could not be derived. A fourth oral, feeding study in rats involved three experiments with varying timeframes; 1, 1.5 and 2 years. The study concluded no significant effects on growth were observed at dietary levels of 0.05% $NaHSO_3$. At dietary levels of 0.1% or above, toxic effects were observed, e.g. growth retardation, clinical (polyneuritis, bleached teeth, spectacle eyes) and pathological/histopathological changes (brown uteri,	ECHA, 2020

testicular atrophy, gastric epithelial hyperplasia, and calcified renal tubular casts). At a dietary level of 2.0%, the majority of testes showed oedema. ECHA reports that taking all information from the different experiments together, the dose level of 0.05% $NaHSO_3$ can be regarded as the NOAEL based on the results of these studies, corresponding to 25 mg/kg bw/d $NaHSO_3$.	
Sensitisation of the skin or respiratory system Based on the GHS classification criteria sodium bisulphite is not classified by ECHA as a skin sensitiser. ECHA presents a skin sensitising study (in vivo mouse local lymphnode assay) assessing SO_3Na_2, with the study concluding the test substance was not sensitising. Six female mice were exposed to sodium sulphite at concentrations of 10%, 25% and 50% (w/w) in aqua ad injectabilia (water for injection). Dermatitis has been observed from exposure of restaurant workers to preservatives in meat. Adverse reactions in humans have been reported while challenge tests have reported decrements in lung function associated with inhalation exposures.	ECHA, 2020 HSDB, 2020
Corrosion (irreversible)/irritation (reversible) effects on the skin or eye Sodium bisulphite is not classified by ECHA as causing skin corrosion/irritation or eye damage/irritation based on the GHS classification criteria. ECHA list a skin irritation/corrosion study for SO_3Na_2 on 2 male and 2 female rabbits. An approximate 0.5 mm thick layer of a 50% solution of SO_3Na_2 was applied (comparable to 0.5 g of the test substance), with occlusive coverage. The observation period was 8 days, with readings at 30 – 60 minutes after application, as well as at 24 hours and 8 days. The study concluded the test substance was not irritating. ECHA presents an eye irritation study of six rabbits (2 males/ 4 females), again using SO_3Na_2, which concludes that the test substance is not an eye irritant. 162 mg of the test substance (Sodium sulphite + 0.5% cobalt sulfate) was applied and observations were taken at 1 h, 24 h, 8 h, 72 h and 8 days after application. IPCS (2018) notes that Sodium bisulphite is irritating to the skin, eyes, respiratory tract and gastrointestinal tract. Exposure could cause asthma-like reactions or urticaria in sensitive persons. Safe Work Australia (2020) classifies sodium bisulphite (sodium hydrogensulphite) as Category 1 for serious eye damage/irreversible affects on the eye (H318 - Causes serious eye damage).	ECHA, 2020 IPCS, 2018 Safe Work Australia, 2020

Physical Hazards	Reference
Flammable Potential Considered non-flammable Sodium bisulphite can decompose on heating and on contact with acids. This reaction can produce sulfuret oxides, which generates fire and explosive hazards.	ECHA, 2020 IPCS, 2018
Explosive Potential Considered non-explosive	ECHA, 2020

Toxicity Values	Value	Reference
Human Toxicity Data		
High Chronic/Repeat Dose Toxicity		
LOAEC	NDF	
LOAEL	NDF	
Animal Toxicity Data		
Acute Toxicity		
LD_{50}		
Rat, oral, SO_3Na_2	2610 mg/kg	ECHA, 2020
Rat, dermal, SO_3Na_2	> 2,000 mg/kg	ECHA, 2020
LC_{50}		
Rat, SO_3Na_2	> 5.5 mg/L	ECHA, 2020
High Chronic/Repeat Dose Toxicity		
NOAEL, rats, oral, growth, $NaHSO_3$	25 mg/kg bw/day	ECHA, 2015

Toxicity Values	Value	Reference
NOAEL, rabbits, oral, maternal and developmental toxicity, $NaHSO_3$	> 100 mg/kg bw/d	ECHA, 2020
NOAEL, hamsters, oral, maternal and developmental toxicity, $NaHSO_3$	> 120 mg/kg bw/d	ECHA, 2020
NOAEL, mice, oral, maternal and developmental toxicity, $NaHSO_3$	> 150 mg/kg bw/d	ECHA, 2020
NOAEL, rats, oral, maternal and developmental toxicity, $NaHSO_3$	> 110 mg/kg bw/d	ECHA, 2020
NOAEL, rats, oral, fertility, $Na_2S_2O_5$	> 955 mg/kg bw/d	ECHA, 2015
NOAEL, rats, oral, systemic toxicity and effects on reproduction	> 53 mg/kg bw/day	ECHA, 2015

Footnotes:
LD_{50} – lethal dose for 50% of experimental population
LC_{50} – lethal air concentration for 50% of experimental population
LOAEL – Lowest Observed Adverse Effect Level
LOAEC – Lowest Observed Adverse Effect Concentration
NDF – No data found within the limits of the search strategy

Human Health Toxicity Ranking		
	Hazard data	**Comment**
Hazard Band 4		
Carcinogenicity (IARC Group 1 or 2A)	No	IARC, 2019
Mutagenicity/Genotoxicity (GHS Category 1A and 1B)	No	ECHA, 2020
Reproductive Toxicity/Developmental toxicity (GHS Category 1, 1A and 1B)	No	ECHA, 2020
Endocrine Disruption[1]	No	EC, 2000
Hazard Band 3		
Carcinogenicity (IARC Group 2B)	No	IARC, 2019
Mutagenicity/Genotoxicity (GHS Category 2)	No	ECHA, 2020
Reproductive Toxicity/Developmental toxicity (GHS Category 2)	No	ECHA, 2020
Acute Toxicity (oral, dermal or inhalation) Very Toxic/Toxic • oral LD_{50} ≤ 300 mg/kg [2] • dermal LD_{50} ≤ 1000 mg/kg • inhalation LC_{50} ≤ 10 mg/L (or mg/m^3) (vapour)	No	Oral LD_{50} of 2,620 mg/kg, Dermal LD_{50} of > 2,000 mg/kg, LC_{50} of > 5.5 mg/L (ECHA, 2020)
High Chronic/repeat dose toxicity • oral LOAEL ≤ 10 mg/kg/d [2]; • dermal LOAEL ≤ 2 0 mg/kg/d; • inhalation LOAEC (6 h/d) ≤ 50 ppm/d for gases, ≤ 0.2 mg/L/d for vapours or ≤ 0.02 mg/L/d for dust/mists/fumes [3]	No	Oral NOAEL of 25 mg/kg bw/day (ECHA, 2020)
Corrosive (irreversible effect)	Yes	Safe Work Australia (2020) Category 1 - serious eye damage/irreversible affects on the eye (H318 - Causes serious eye damage)

Human Health Toxicity Ranking		
	Hazard data	**Comment**
Respiratory sensitiser	No	ECHA, 2020
Hazard Band 2		
Harmful chronic/repeat dose toxicity • oral LOAEL > 10 mg/kg/d and ≤ 100 mg/kg/d • dermal LOAEL > 20 mg/kg/d and ≤ 200 mg/kg/d • inhalation (6-h/d) LOAEC > 50 mg/L ≤ 250 mg/L/d for gases, > 0.2 mg/L ≤ 1 .0 mg/L/d for vapours or > 0.02 mg/L ≤ 0.2 mg/L/d for dust/mists/fumes [3]	Yes	Oral LOAEL for organ toxicity of approximately 50 mg/kg bw/day in a chronic rat study (ECHA, 2020)
Skin Sensitiser	No	ECHA, 2020
Hazard Band 1		
Acute Toxicity-Harmful • oral LD_{50} > 300 mg/kg ≤ 2000 mg/kg • dermal LD_{50} >1 000 mg/kg ≤ 2000 mg/kg; • inhalation LC_{50} (6 h/d) > 10 mg/L ≤ 20 mg/L for vapours) [3]	Yes	Although the oral LD_{50} of 2,620 mg/kg, Dermal LD_{50} of > 2,000 mg/kg, LC_{50} of > 5.5 mg/L are reported, the hazard classification published by regulatory agencies reflects a classification as harmful for acute oral toxicity (ECHA, 2020 and Safe Work Australia 2020)
Irritant (reversible effect)	No	ECHA, 2020
Hazard Band 0 **All indicators outside criteria listed in Hazards 1-4**	-	
Physical Hazards		
Flammable potential	Non-flammable	ECHA 2020
Explosive potential	Non-explosive	ECHA 2020

Human Health Toxicity Ranking		
	Hazard data	**Comment**
Hazard Evaluation (highest band) not including physical hazards	3	Based potential for serious eye damage (Safe Work Australia, 2020)
Data confidence (available points out of 12 parameters)	12/12	100%

* Based on IMAP Framework [NICNAS (2013) Inventory Multi-tiered Assessment and Prioritisation (IMAP) Framework. National Industrial Chemicals Notification and Assessment Scheme. Department of Health and Aging, Canberra].

"[1]Based on list of endocrine disrupting chemicals from the European Commission's Endocrine Disrupters website.
[2] milligrams per kilogram body mass (mg/kg) or milligrams per kilogram body mass per day (mg/kg/d)

[3] Based on GHS cut-offs for hazard classification. For chronic/repeat dose toxicity, GHS cut-offs are provided as guidance values (i.e. the dose/concentration at or below which significant health effects are observed)". (p 18, NICNAS 2013).

Human Health Guidelines		
Media	**Concentration (mg/m^3; mg/L; mg/kg)**	**Reference**
Occupational Exposure Limits		
Air (OEL)		
8-h TWA	5 mg/m^3	Safe Work Australia 2020
STEL	NDF	
Peak Limitation	NDF	
Environmental Exposure		
Air, ambient, residential	NDF	
Air, commercial/industrial	NDF	

Water, potable	NDF	
Water, recreational	NDF	
Soil, residential	NDF	
Soil, commercial/industrial	NDF	
Soil, protection of groundwater	NDF	

Footnotes:

OEL = Occupational Exposure Limit

TWA = 8 h Time-Weighted Average

STEL = (15 min) Short-term Exposure Limit

Qualifying Summary Comments

Sodium bisulphite exhibits an overall low order of toxicity across toxicological parameters such as carcinogenicity, developmental, reproductive and neurotoxicity with acute toxicity considered to be low as reflected in its use as a preservative in the food and allied industries. At concentration of > 25% is it considered harmful if swallowed (acute oral toxicity). In an oral rat study organ toxicity (kidney, stomach, teste, uterus) was noted at approximately 50 mg/kg bw/d. Although ECHA (2020) do not classify sodium bisulphite, Safe Work Australia has classified it as category 1 serious eye damage. Based on this, it has been ranked in Hazard Band 3.

References

EC (European Commission) 2000. *Towards the establishment of a priority list of substances for further evaluation of their role in endocrine disruption*. M0355008/1786Q/10/11/00. Report dated 10 November 2000.

ECHA (European Chemicals Agency), 2020. Dossier for sodium hydrogensulphite. Available at http://apps.echa.europa.eu/registered/data/dossiers/DISS-9eb5bf0a-f2e8-36c3-e044-00144f67d031/DISS-9eb5bf0a-f2e8-36c3-e044-00144f67d031_DISS-9eb5bf0a-f2e8-36c3-e044-00144f67d031.html, accessed January 2020.

HSDB (Hazardous Substances Data Bank) 2020. *Dossier for Sodium Bisulfite*. Toxicology Data Network (PUBCHEM). Available at https://pubchem.ncbi.nlm.nih.gov/compound/23665763, accessed January 2020.

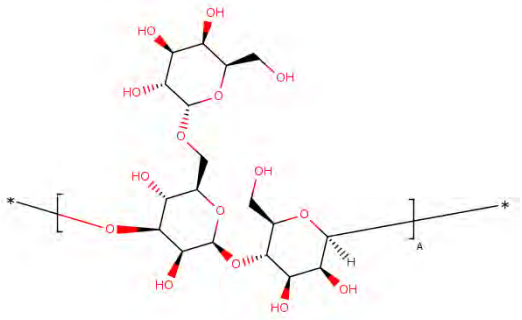
IARC (International Agency for Research on Cancer) 2019. *Monographs on the Evaluation of Carcinogenic Risks to Humans*. Last updated 12 December 2019. Available at: http://monographs.iarc.fr/ENG/Classification/latest_classif.php, accessed January 2020.

IPCS (2018). *Sodium sulphite*. International Chemical Safety Card 1134 (sodium bisulphite 38-40% aqueous solution). Available at http://www.inchem.org/documents/icsc/icsc/eics1134.htm, accessed January 2020.

Safe Work Australia (2020). HCIS (Hazardous Chemical Information System), 2020. *Hazardous Chemical Information System: Sodium hydorgensulphite….%*. Safe Work Australia. Available at http://hcis.safeworkaustralia.gov.au/HazardousChemical/Details?chemicalID=4176, accessed January 2020.

U.S. FDA (U.S. Food and Drug Asministration), 2015. Listing for Sodium bisulfite, revised as of April 1, 2019. Available at http://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfcfr/CFRSearch.cfm?fr=182.3739 & https://www.ecfr.gov/cgi-bin/text-idx?SID=e8fca02f2a6bd2da41a6b3a54b7d75f1&mc=true&node=se21.3.182_13739&rgn=div8, accessed January 2020.

Created by:	LPA	Date: 18/12/2019
Reviewed by:	CLB	Date and Revision: 23/01/2020

Name	Guar Gum
Synonyms	Guar gum, carboxymethyl 2-hydroxypropyl ether, sodium salt
CAS number	9000-30-0
Molecular formula	Not available
Surrogates	Carboxymethyl guar gum sodium salt (CAS Reg. No. 39346-76-4) Carboxymethyl-hydroxypropyl guar (CAS Reg. No. 68130-15-4)
Molecular structure	 Guar Gum (ChemID*plus*, 2020)

Overview	References
Carboxymethyl guar and carboxymethyl-hydroxypropyl guar are slightly modified forms of guar gum (CAS 9000-30-0), a natural polymer that has been affirmed as generally recognized as safe (GRAS) by the US Food and Drug Administration (FDA) and a substance of low toxicity. Carboxymethyl guar and carboxymethyl-hydroxypropyl guar are also structurally similar to hydroxypropyl guar, another slightly modified form of guar gum. They all have same toxicity pattern but the exact mode of action is not known. Based upon the structural similarities between carboxymethyl guar gum, carboxymethyl-hydroxypropyl guar, guar gum, and hydroxypropyl guar, the risk assessment for carboxymethyl guar and carboxymethyl-hydroxypropyl guar relies upon available data on all four substances. Sub-chronic, reproductive and developmental, and carcinogenicity studies with guar gum showed no long term, reproductive/developmental, or carcinogenic effects. Overall, a low toxicity profile is expected with both carboxymethyl guar and carboxymethyl-hydroxypropyl guar because of likelihood of low absorption via any route of exposure due to their high molecular weights.	FR, 2011 FDA, 2020

Human Health Toxicity Summary	Reference
Carcinogenicity No evidence of carcinogenicity was found in male and female F344 rats and B6C3F1 mice administered diets containing 25,000 or 50,000 ppm (approximately 3,570 or 7,140 mg/kg/day) guar gum for 103 weeks. A reduction in the mean body weight of the higher dose females and of the feed consumption was observed, as compared with the controls. No compound-related clinical signs of adverse effects on survival were observed. There was no increase in the incidence of tumors that could be related to the test substance.	FR, 2011
Mutagenicity/Genotoxicity Results of mutagenicity studies performed with guar gum, hydroxypropyl guar, and carboxymethyl-hydroxypropyl guar were all negative.	FR, 2011
Reproductive Toxicity The NOAEL for developmental and reproductive toxicity is 7,500 mg/kg/day for Osborne-Mendel rats fed guar gum.	FR, 2011
Developmental Toxicity/Teratogenicity Teratogenicity studies with guar gum in mice, rats, and hamsters did not indicate that guar gum is a teratogen; in mice at doses up to 800 mg/kg/day, in rats up to 900 mg/kg/day and in hamsters up to 600 mg/kg/day. Male and female Osborne-Mendel rats were fed guar gum at 0, 1, 2, 4, 5, 7, or 15% (approximately 0, 500, 1,000, 2,000, 3,750 or 7,500 mg/kg/day) in the diet for 13 weeks before mating, during mating, and throughout gestation. No effects on parental fertility, fetal development, sex distribution, and no malformations of the pups were observed.	FR, 2011
Endocrine Disruption Not listed as an endocrine disruptor by the European Commission.	EC, 2000
Acute Toxicity (oral, dermal, inhalation) Acute oral toxicity studies conducted with guar, hydroxypropyl guar, and carboxymethyl guar resulted in oral LD_{50} values ranging from 7,060 milligrams per kilogram of body weight (mg/kg bw) to 17,800 mg/kg bw.	FR, 2011
Chronic/repeat dose toxicity (oral, dermal, inhalation) There are three 90-day toxicity studies available for guar gums: 1. A LOAEL for guar gum in a diet was reported to be 1% (equivalent to 580 mg/kg/day) based on effects on body weight gains, and dose related decrease in kidney weights. A NOAEL was not established. 2. Rats received doses up to 6% (equivalent to 3,000 mg/kg/day), no effects were observed.	FR, 2011

3. Rats were exposed to a dietary concentration of 2 and 5%. Observations included decreases in body weight gains, decreases in food efficiency, increases in blood urea nitrogen and thyroid toxicity (males only). A NOAEL was reported as 1% (equivalent to 500 mg/kg/day). In other studies, no adverse effects were reported in dogs that were fed 0, 1, 5, or 10% (approximately 0, 250, 1,250, or 2,500 mg/kg/day) of a precooked mixture of guar and carob bean for 30 weeks. No effects were observed in monkeys that were fed 1 gram (equal to 10 mg/kg/day) of guar flour for 2 months.	
Sensitisation of the skin or respiratory system Results of skin sensitization studies performed with guar gum, hydroxypropyl guar, and carboxymethyl-hydroxypropyl guar were all negative. Occupational asthma has been reported in subjects working with industrial production of guar gum**.**	FR, 2011 NLM, 2020
Corrosion (irreversible)/irritation (reversible) of the skin or eye Dermal irritation studies conducted with guar, hydroxypropyl guar, and carboxymethyl guar resulted in no irritation to slight irritation. Eye irritation studies conducted with guar, hydroxypropyl guar, and carboxymethyl-hydroxypropyl guar demonstrated a range of results from non-irritation to severe irritation. ECHA classify Guar Gum as a Category 2 eye irritant (H319: causes serious eye irritation).	FR, 2011 ECHA, 2020

Physical Hazards	Reference
Flammable Potential NDF	
Explosive Potential NDF	

Toxicity Values	Value	Reference
Human Toxicity Data		
Acute Toxicity		
	NDF	
	NDF	
High Chronic/Repeat Dose Toxicity		
LOAEC	NDF	
LOAEL	NDF	
Animal Toxicity Data		
Acute Toxicity		
LD_{50}		
Rat, oral	6770 mg/kg	NLM, 2020 (Guar Gum)
Mouse, oral	8100 mg/kg	NLM, 2020 (Guar Gum)
Rabbit, oral	7000 mg/kg	NLM, 2020 (Guar Gum)
Rat, dermal	NDF	

Rabbit, dermal	NDF	
Mouse, dermal	NDF	
LC_{50}		
Rat	NDF	
High Chronic/Repeat Dose Toxicity		
LOAEL, decrease kidney weight	580 mg/kg/day	FR, 2011 (Guar Gum)
LOAEC	NDF	
NOAEL, rats, parental, developmental and reproductive	7,500 mg/kg/day	FR, 2011 (Guar Gum)

Footnotes:
LD_{50} – lethal dose for 50% of experimental population
LC_{50} – lethal air concentration for 50% of experimental population
LOAEL – Lowest Observed Adverse Effect Level
LOAEC – Lowest Observed Adverse Effect Concentration
NDF – No data found within the limits of the search strategy

Human Health Toxicity Ranking		
	Hazard data	**Comment**
Hazard Band 4		
Carcinogenicity (IARC Group 1 or 2A)	No	FR, 2011
Mutagenicity/Genotoxicity (GHS Category 1A and 1B)	No	FR, 2011
Reproductive Toxicity/Developmental toxicity (GHS Category 1, 1A and 1B)	No	FR, 2011
Endocrine Disruption[1]	No	EC, 2000
Hazard Band 3		
Carcinogenicity (IARC Group 2B)	No	FR, 2011
Mutagenicity/Genotoxicity (GHS Category 2)	No	FR, 2011
Reproductive Toxicity/Developmental toxicity (GHS Category 2)	No	FR, 2011
Acute Toxicity (oral, dermal or inhalation) Very Toxic/Toxic • oral LD_{50} ≤ 300 mg/kg [2] • dermal LD_{50} ≤ 1000 mg/kg • inhalation LC_{50} ≤ 10 mg/L [3] (or mg/m^3) (vapour)	No	NLM, 2020
High Chronic/repeat dose toxicity • oral LOAEL ≤ 10 mg/kg/d [2]; • dermal LOAEL ≤ 2 0 mg/kg/d; • inhalation LOAEC (6 h/d) ≤ 50 ppm/d for gases, ≤ 0.2 mg/L/d for vapours or ≤ 0.02 mg/L/d for dust/mists/fumes [3]	No	NLM, 2020
Corrosive (irreversible effect)	No	FR, 2011

Human Health Toxicity Ranking		
	Hazard data	**Comment**
Respiratory sensitiser	Yes	Occupational asthma has been reported in subject working with industrial production of guar gum
Hazard Band 2		
Harmful chronic/repeat dose toxicity • oral LOAEL > 10 mg/kg/d and ≤ 100 mg/kg/d • dermal LOAEL > 20 mg/kg/d and ≤ 200 mg/kg/d • inhalation (6-h/d) LOAEC > 50 mg/L ≤ 250 mg/L/d for gases, > 0.2 mg/L ≤ 1 .0 mg/L/d for vapours or > 0.02 mg/L ≤ 0.2 mg/L/d for dust/mists/fumes [3]	No	NLM, 2020
Skin Sensitiser	No	FR, 2011
Hazard Band 1		
Acute Toxicity-Harmful • oral LD_{50} > 300 mg/kg ≤ 2000 mg/kg • dermal LD_{50} >1 000 mg/kg ≤ 2000 mg/kg; • inhalation LC_{50} (6 h/d) > 10 mg/L ≤ 20 mg/L for vapours) [3]	No	NLM, 2020
Irritant (reversible effect)	Yes	FR, 2011 ECHA, 2020
Hazard Band 0 **All indicators outside criteria listed in Hazards 1-4**		
Physical Hazards		
Flammable potential	NDF	
Explosive potential	NDF	
Hazard Evaluation (highest band) not including physical hazards	3	

Human Health Toxicity Ranking		
	Hazard data	**Comment**
Data confidence (available points out of 12 parameters)	10/12	83% Data based on surrogate compounds

* Based on IMAP Framework [NICNAS (2013) Inventory Multi-tiered Assessment and Prioritisation (IMAP) Framework. National Industrial Chemicals Notification and Assessment Scheme. Department of Health and Aging, Canberra].

"[1]Based on list of endocrine disrupting chemicals from the European Commission's Endocrine Disrupters website.

[2] milligrams per kilogram body mass (mg/kg) or milligrams per kilogram body mass per day (mg/kg/d)

[3] Based on GHS cut-offs for hazard classification. For chronic/repeat dose toxicity, GHS cut-offs are provided as guidance values (i.e. the dose/concentration at or below which significant health effects are observed)". (p 18, NICNAS 2013).

Human Health Guidelines		
Media	**Concentration (mg/m^3; mg/L; mg/kg)**	**Reference**
Occupational Exposure Limits		
Air (OEL)		
8-h TWA	NDF	
STEL	NDF	
Peak Limitation	NDF	
Environmental Exposure		
Air, ambient, residential	NDF	
Air, commercial/industrial	NDF	
Water, potable	NDF	
Water, recreational	NDF	

Soil, residential	NDF	
Soil, commercial/industrial	NDF	
Soil, protection of groundwater	NDF	

Footnotes:

OEL = Occupational Exposure Limit

TWA = 8 h Time-Weighted Average

STEL = (15 min) Short-term Exposure Limit

Qualifying Summary Comments

Sodium carboxymethyl-hydroxypropyl guar and related guar gums exhibit limited human health hazards across a diverse range of toxicological parameters and subsequently have been excepted in the US from the need for tolerance thresholds as additives in pesticides used for crop protection. The Hazard Band 3 rating is a reflection of reported occupational asthma suggestive of Type 1 hypersensitivity responses while dermal and eye irritancy is the other main consideration. The potential for dust generation with such a product may result in both of these adverse outcomes under conditions of occupational exposure and subsequently warrant management measures. In addition, as the product is an organic dust, ignition and explosion are further concerns related to worker safety during on-site use of this product during chemical stimulation activities.

References

EC, 2000. Towards the establishment of a priority list of substances for further evaluation of their role in endocrine disruption, preparation of a candidate list of substances as a basis for priority setting, Final Report (Incorporating corrigenda to final report dated 21 June 2000). European Commission.

ECHA (European Chemicals Agency) 2020. Summary of Classification and Labelling: Guar Gum. Available at https://echa.europa.eu/information-on-chemicals/cl-inventory-database/-/discli/details/54495, Accessed January 2020

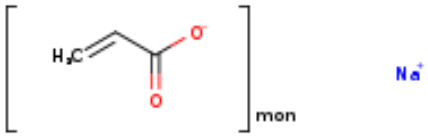
FR, 2011. Carboxymethyl Guar Gum Sodium Salt and Carboxymethyl-Hydroxypropyl Guar; Exemption From the Requirement of a Tolerance - A Rule by the Environmental Protection Agency on 07/27/2011. The Daily Journal of the United States Government – Federal Register, United States Government. Available at https://www.federalregister.gov/articles/2011/07/27/2011-18588/carboxymethyl-guar-gum-sodium-salt-and-carboxymethyl-hydroxypropyl-guar-exemption-from-the#h-13 [Accessed 7 January 2020]

National Center for Biotechnology Information. PubChem Database. Guar gum, CID=44134661, https://pubchem.ncbi.nlm.nih.gov/compound/Guar-gum Accessed January 2020

U.S. Food and Drug Administration (FDA) 2020. *SCOGS (Select Committee on GRAS Substances) Database*. Available at: https://www.accessdata.fda.gov/scripts/fdcc/?set=SCOGS accessed January 2020.

U.S National Library of Medicine (NLM) 2020. ChemID*plus*: Guar Gum. Available at: https://chem.nlm.nih.gov/chemidplus/rn/9000-30-0 accessed January 2020.

Created by:	LPA	Date: 18/12/2019
Reviewed by:	CLB	Date and Revision: 28/01/2020

Name	Sodium polyacrylate
Synonyms	2-Propenoic acid, homopolymer, sodium salt
CAS number	9003-04-7
Molecular formula	$(C_3H_4O_2)x.xNa$
Molecular Structure	 Source: ChemID*plus*, 2019)

Overview	References
Sodium polyacrylate is part of a family of various polycarboxylates, distinguished by the monomer used for their preparation, acrylic acid and their molecular weight (MW). The family of linear homopolymers of acrylic acid and their sodium salts covers polymers with a broad molecular weight ranging from 1,000 to 78,000 g/mol. The polymer mostly used in detergents has a molecular weight of approximately 4,500 g/mol. These polymers are present in many commonly used low-phosphate and phosphate-free household, industrial and institutional detergents, for avoiding incrustation and soil redeposition. They are primarily used in automatic dishwashing detergents but are also used in laundry detergents. Typical average concentrations are approximately 0.5% in automatic dishwashing detergents. Based on a typical molecular weight polymer of 4,500 g/mol, the melting (decomposition) point is > 150°C and a water solubility of > 400 g/L. Due to the primary use being detergents, polycarboxylates can enter the environment via domestic wastewater and sewage treatment to surface waters. Once in the environment, lower molecular weight polymers (MW < 2000 g/mol) are partly biodegraded. However, high MW polymers are considered poorly biodegradable. In soils, insoluble salts will likely form in the presence of calcium cations, leading to adsorption or precipitation. Abiotic degradation photolytic and hydrolytic processing are considered to not significantly influence the environmental fate of polycarboxylates. In addition, bioaccumulation is considered not significant based on potential uptake paths.	HERA, 2014

Human Health Toxicity Summary	Reference
Carcinogenicity Sodium polyacrylate has not been evaluated by the International Agency for Research on Cancer (IARC) as to its carcinogenicity. HERA conclude that a carcinogenic risk appears negligible based on no evidence of carcinogenic in repeated dose studies or *in-vitro* and *in-vivo* genotoxic studies. In addition, HERA identify that the monomers do not include alerting groups for a genotoxic or carcinogenic potential.	IARC, 2019 HERA, 2014
Mutagenicity/Genotoxicity HERA concluded that tests performed to determine the potential of these polymer to induce DNA damage *in-vitro* (Ames test and Induction of Unscheduled DNA Synthesis) were negative. A negative result was also reported for test of the potential to induce chromosomal aberration in-vitro. The *in-vitro* results were supported by a test for chromosomal aberration *in-vivo*.	HERA, 2014
Reproductive Toxicity HERA concluded that reproductive toxicity potential was negligible, based on no observed effects on the reproductive organs of the test animals in a 91 day repeat dose inhalation study (see below).	HERA, 2014
Developmental Toxicity/Teratogenicity The polymer (MW= 4,500) was tested in a rat developmental toxicity study in which the compound was administered by gavage on day 6 -15 of pregnancy at does levels of 500, 1,000, and 3,000 mg/kg/bw. The study reported no treatment related effects on foetal development or on pregnancy were noted. A NOEL of 3,000 mg/kg bw/day was established.	HERA, 2014
Endocrine Disruption Sodium polyacrylate is not identified in the European Commission (EC)'s report, "Towards the establishment of a priority list of substances for further evaluation of their role in endocrine disruption" as a substance of interest.	EC, 2000
Acute Toxicity (oral, dermal, inhalation) HERA concluded that based on the available data, the acute **oral** toxicity of the homopolymers with MW 1,000 – 78,000 is very low. In rats the reported LD_{50} values ranged between > 5 000 – 10 000 mg/kg bw (milligrams/kilogram body weight). These polymers were also reported to have low acute **dermal** toxicity to rabbits. Dermal exposure of the homopolymers with MW 1,000 – 4,500 g/mol in rabbits reported LD_{50} > 5,000 mg/kg bw. There was no data available on acute **inhalation** toxicity.	HERA, 2014
Chronic/repeat dose toxicity (oral, dermal, inhalation) Repeat dose **Oral** exposure was tested in an oral feed study for 28 days to examine the effect of the test substance on mineral homeostasis. This test is a Non-Guideline study and involved 6 male rats	HERA, 2014

being fed 2.5% of the polymer in their diet (about 1136 mg/kg bw/d). The applied dose was interpreted as a NOAEL. For repeat dose **inhalation** exposure, the primary study cited by HERA involved a 91-day study, conducted in compliance with the guidelines for the EPA's Toxic Substance Control Act and in compliance with the EPA GLP Regulations (40 CR, Part 792). The study involved 25 male and 25 female rats being exposure to 0.2, 1.0 and 5.0 mg/m^3 of the polymer as a dust aerosol for 6 h/d, 5 d/wk for 13 weeks. A NOEC of 0.2 mg/m^3 was established for respirable dust of the polymer (MW of 4,500) for local lung effects typical of insoluble respirable polymer dust, and a NOEC of greater than 5 mg/m^3 was established for systemic effects. There is no data available for the **dermal** exposure route. However, HERA conclude that the based on the similar acute oral and dermal toxicities, the repeat does oral toxicity can serve as a substitute for potential dermal toxicity.	
Sensitisation of the skin or respiratory system HERA concluded that homopolymers of acrylic acid and their sodium salts show no sensitising potential for the skin. This is based on the results of two Guinea Pig Maximisation tests which showed no skin reactions at doses ranging 0.1% - 20%, testing low and high molecular weight (4,500-78,000) polymers.	HERA, 2014
Corrosion (irreversible)/irritation (reversible) effects on the skin or eye HERA concluded that based on the studies they reviewed homopolymers of acrylic acid and their sodium salts show no skin irritation potential. Several skin irritation studies on rabbits were cites, testing different molecular weights (1,000-78,000) and concentrations between 15-45% or neat undiluted material, with exposure for 4 h-24 h and occlusive or semi-occlusive dressing. HERA concluded that based on the studies they reviewed that homopolymers of acrylic acid and their sodium salts, either as undilute neat substances or at very high concentrations, show non- to slight irritation (reversible) potential in rabbit studies. Several eye irritation studies were cited, testing different molecular weights (1,200 – 8,000), using a 45% solutions, according to OECD Guideline 405, but not according to GLP.	HERA, 2014

Physical Hazards	Reference
Flammable Potential No data available.	
Explosive Potential Reacts violently with oxidants. This generates fire and explosion hazard.	INCHEM, 2017

Toxicity Values	Value	Reference
Human Toxicity Data		
High Chronic/Repeat Dose Toxicity		
LOAEC	NDF	
LOAEL	NDF	
Animal Toxicity Data		
Acute Toxicity		
LD_{50}		
Rat, oral	LD_{50} (MW 1,000 – 78,000) > 5 000 – 10 000 mg/kg bw LD_{50} > 40 000 mg/kg	HERA, 2014 ChemID*plus*, 2019
Rabbit, dermal	LD_{50} > 5,000 mg/kg	HERA, 2014
High Chronic/Repeat Dose Toxicity		
NOAEL	NOAEL (oral, rat, 4 wk, MW = 2,500): 1 136 mg/kg/d	HERA, 2014.
NOAEC	NOEC (inhalation, rat, 91 d, local lung effects, MW = 4,500): 0.2 mg/m^3 NOEC (inhalation, rat, 91 d, systemic effects, MW = 4,500): 5 mg/m^3	HERA, 2014.

Footnotes:
LD_{50} – lethal dose for 50% of experimental population
LC_{50} – lethal air concentration for 50% of experimental population
NOAEL – No Observed Adverse Effect Level
NOAEC – No Observed Adverse Effect Concentration
NDF – No data found within the limits of the search strategy

Human Health Toxicity Ranking		
	Hazard data	**Comment**
Hazard Band 4		
Carcinogenicity (IARC Group 1 or 2A)	No	
Mutagenicity/Genotoxicity (GHS Category 1A and 1B)	No	
Reproductive Toxicity/Developmental toxicity (GHS Category 1, 1A and 1B)	No	
Endocrine Disruption[1]	No	
Hazard Band 3		
Carcinogenicity (IARC Group 2B)	No	
Mutagenicity/Genotoxicity (GHS Category 2)	No	
Reproductive Toxicity/Developmental toxicity (GHS Category 2)	No	
Acute Toxicity (oral, dermal or inhalation) Very Toxic/Toxic • oral LD_{50} ≤ 300 mg/kg [2] • dermal LD_{50} ≤ 1000 mg/kg • inhalation LC_{50} ≤ 10 mg/L [3] (or mg/m^3) (vapour)	No	
High Chronic/repeat dose toxicity • oral LOAEL ≤ 10 mg/kg/d [2]; • dermal LOAEL ≤ 2 0 mg/kg/d; • inhalation LOAEC (6 h/d) ≤ 50 ppm/d for gases, ≤ 0.2 mg/L/d for vapours or ≤ 0.02 mg/L/d for dust/mists/fumes [3]	Yes	NOEC for inhalation of systematic effects of 5 mg/m^3 (0.005 mg/L) for respirable dust of the polymer.
Corrosive (irreversible effect)	No	
Respiratory sensitiser	-	
Hazard Band 2		

Human Health Toxicity Ranking		
	Hazard data	**Comment**
Harmful chronic/repeat dose toxicity • oral LOAEL > 10 mg/kg/d and ≤ 100 mg/kg/d • dermal LOAEL > 20 mg/kg/d and ≤ 200 mg/kg/d • inhalation (6-h/d) LOAEC > 50 mg/L ≤ 250 mg/L/d for gases, > 0.2 mg/L ≤ 1 .0 mg/L/d for vapours or > 0.02 mg/L ≤ 0.2 mg/L/d for dust/mists/fumes [3]	*No*	
Skin Sensitiser	No	
Hazard Band 1		
Acute Toxicity-Harmful • oral LD_{50} > 300 mg/kg ≤ 2000 mg/kg • dermal LD_{50} >1 000 mg/kg ≤ 2000 mg/kg; • inhalation LC_{50} (6 h/d) > 10 mg/L ≤ 20 mg/L for vapours) [3]	No	LD_{50} (oral, MW 1,000 – 78,000) > 5 000 – 10 000 mg/kg LD_{50} (dermal) > 5,000 mg/kg
Irritant (reversible effect)	Yes	Irritation effects in the eyes.
Hazard Band 0 **All indicators outside criteria listed in Hazards 1-4**	-	
Physical Hazards		
Flammable potential	-	
Explosive potential	Yes	Reacts with oxidants. INCHEM, 2017
Hazard Evaluation (highest band) not including physical hazards	3	Based on NOEC for inhalation of systematic effects of 5 mg/m^3 (0.005 mg/L) for respirable dust of the polymer.
Data confidence (available points out of 12 parameters)	9/12	75%

* Based on IMAP Framework [NICNAS (2013) Inventory Multi-tiered Assessment and Prioritisation (IMAP) Framework. National Industrial Chemicals Notification and Assessment Scheme. Department of Health and Aging, Canberra].

"[1]*Based on list of endocrine disrupting chemicals from the European Commission's Endocrine Disrupters website.*

[2] *milligrams per kilogram body mass (mg/kg) or milligrams per kilogram body mass per day (mg/kg/d)*

[3] *Based on GHS cut-offs for hazard classification. For chronic/repeat dose toxicity, GHS cut-offs are provided as guidance values (i.e. the dose/concentration at or below which significant health effects are observed)". (p 18, NICNAS 2013).*

Human Health Guidelines		
Media	**Concentration (mg/m^3; mg/L; mg/kg)**	**Reference**
Occupational Exposure Limits		
Air (OEL)		
8-h TWA	NDF	
STEL	NDF	
Peak Limitation	NDF	
Environmental Exposure		
Air, ambient, residential	NDF	
Air, commercial/industrial	NDF	
Water, potable	NDF	
Water, recreational	NDF	
Soil, residential	NDF	
Soil, commercial/industrial	NDF	
Soil, protection of groundwater	NDF	

Footnotes:

OEL = Occupational Exposure Limit

TWA = 8 h Time-Weighted Average

STEL = (15 min) Short-term Exposure Limit
NDF – No data found within the limits of the search strategy

Qualifying Summary Comments

Sodium polyacrylate is part of a family of various polycarboxylates, distinguished by the monomer used for their preparation, acrylic acid and their molecular weight. The family of linear homopolymers of acrylic acid and their sodium salts covers polymers with a broad molecular weight ranging from 1,000 to 78,000 g/mol. The polymer mostly used in detergents has a molecular weight of approximately 4,500 g/mol. These polymers are present in many commonly used low-phosphate and phosphate-free household, industrial and institutional detergents, for avoiding incrustation and soil redeposition.

Sodium polyacrylate was ranked in Hazard Band 3 based on the potential effects of inhalation of the respirable dust of the polymer. It is noted that this is based upon a no observed effect concentration, which was the highest concentration in a study. Given the limited information, it is concluded that there is the potential for toxicity effects due to chronic inhalation of respirable dust. Potential inhalation exposures would require management.

Sodium polyacrylate was reported to present low toxicity potential for acute oral and dermal exposure. These polymers also showed no skin irritation or sensitising potential. Studies assessing irritation of the eyes in rabbits reported non- to slight irritation (reversible) potential.

References

ChemID*plus*, 2019. Dossier for Substance Name: Polyacrylic acid, sodium salt. National Institutes of Health, Health &Human Services, U.S. National Library of Medicine. Available at: https://chem.nlm.nih.gov/chemidplus/rn/9003-04-7, accessed December 2019.

European Commission (EC), 2000. *Towards the establishment of a priority list of substances for further evaluation of their role in endocrine disruption, preparation of a candidate list of substances as a basis for priority setting, Final Report* (Incorporating corrigenda to final report dated 21 June 2000).

Human & Environmental Risk Assessment (HERA), 2014. *Human & Environmental Risk Assessment on ingredients of European household cleaning products. Polycarboxylates used in detergents (Part I). Polyacrylic acid homopolymers and their sodium salts (CAS 9003-04-7).* Version 3.0, January 2014. Available at: https://www.heraproject.com/files/HERA_P-AA_final_v3_23012014.pdf, accessed December 2019.

International Agency for Research on Cancer (IARC), 2019. Agents Classified by the *IARC Monographs*, Volumes 1–125, last updated 29 November, 2019. Available at https://monographs.iarc.fr/agents-classified-by-the-iarc/, accessed December 2019.

INCHEM (2017) International Programme on Chemical Safety (IPCS) POLYACRYLIC ACID, SODIUM SALT http://www.inchem.org/documents/icsc/icsc/eics1429.htm accessed January 2020.

U.S. Environmental Protection Agency (U.S. EPA), 2019. Substance Registry Services (SRS): Sodium polyacrylate. Available at: https://iaspub.epa.gov/sor_internet/registry/substreg/searchandretrieve/advancedsearch/externalSearch.do?p_type=CASNO&p_value=9003-04-7, accessed December 2019.

Created by:	MGT	Date: 13/12/2019
Reviewed by:	CLB	Date and Revision: 28/01/2020

Name	Crystalline silica, quartz
Synonyms	Quartz (SiO_2); silicon oxide, di- (sand); silica dust; fibrous glass; aventurine
CAS number	14808-60-7
Molecular formula	O_2Si
Molecular structure	 (Source: NICNAS, 2018)

Overview	References
The Australian National Industrial Chemicals Notification and Assessment Scheme (NICNAS) undertook a Human Health Tier II assessment of compounds comprising the Crystalline Silica group in 2018. This group contained quartz (CAS No.: 14808-60-7), as well as silica (CAS No.: 7631-86-9), cristobalite (SiO2) (CAS No.: 14464-46-1) and fumes, silica (CAS No.: 69012-64-2). The grouping of these chemicals is due to their similar physico-chemical properties, related end-uses and toxicity. In addition, NICNAS outline that this group of crystalline silica should not be considered analogous to amorphous (polymorphic) form(s) of silicon dioxide, especially with respect to their toxicity. This is because crystalline silica has a regular repeating 3-dimensional patters that is not present in amorphous forms of silica, resulting in a key physico-chemical difference between the two. The NICNAS assessment has been primarily used to complete this human health profile. Quartz has reported domestic and commercial uses in Australia. Domestic uses include as additives in construction materials and commercial uses also include as process regulators in the paper and pulp industry, in mining and metal extraction and as vulcanising agents (for the hardening of rubbers). Internationally, numerous domestic and commercial uses have been reported. With examples of domestic uses including as adhesives and binding agents, as cleaning and washing agents, as colouring agents, as corrosion inhibitors, as fertilisers and in construction materials. Examples of commercial uses include as anti-adhesive agents, anti-static agents, conductive agents, complexing and flocculating agents and stabilisers, in construction material, in pharmaceuticals and in pesticides. The NICNAS assessment notes the ubiquitous dermal and oral exposure of humans to silica, including quartz (sand) and silica food additives. Based on this NICNAS consider that acute toxicity, repeated dose toxicity, irritation and sensitisation from oral and dermal exposures are not relevant for their risk assessment. However, the use of crystalline silica in industrial applications have been associated with irreversible toxicity in the lungs, including carcinogenicity secondary to lung damage, due to worker exposure to respirable dusts (i.e. dust particles small enough to penetrate deep into the respiratory system). Due to this, NICNAS's assessment only considers inhalation toxicity of crystalline silica.	NICNAS, 2018

NICNAS reports that crystalline silica dust is largely insoluble in bodily fluids but can form silicic acid, which is readily excreted via the kidneys (US EPA, 1996, cited by NICNAS, 2018). Crystalline silica is cytotoxic towards macrophages (SCOEL, 2003, cited by NICNAS, 2018) and therefore, following inhalation exposure it can accumulate in the lungs because it disrupts macrophage-mediated mechanical clearance. This is generally seen when there are high levels of crystalline silica dust, with the phenomenon often referred to as 'particle overload' (WHO, 2000, cited by NICNAS, 2018). Although the implication of particle overload in humans has not been characterised, it is reported to initiate an inflammatory response in the rodent lung (WHO, 2000, cited by NICNAS, 2018). Inhaled particles of crystalline silica are reported to be transported to other parts of the body through the lymphatic system (US EPA, 1996, cited by NICNAS, 2018).	

Human Health Toxicity Summary	Reference
Carcinogenicity Crystalline silica, quartz (CAS No. 14808-60-7) has been evaluated by the International Agency for Research on Cancer (IARC) as to its carcinogenicity. Quartz was assigned Group 1, indicating carcinogenic to humans, based on sufficient evidence for carcinogenicity in humans and experimental animals. Crystalline silica, quartz (CAS No. 14808-60-7) (respirable fraction) is classified by Safe Work Australia for carcinogenicity as Category 1A (Hazard statement: H350i (May cause cancer by inhalation). An occupational exposure standard has been established in Australia of 0.1 mg/m^3 for the respirable fraction for quartz. However, based on the available epidemiological data for crystalline silica, NICNAS outline concerns that this standard might not be sufficiently protective to worker's health. NICNAS suggest a Tier III assessment might be necessary to provide further information as to whether or not the current standard is adequately protective of workers. Epidemiological pooled data and meta-analyses of available data provide the strongest evidence supporting carcinogenicity of crystalline silica in the lung. IARC concluded that crystalline silica is a confirmed human carcinogen based largely on nine studies of cohorts in four industry sectors there were considered to be least influenced by confounding factors, including gold mining, quarriers and granite works, ceramic/pottery/refractory brick industries and the diatomaceous earth industry (IARC, 2012, cited by NICNAS, 2018). Lung cancer tended to increase with cumulative exposure, duration of exposure, peak intensity of exposure and presence of silicosis, based on analysis from numerous epidemiology studies (Environment & Health Canada, 2013, cited by NICNAS, 2018). Studies conducted in experimental animals have shown clear and consistent increases in lung tumours after chronic inhalation exposure, supporting the positive results from human data (Environment & Health Canada, 2013, cited by NICNAS, 2018). Free silica (crystalline silicon dioxide) is restricted for use in abrasive blasting at a concentration of greater than 1 % and is listed in Schedule 10 (prohibited carcinogens, restricted carcinogens and restricted hazardous chemicals) of the Work Health and Safety Regulations (WHS, 2011, cited by NICNA, 2018).	IARC, 2020 Safe Work Australia, 2020a; NINCAS, 2018
Mutagenicity/Genotoxicity	

Crystalline silica, quartz has not been classified by NICNAS for genotoxicity, as based on the information available, it is not expected that these chemicals directly induce heritable mutations in human germ cells. Both positive and negative results have been reported in in vitro studies with chemicals in the crystalline silica group. NICNAS report that the majority of positive genotoxicity assay results can be explained by the generation of reactive oxygen specific (OECD, 2011, cited by NICNAS, 2018) resulting in DNA damage. As DNA damage is secondary to crystalline silica-induced oxidative damage, a direct genotoxic effect is not expected.	NICNAS, 2018
Reproductive Toxicity Crystalline silica, quartz is considered to be of low reproductive toxicity for exposure via the oral and dermal routes, based on ubiquitous exposure of humans to silica, including quartz (sand) and silica food additives. This end-point has therefore not been included in NICNAS's assessment. Data for reproductive toxicity from inhalation exposure is not available.	NICNAS, 2018
Developmental Toxicity/Teratogenicity No data found.	
Endocrine Disruption Crystalline silica, quartz is not identified in the European Commission (EC)'s report, "*Towards the establishment of a priority list of substances for further evaluation of their role in endocrine disruption*" as a substance of interest.	EC, 2000
Acute Toxicity (oral, dermal, inhalation) Crystalline silica, quartz is considered to be of low acute toxicity for exposure via the **oral** and **dermal** routes, based on ubiquitous exposure of humans to silica, including quartz (sand) and silica food additives. These end-points have therefore not been included in NICNAS's assessment. No data is available to assess toxicity of acute **inhalation** exposure. However, exposure to respirable-sized, high quartz-content dust over a short period of time has been observed to cause the rare and fatal conditions of acute silicosis or silico-proteinosis. Although, it is noted that this condition has only been reported in historical case reports (e.g. during the building of the Gauley Bridge hydroelectric tunnel in West Virginia, USA IN 1930-2931). This condition is clinically similar to pulmonary oedema with the symptoms including shortness of breath and fluid accumulation in the upper and middle area so the lungs.	NICNAS, 2018
Chronic/repeat dose toxicity (oral, dermal, inhalation) Crystalline silica, quartz is considered to have repeated dose **inhalation** toxicity, based on available data in humans and animals. It has been classified for repeat dose toxicity as Category 1 (H372; causes damage to lungs through prolonged or repeated exposure through inhalation). The LOAEC for adverse pulmonary effects in various rat and mice studies ranged between 1 – 5 mg/m^3 (US EPA, 1996, cited by NICNAS, 2018). Non-neoplastic adverse effects specific to the lungs	NICNAS, 2018

of rodents included granulomatous lesions in the walls of the large bronchi, pulmonary fibrosis, hyperplasia of the alveolar compartment and increases in lung collagen content. Repeated occupational exposure to crystalline silica dust, mainly from quartz, has been reported to result in two forms of silicosis; accelerated (develops 5 – 10 years after initial exposure) and chronic (Develops 10 years after initial exposure) (US EPA, 1996, WHO, 2000, cited by NICNAS, 2018). This is based on observation in workers and epidemiological data. For repeat dose **dermal** exposure, long-term (3 – 34 years) of occupational exposure to silica dusts has been reported to be associated with connective tissue diseases with a potential to produce progressive systemic scleroderma. NICNAS note that there is debate about a true cause and effect relationship, although there is evidence to show a link between scleroderma and lung silicosis in occupational settings (Thomas et al., 2000, cited by NICNAS, 2018).	
Sensitisation of the skin or respiratory system Crystalline silica, quartz is considered to be of low sensitisation potential for exposure via the oral and dermal routes, based on ubiquitous exposure of humans to silica, including quartz (sand) and silica food additives. This end-point has therefore not been included in NICNAS's assessment. Data for sensitisation from inhalation exposure is not available.	NICNAS, 2018
Corrosion (irreversible)/irritation (reversible) effects on the skin or eye Crystalline silica, quartz is considered to be of low corrosion and irritation potential for exposure via the oral and dermal routes, based on ubiquitous exposure of humans to silica, including quartz (sand) and silica food additives. This end-point has therefore not been included in NICNAS's assessment. Data for irritation or corrosion from inhalation exposure is not available.	NICNAS, 2018

Physical Hazards	Reference
Flammable Potential NDF	
Explosive Potential NDF	

Toxicity Values	Value	Reference
Human Toxicity Data		
High Chronic/Repeat Dose Toxicity		
LOAEC	NDF	
LOAEL	NDF	
Animal Toxicity Data		
Acute Toxicity		
LD_{50}		
Rat, oral	NDF	
LC_{50}		
Rat	NDF	
High Chronic/Repeat Dose Toxicity		
LOAEL	NDF	
LOAEC	LOAEC (adverse pulmonary effects, rat and mice): 1 – 5 mg/m^3	Cited by NICNAS, 2018

Footnotes:
LD_{50} – lethal dose for 50% of experimental population
LC_{50} – lethal air concentration for 50% of experimental population
LOAEL – Lowest Observed Adverse Effect Level
LOAEC – Lowest Observed Adverse Effect Concentration
NDF – No data found within the limits of the search strategy

Human Health Toxicity Ranking		
	Hazard data	**Comment**
Hazard Band 4		
Carcinogenicity (IARC Group 1 or 2A)	Yes	IARC Group 1
Mutagenicity/Genotoxicity (GHS Category 1A and 1B)	No	
Reproductive Toxicity/Developmental toxicity (GHS Category 1, 1A and 1B)	No	
Endocrine Disruption[1]	No	
Hazard Band 3		
Carcinogenicity (IARC Group 2B)	See above.	
Mutagenicity/Genotoxicity (GHS Category 2)	No	
Reproductive Toxicity/Developmental toxicity (GHS Category 2)	No	
Acute Toxicity (oral, dermal or inhalation) Very Toxic/Toxic • oral LD_{50} ≤ 300 mg/kg [2] • dermal LD_{50} ≤ 1000 mg/kg • inhalation LC_{50} ≤ 10 mg/L [3] (or mg/m^3) (vapour)	No	NDF for acute inhalation exposure. However, exposure to respirable sized, high quart-content dust over a short period of time has been reported to cause a rare and fatal condition of acute silicosis or silico-proteinosis in an occupational setting.
High Chronic/repeat dose toxicity • oral LOAEL ≤ 10 mg/kg/d [2]; • dermal LOAEL ≤ 2 0 mg/kg/d; • inhalation LOAEC (6 h/d) ≤ 50 ppm/d for gases, ≤ 0.2 mg/L/d for vapours or ≤ 0.02 mg/L/d for dust/mists/fumes [3]	Yes	LOAEC of 1 – 5 mg/m^3 for respirable dust (equivalent to 0.001 – 0.005 mg/L)
Corrosive (irreversible effect)	No	
Respiratory sensitiser	No	

Human Health Toxicity Ranking		
	Hazard data	**Comment**
Hazard Band 2		
Harmful chronic/repeat dose toxicity • oral LOAEL > 10 mg/kg/d and ≤ 100 mg/kg/d • dermal LOAEL > 20 mg/kg/d and ≤ 200 mg/kg/d • inhalation (6-h/d) LOAEC > 50 mg/L ≤ 250 mg/L/d for gases, > 0.2 mg/L ≤ 1 .0 mg/L/d for vapours or > 0.02 mg/L ≤ 0.2 mg/L/d for dust/mists/fumes [3]	See above.	
Skin Sensitiser	No	
Hazard Band 1		
Acute Toxicity-Harmful • oral LD_{50} > 300 mg/kg ≤ 2000 mg/kg • dermal LD_{50} >1 000 mg/kg ≤ 2000 mg/kg; • inhalation LC_{50} (6 h/d) > 10 mg/L ≤ 20 mg/L for vapours) [3]	See above.	
Irritant (reversible effect)	No	
Hazard Band 0 **All indicators outside criteria listed in Hazards 1-4**	No	
Physical Hazards		
Flammable potential	NDF	
Explosive potential	NDF	
Hazard Evaluation (highest band) not including physical hazards	1	Based on carcinogenicity
Data confidence (available points out of 12 parameters)	12/12	100%

* Based on IMAP Framework [NICNAS (2013) Inventory Multi-tiered Assessment and Prioritisation (IMAP) Framework. National Industrial Chemicals Notification and Assessment Scheme. Department of Health and Aging, Canberra].

"[1]Based on list of endocrine disrupting chemicals from the European Commission's Endocrine Disrupters website.
[2] milligrams per kilogram body mass (mg/kg) or milligrams per kilogram body mass per day (mg/kg/d)

[3] Based on GHS cut-offs for hazard classification. For chronic/repeat dose toxicity, GHS cut-offs are provided as guidance values (i.e. the dose/concentration at or below which significant health effects are observed)". (p 18, NICNAS 2013).

Human Health Guidelines		
Media	**Concentration (mg/m^3; mg/L; mg/kg)**	**Reference**
Occupational Exposure Limits		
Air (OEL)		
8-h TWA	0.1 mg/m^3 (for respirable dust)	Safe Work Australia, 2020b
STEL	NDF	
Peak Limitation	NDF	
Environmental Exposure		
Air, ambient, residential	0.0031 mg/m^3 (for silica (crystalline, respirable, CAS No.: 7631-86-9)	US EPA, 2019
Air, commercial/industrial	0.013 mg/m^3 (for silica (crystalline, respirable, CAS No.: 7631-86-9)	US EPA, 2019
Water, potable	NDF	
Water, recreational	NDF	
Soil, residential	NDF *	
Soil, commercial/industrial	NDF *	
Soil, protection of groundwater	NDF*	

Footnotes:

OEL = Occupational Exposure Limit

TWA = 8 h Time-Weighted Average

STEL = (15 min) Short-term Exposure Limit

* US EPA (2019) provide soil values for silica (crystalline, respirable, CAS No.: 7631-86-9), however these are above practical quantification (>1 000 000 mg/kg) and have therefore not been included.

Qualifying Summary Comments

Crystalline silica, quartz (CAS No. 14808-60-7), commonly known as sand, has reported domestic and commercial uses in Australia. Domestic uses include as additives in construction materials and commercial uses also include as process regulators in the paper and pulp industry, in mining and metal extraction and as vulcanising agents (for the hardening of rubbers). NICNAS (2018) outline the ubiquitous dermal and oral exposure of humans to silica, including quartz (sand) and silica food additives. Based on this NICNAS consider that acute toxicity, repeated dose toxicity, irritation and sensitisation from oral and dermal exposures are not relevant for their risk assessment.

Crystalline silica, quartz (CAS No. 14808-60-7) has been ranked in Hazard Band 1, based on health effects associated with respirable dust. NICNAS (2018) outline that the critical health effects associated with respirable dust from crystalline silica, quartz are long term effects (carcinogenicity) and harmful effects following repeated exposure through inhalation (silicosis). Exposure to respirable dust is most likely in the occupational setting and exposure of the general public is considered low. Crystalline silica, quartz was assigned Group 1 by IARC, indicating carcinogenic to humans, and has been classified for repeat dose toxicity as Category 1 (H372; causes damage to lungs through prolonged or repeated exposure through inhalation). Epidemiological studies have indicated that silicosis is associated with the development of lung cancer. Therefore, preventing the onset of silicosis is likely to reduce the risk of lung cancer (SCOEL, 2003, cited by NICNAS, 2018). Although there is limited data to assess acute effects of inhalation exposure, based on historical case reports from occupational settings, high quart-content dust over a short period of time has been observed to cause a rare and fatal condition of acute silicosis or silico-proteinosis.

The principle hazard is subsequently the generation of dusts under occupational settings which require management. Products in the workplace should be appropriately classified and labelled. An occupational exposure standard has been established in Australia of 0.1 mg/m^3 for the respirable fraction for quartz. However, based on the available epidemiological data for crystalline silica, NICNAS outline concerns that this standard might not be sufficiently protective to worker's health. NICNAS suggest a Tier III assessment might be necessary to provide further information as to whether or not the current standard is adequately protective of workers.

References

European Commission (EC), 2000. Towards the establishment of a priority list of substances for further evaluation of their role in endocrine disruption, preparation of a candidate list of substances as a basis for priority setting, Final Report (Incorporating corrigenda to final report dated 21 June 2000).

International Agency for Research on Cancer (IARC), 2019. Agents Classified by the IARC Monographs, Volumes 1–125, last updated 12 December 2019. Available at https://monographs.iarc.fr/agents-classified-by-the-iarc/, accessed February 2020.

National Industrial Chemicals Notification and Assessment Scheme (NICNAS), 2018. Crystalline silica: Human health tier II assessment, 26 October 2018. Available at: https://www.nicnas.gov.au/chemical-information/imap-assessments/imap-group-assessment-report?assessment_id=1120#cas-A_14808-60-7, accessed February 2020.

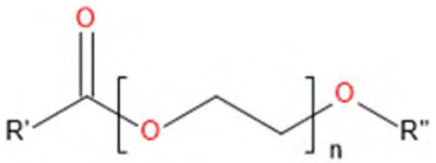
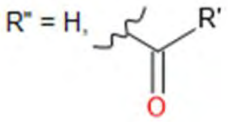
Safe Work Australia, 2020a. Hazardous Chemical Information System (HCIS): Hazardous Chemical Details for Quartz (SiO2) (respirable fraction). Available at: http://hcis.safeworkaustralia.gov.au/HazardousChemical/Details?chemicalID=4837, accessed February 2020.

Safe Work Australia, 2020b. Hazardous Chemical Information System (HCIS): Exposure Standards for Quartz (respirable). Available at: http://hcis.safeworkaustralia.gov.au/ExposureStandards/Details?exposureStandardID=527, accessed February 2020

U.S. Environmental Protection Agency (U.S. EPA), 2019. Regional Screening Levels (RSLs) – Generic Tables (Tables as of November 2019). Available at: https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables, accessed February 2020.

Created by:	MGT	Date: 12/02/2020
Reviewed by:	CLB	Date and Revision: 12/02/2020

https://golderassociates.sharepoint.com/sites/117999/project files/6 deliverables/report 014/appendix e - human health summaries/19133367_hh_14808-60-7_crystalline silica, quart_2020.docx

Name	Fatty acids, tall-oil, ethoxylated
Synonyms	-
CAS number	61791-00-2
Molecular formula	C(18-50)H(34-98)O(3-8)
Molecular structure	 n = 1 - 5 R' = saturated and unsaturated alkyl chain from fatty acids, tall oil  Source: ECHA, 2019

Overview	References
Fatty acids, tall-oil, ethoxylated is a liquid (at 20°C and 2013 hPa), that has a freezing point of -85°C. At a temperature of approximately 172°C the substance was observed to change state from a liquid to highly viscous. It is a component of a variety of products including coating, inks, adhesives, sealants and construction chemicals Following oral and dermal exposure of humans, the bioavailability of fatty acids, tall-oil, ethoxylated is considered likely negligible. Bioaccumulation is also not expected. Once in the environment, adsorption of fatty acids, tall-oil, ethoxylated to soil is expected. In water, fatty acids, tall-oil, ethoxylated is considered readily biodegradable (based on analytical results for a surrogate compound). Bioaccumulation of fatty acids, tall-oil, ethoxylated in aquatic organisms is not expected, based on rapid environmental biodegradation, metabolization in aquatic organisms to monoesters and diesters, and sterical hinderance of crossing biological membranes (high molecule weight of diesters).	ECHA, 2019

Human Health Toxicity Summary	Reference
Carcinogenicity Fatty acids, tall-oil, ethoxylated has not been evaluated by the International Agency for Research on Cancer (IARC) as to its carcinogenicity.	IARC, 2019

Mutagenicity/Genotoxicity The ECHA dossier outlines that, based on the available information, fatty acids, tall-oil, ethoxylated does not warrant a classification for genetic toxicity, in accordance with EU CLP Regulation No. 1272/2008. The ECHA dossier cites that the test substance is considered not mutagenic in bacteria or mammalian cells (determined in an OECD 471 study and an OECD 476 study, respectively) and not chromosome damaging (determined in an OECD 487 study).	ECHA, 2019
Reproductive Toxicity The ECHA dossier outlines that, based on the available data, fatty acids, tall-oil, ethoxylated does not warrant classification for reproductive toxicity according to CLP Regulation EC No. 1272/2008, as amended in Regulation EU No. 2017/776. The ECHA dossier cites an oral (sub-acute) Combine Repeated Dose Toxicity Study with the Reproduction/ Developmental Toxicity Screening Test in rats, undertaken in accordance with OECD Guideline 422. The test substance was administered daily to groups of 10 male and 10 female rats by gavage, at doses of 0 mg/kg bw/d, 100 mg/kg bw/d, 300 mg/kg bw/d and 1000 mg/kg bw/d. The treatment duration included a 2-week premating period and mating in both sexes, as well as entire gestation and lactation period in females, up to one day prior to the day scheduled for animal sacrifice. For both parental animals and pubs, no treatment-related, adverse effects were observed at any of the does levels. A NOAEL for reproductive performance and fertility was established to be 1000 mg/kg bw/day.	ECHA, 2019
Developmental Toxicity/Teratogenicity The ECHA dossier outlines that, based on the available data, fatty acids, tall-oil, ethoxylated does not warrant classification for developmental toxicity according to CLP Regulation EC No. 1272/2008, as amended in Regulation EU No. 2017/776. Test summarised in the 'Reproductive Toxicity' section. A NOAEL for developmental toxicity was established to be 1000 mg/kg bw/day.	ECHA, 2019
Endocrine Disruption Fatty acids, tall-oil, ethoxylated is not identified in the European Commission (EC)'s report, *"Towards the establishment of a priority list of substances for further evaluation of their role in endocrine disruption"* as a substance of interest.	EC, 2000
Acute Toxicity (oral, dermal, inhalation) The ECHA dossier outlines that, based on the available data, fatty acids, tall-oil, ethoxylated do not warrant classification for acute oral toxicity and acute inhalation toxicity according to CLP Regulation (EC No. 1272/2008). A key acute **oral** toxicity study of rats is cited by ECHA, with groups consisting of 10 animals/sex/dose treated by a single gavage application with an aqueous solution of the test substance at concentrations of 6 400, 8 000 and 10 000 mg/kg bw. The study was performed similar to OECD	ECHA, 2019

guidelines 401. The animals were observed for mortality and for clinical symptoms of toxicity over a period of 7 days. Based on the results of this study, the acute oral LD_{50} was determined to be > 10 000 mg/kg bw. Two acute **inhalation** studies are cited by ECHA. However, for both studies an LD_{50} can not be established because the tested concentrations were too low in relation to the classification criteria. In the first study, the exposure concentration was estimated to be 0.28 mg/L and the exposure duration was 8 hours. No mortality occurred at the concentration tested. In the second study, the exposure concentrations were estimated to be 0.04 mg/L and 0.34 mg/L and the exposure duration was 8 hours. No mortality occurred following exposure. There was no data available for acute dermal exposure.	
Chronic/repeat dose toxicity (oral, dermal, inhalation) The ECHA dossier outlines that fatty acids, tall-oil, ethoxylated does not warrant classification for specific target organ toxicity following repeated exposure (STOT RE) under Regulation (EC) No 1272-2008, as amended in Regulation (EU) No. 2017/776. The ECHA dossier cites a sub-acute oral study in rats, undertaken in accordance with GLP and OECD Guideline 422. Groups of 10 male and 10 female rats were given the test substance in a suspension daily, at does levels of 0 mg/ kg bw/day, 100 mg/ kg bw/day, 300 mg/ kg bw/day and 1000 mg/ kg bw/day. The study revealed no adverse signs of toxicity at any dose level. Therefore, a NOAEL for general systemic toxicity was established to be 1000 mg/kg bw/d. No studies were available for the assessment of chronic toxicity via dermal or inhalation exposure.	ECHA, 2019
Sensitisation of the skin or respiratory system The ECHA dossier outlines that fatty acids, tall-oil, ethoxylated is classified as sensitising Category 1B (H317): May cause an allergic skin reaction, in accordance with EU classification, CLP Regulation No. (EC) 1272/2008. The radioactive Murine Local Lymph Node Assay was used to assess skin sensitising potential, in compliance with GLP and according to OECD 429. This test concluded that fatty acids, tall-oil, ethoxylated does not show a skin sensitising effect in the Murine Local Lymph Node Assay under the test conditions. However, an animal Buehler test indicated the substance was potentially sensitising to the skin. This test was undertaken in accordance with guidelines OECD 406, 1992 and EEC 92/69 part B6", 1992 and was performed on 30 guinea pigs divided into a test group of 20 animals and a control group of 10 animals. Application of the substance included closed patch topical application for 6 hours once a week for 3 weeks. A challenge application involved a closed patch topical treatment on the flank 4 weeks after first induction. This study concluded that the substance was sensitising to the skin and is the basis for the classification. No studies are available to assess respiratory sensitisation.	ECHA, 2019
Corrosion (irreversible)/irritation (reversible) effects on the skin or eye	ECHA, 2019

The ECHA dossier outlines that classification of fatty acids, tall-oil, ethoxylated for skin and eye irritation is not warranted, in accordance with EU Classification, CLP Regulation No. (EC) 1272/2008, based on the information available. Fatty acids, tall-oil, ethoxylated was found to be not irritating or corrosive to the skin following an *in vitro* Skin Irritation Test (SIT) undertaken in compliance with GLP and OECD 431 and 439. The study was performed with three EpiDerm™ tissues that were incubated, following a single topical application of 30 µL of the test substance, for 1 hour followed by a 42-hour post-incubation period. The *in vitro* test results were supported by animal studies, which also considered the test substance to be not a skin irritant. Due to the SIT results being sufficient for final assessment, further testing in a Skin Corrosion Tests was waivered. Fatty acids, tall-oil, ethoxylated was found to be not irritating to the eyes following an *in vitro* EpiOcular Eye Irritation Test undertaken in compliance with GLP and OECD 492. The study was performed with two EpiOcular™ tissues, which were incubated, following a single topical application of 50 µL of the test substance, for 30 minutes, followed by a 2-hour post-incubation period. The irritation test results were supported by animal studies, in whichthe test substance was considered to be not irritating to the eyes. The results of the EpiOcular test along were sufficient for a final assessment, and therefore, further testing in a Bovine Corneal Opacity and Permeability Test was not warranted.	

Physical Hazards	Reference
Flammable Potential The ECHA dossier states the information on flammability is “conclusive but not sufficient for classification”. Fatty acids, tall-oil, ethoxylated is considered a hardly combustible liquid that does not emit flammable gases in the presence of water and has no self-heating properties. It has a self-ignition temperature of 377°C (at 1013.25 Pa)	ECHA, 2019
Explosive Potential The ECHA dossier states the information on the explosive potential is “conclusive but not sufficient for classification”. The substance was not classified as the exothermic decomposition energy is less than 500 J/g.	ECHA, 2019

Toxicity Values	Value	Reference
Human Toxicity Data		
High Chronic/Repeat Dose Toxicity		
LOAEC	NDF	
LOAEL	NDF	
Animal Toxicity Data		
Acute Toxicity		
LD_{50}		
Rat, oral	LD_{50} > 10 000 mg/kg bw	Cited by ECHA, 2019.
LC_{50}		
Rat	NDF	
High Chronic/Repeat Dose Toxicity		
LOAEL		

NOAEL	NOAEL (oral, rat, systemic toxicity, reproductive performance and fertility, and developmental toxicity): 1000 mg/kg bw/d.	Cited by ECHA, 2019
LOAEC	NDF	

Footnotes:
LD_{50} – lethal dose for 50% of experimental population
LC_{50} – lethal air concentration for 50% of experimental population
LOAEL – Lowest Observed Adverse Effect Level
NOAEL – No Observed Adverse Effect Level
LOAEC – Lowest Observed Adverse Effect Concentration
NDF – No data found within the limits of the search strategy

Human Health Toxicity Ranking		
	Hazard data	**Comment**
Hazard Band 4		
Carcinogenicity (IARC Group 1 or 2A)	No	
Mutagenicity/Genotoxicity (GHS Category 1A and 1B)	No	
Reproductive Toxicity/Developmental toxicity (GHS Category 1, 1A and 1B)	No	
Endocrine Disruption[1]	No	
Hazard Band 3		
Carcinogenicity (IARC Group 2B)	No	
Mutagenicity/Genotoxicity (GHS Category 2)	No	
Reproductive Toxicity/Developmental toxicity (GHS Category 2)	No	
Acute Toxicity (oral, dermal or inhalation) Very Toxic/Toxic • oral LD_{50} ≤ 300 mg/kg [2] • dermal LD_{50} ≤ 1000 mg/kg • inhalation LC_{50} ≤ 10 mg/L [3] (or mg/m^3) (vapour)	No	
High Chronic/repeat dose toxicity • oral LOAEL ≤ 10 mg/kg/d [2]; • dermal LOAEL ≤ 2 0 mg/kg/d; • inhalation LOAEC (6 h/d) ≤ 50 ppm/d for gases, ≤ 0.2 mg/L/d for vapours or ≤ 0.02 mg/L/d for dust/mists/fumes [3]	No	
Corrosive (irreversible effect)	No	
Respiratory sensitiser	NDF	
Hazard Band 2		

Human Health Toxicity Ranking		
	Hazard data	**Comment**
Harmful chronic/repeat dose toxicity • oral LOAEL > 10 mg/kg/d and ≤ 100 mg/kg/d • dermal LOAEL > 20 mg/kg/d and ≤ 200 mg/kg/d • inhalation (6-h/d) LOAEC > 50 mg/L ≤ 250 mg/L/d for gases, > 0.2 mg/L ≤ 1 .0 mg/L/d for vapours or > 0.02 mg/L ≤ 0.2 mg/L/d for dust/mists/fumes [3]	No	
Skin Sensitiser	Yes	Classified as sensitising to the skin, Category 1B.
Hazard Band 1		
Acute Toxicity-Harmful • oral LD_{50} > 300 mg/kg ≤ 2000 mg/kg • dermal LD_{50} >1 000 mg/kg ≤ 2000 mg/kg; • inhalation LC_{50} (6 h/d) > 10 mg/L ≤ 20 mg/L for vapours) [3]	No	
Irritant (reversible effect)	No	
Hazard Band 0 **All indicators outside criteria listed in Hazards 1-4**	-	
Physical Hazards		
Flammable potential	No	
Explosive potential	No	
Hazard Evaluation (highest band) not including physical hazards	2	Based on skin sensitisation potential.
Data confidence (available points out of 12 parameters)	11/12	92%

* Based on IMAP Framework [NICNAS (2013) Inventory Multi-tiered Assessment and Prioritisation (IMAP) Framework. National Industrial Chemicals Notification and Assessment Scheme. Department of Health and Aging, Canberra].

"[1]Based on list of endocrine disrupting chemicals from the European Commission's Endocrine Disrupters website.

[2] milligrams per kilogram body mass (mg/kg) or milligrams per kilogram body mass per day (mg/kg/d)

[3] Based on GHS cut-offs for hazard classification. For chronic/repeat dose toxicity, GHS cut-offs are provided as guidance values (i.e. the dose/concentration at or below which significant health effects are observed)". (p 18, NICNAS 2013).

Human Health Guidelines		
Media	**Concentration (mg/m^3; mg/L; mg/kg)**	**Reference**
Occupational Exposure Limits		
Air (OEL)		
8-h TWA	NDF	
STEL	NDF	
Peak Limitation	NDF	
Environmental Exposure		
Air, ambient, residential	NDF	
Air, commercial/industrial	NDF	
Water, potable	NDF	
Water, recreational	NDF	
Soil, residential	NDF	
Soil, commercial/industrial	NDF	
Soil, protection of groundwater	NDF	

Footnotes:

OEL = Occupational Exposure Limit

TWA = 8 h Time-Weighted Average

STEL = (15 min) Short-term Exposure Limit

NDF – No data found within the limits of the search strategy

Qualifying Summary Comments

Fatty acids, tall-oil, ethoxylated is a liquid (at 20°C and 2013 hPa) and a component of a variety of products including coating, inks, adhesives, sealants and construction chemicals. Once in the environment, fatty acids, tall-oil, ethoxylated will likely adsorb to soil and is considered readily biodegradable in water. Fatty acids, tall-oil, ethoxylated was ranked in Hazard Band 2 based on the potential for it to be sensitising to skin. Although it is noted that sensitising test produced mixed results. Fatty acids, tall-oil, ethoxylated has low oral acute and chronic toxicity.

References

European Commission (EC), 2000. Towards the establishment of a priority list of substances for further evaluation of their role in endocrine disruption, preparation of a candidate list of substances as a basis for priority setting, Final Report (Incorporating corrigenda to final report dated 21 June 2000).

European Chemicals Agency (ECHA), 2019. Registration Dossier for Fatty acids, tall-oil, ethoxylated. Available at https://echa.europa.eu/registration-dossier/-/registered-dossier/25307. Last modified 02/06/2018, accessed December 2019.

International Agency for Research on Cancer (IARC), 2019. Agents Classified by the IARC Monographs, Volumes 1–125, last updated 12 December 2019. Available at https://monographs.iarc.fr/agents-classified-by-the-iarc/, accessed December 2019.

Created by:	MGT	Date: 18/12/2019
Reviewed by:	CLB	Date and Revision: 21/01/20

Name	Hydrotreated light petroleum distillate
Synonyms	Distillates (petroleum), hydrotreated light; kerosines
CAS number	64742-47-8
Molecular formula	Too complex
Molecular structure	Hydrocarbons, C8 Hydrocarbons, C9 Hydrocarbons, C10 Hydrocarbons, C11 Hydrocarbons, C12 Hydrocarbons, C13 Hydrocarbons, C14 Hydrocarbons, C15 Hydrocarbons, C16 Hydrocarbons, C17 Hydrocarbons, C18 Hydrocarbons, C19 Hydrocarbons, Non-aromatic Hydrocarbons, Mono-aromatic Hydrocarbons, Di-aromatic (Source: ECHA,2020)

Overview	References
This assessment has been based on an ECHA dossier for CAS RN 64742-47-8 and a NICNAS assessment of Kerosines (including CAS RN 64742-47-8, as well as CAS RNs: 68477-39-4, 68477-40-7, 68477-54-3, 8008-20-6, 64741-73-7, 64742-31-0, 64742-81-0, 64742-88-7, 64742-91-2, 64742-94-5, 64742-96-7, 68333-23-3, and 70892-10-3). Information from the NICNAS assessment specific to CAS RN 64742-47-8 has primarily been adopted in this profile, with information applicable to the broader kerosine group also considered. NICNAS outlines the grouping is based on those chemicals assigned in the 'kerosines' category (including straight run, cracked and 'other') by the CONservation of Clean Air and Water in Europe (CONCAWE). Kerosines are the lighter end of a group of petroleum substances known as middle distillates, the heavier end being gas oils. NICNAS outline that chemicals in this group are of unknown or variable compositions, complex rection products or biological materials (UVCBs) containing branched and straight chain paraffins and naphthenes (at least 70%), aromatic hydrocarbons (up to 25%), olefins (less than 5%) and minor quantities of additives (less than 0.1%) (US EPA, 2011, cited by NICNAS, 2016). The chemical composition depends both on the original source of the chemical and on the refinery process used during manufacture. Chemicals in this group are considered to primarily comprise C_9-C_{16} range compounds, have moderate to high volatility and low to moderate water solubility, with a boiling point range covering 140°C to 320°C.	ECHA, 2020 and NICNAS, 2016

The ECHA profile outlines that Distillates (petroleum), hydrotreated light (CAS RN 64742-47-8) is identified as a complex combination of hydrocarbons obtained by treating a petroleum fraction with hydrogen in the presence of a catalyst. It consists of hydrocarbons having carbon numbers predominantly in the range of C_9 through to C_{16}. The boiling range is approximately 150°C to 290°C. The ECHA profile outlines physical and chemical properties of kerosene (a low-viscous liquid mixture of hydrocarbons). Kerosine is reported to have a density from 0.77 to 0.85 g/cm^3 at 15°C. It has a flash point of 29°C to 70°C and an auto-flammability of 220°C to 250°C. NICNAS identify that CAS RN 64742-47-8 has reported commercial uses in Australia as an adhesive, binding agent, floatation agent, lubricant and solvent. Internationally, potential domestic uses include as health fuels, in cleaning and washing agents, in automotive products, as corrosion inhibitors, in paints, lacquers and varnishes, as hydraulic fluids and additives, in adhesives and binding agents, in wood stains, flooring adhesives and adhesive strippers, and in auto products including engine and car body products and cleaning products. Once in the environment, there is a low potential for hydrolysis as chemical constituents that consist entirely of carbon and hydrogen do not contain hydrolysable groups. The potential for photo-transformation in water and soil is also considered low. Kerosine is inherently to readily biodegradable. Hydrotreated light petroleum distillates is reported to have a low bioaccumulation potential. NICNAS outlines that the chemicals in this category have unknown or variable compositions (UVCB substances) and therefore, definitive toxicokinetic data, on absorption, distribution, metabolisms and excretion, are difficult to ascertain (ATSDR, 1995, cited by NICNAS, 2016). However, generally these compounds are expected to be readily absorbed following inhalation and oral exposure, and to a lesser extent, following dermal exposure. The chemicals are expected to be excreted rapidly (within 24 hours of exposure), primarily in the urine, following absorption. Metabolism of aliphatic hydrocarbons typically involve side chain oxidation to alcohol and carboxylic acid derivations (OECD, 2011, cited by NICNAS, 2016). The NICNAS profile identifies that the toxicity of other petroleum substances is predominantly driven by the levels of either benzene and/or polycyclic aromatic compounds containing 3 – 7 fused-rings. Chemical mixtures in the kerosine group contain negligible levels of these constituents (AIP, 2010, cited by NICNAS, 2016).	

Human Health Toxicity Summary	Reference
Carcinogenicity Hydrotreated light petroleum distillates have not been evaluated by the International Agency for Research on Cancer (IARC) as to their carcinogenicity. Kerosines are classified as non-carcinogenic based on the data available, according to the EU CLP Regulations EC No. 1272/2008, as outlined on the ECHA dossier. Kerosine is not carcinogenic when animals were exposed via the oral or inhalation routes. However, chronic skin contact with kerosine and jet fuels may lead to tumour formation as a consequence of repeated cycles of irritation, skin damage and repair. As summarised in the ECHA dossier, jet fuels and kerosines were found to be not mutagenic or genotoxic, with the observations from animal studies	IARC, 2020 ECHA, 2020

confirming the non-genotoxic nature of the skin tumour formation. Although dermal irritation alone seems not sufficient to cause dermal tumourigenicity, studies have shown that dermal irritation and inflammation are prerequisites for dermal carcinogenicity. No skin tumours were observed in studies where irritation and/or inflammation were prevented but other factors (such as dermal update of polycyclic aromatic compounds were kept identical). NICNAS concluded that overall there is considered inadequate evidence of carcinogenicity for the chemicals in the kerosine group.	NICNAS, 2016
Mutagenicity/Genotoxicity Kerosine and jet fuels did not meet criteria for classification as mutagens under the EU CLP Regulation (EC No. 1272/2008), based on the weight of evidence from in vitro and in vivo mutagenic studies indicating these substances were likely not mutagens. ECHA report that there were no studies available that described mutagenic or genotoxic effects of kerosine or jet fuels in humans. Available animal studies include in vitro gene mutation studies in bacteria and mammalian cells and cytogenicity in mammalian cells studies, and in vivo chromosome aberration and dominant lethal assays. Some contradictory results were reported in in vivo cytogenicity animal testing, where negative results were obtained for hydrodesulfurised kerosine in rats and female mice, but positive results were obtained for male mice. However, the overall conclusions is that kerosines and jet fuels are not mutagenic or genotoxic, taking into account that the great majority of the studies were negative and that the data on various individual components of kerosine and jet fuels were negative. NICNAS also conclude that the kerosine chemical group is not considered to be genotoxic, based on the weight of evidence from the available in vitro and in vivo genotoxicity studies	ECHA, 2020 NICNAS, 2016
Reproductive Toxicity Kerosines are not classified as toxic for reproduction under the EU CLP Regulation (EC No. 1272/2008), as outlined in the ECHA dossier. This was based on available data indicating that long-term oral or inhalation exposure to jet fuels and kerosines has no effect on the fertility of male rats up to a dose of 3 000 mg/kg bw/day or a concentration 1 000 mg/m^3 (highest concentration tested) and no effect on the fertility of female rats up to a dose of 1 500 mg/kg bw/day (highest concentrations tested). The key oral test cited by ECHA is a sub-chronic reproductive toxicity screening, where male rats were treated for 70 to 90 days with 0, 750, 1 500 or 3 000 mg/kg bw day of undiluted JP-8 jet fuel, then mated to untreated females. In the second part of the study, female rats were administered the test compound at doses of 0, 375, 750 or 1 500 mg/kg bw day undiluted JP-8 jet fuel for 90 days prior to mating, through mating, gestation, delivery and lactation for a total of 21 weeks. During mating, they were housed with untreated males. The study reported no systemic signs of toxicity. A supporting inhalation study is presented, where male rats were exposed for 6 hours a day for 91 consecutive days to JP-8 Jet Fuel vapour at concentrations of 0, 250, 500 and 1 000 mg/m^3. The study concluded that rats did not exert any overt signs of clinical toxicity. A dermal reproductive/developmental toxicity screening study is also presented. This study involved 10 rats/sex/group being treated dermally with hydrodesulfurised kerosine at concentrations of 0, 165, 330 or 494 mg/kg bw/day in a mineral oil in a dosing volume of 1 mL/kg for a minimum of 6 hours,	ECHA, 2020

7 days/ week beginning pre-mating, during the mating period and through 20 days of gestation. Skin irritation occurred in both males (all doses) and females (high dose only). At terminal sacrifice, no findings were reported except for those on the skin. NICNAS concluded that there was no evidence indicating reproductive toxicity for the chemicals in the kerosine group.	NICNAS, 2016
Developmental Toxicity/Teratogenicity Kerosines are not classified as a developmental toxicant according to the EU CLP Regulation (EC No. 1272/2008), as outlined in the ECHA dossier. This was based on developmental studies not providing sufficient evidence to cause a strong suspicion of developmental toxicity in the absence of signs of marked maternal toxicity. The key study cited presents an oral, sub-acute NOAEL of 1 000 mg/kg bw/d for rats, with decreased body weight of female rats and pups observed at a dose of 1 500 mg/kg bw. This study involved 30 rats/dose being administered undiluted JP-8 jet fuel by gavage at doses of 0, 500, 1000, 1 500 and 2 000 mg/kg bw/day from day 6 through 15 of gestation. Significant decreases in foetal weight in both male and female foetuses was observed for doses of 1 500 mg/kg bw/day and 2 000 mg/kg bw/day. The dermal reproductive/developmental toxicity screening study outlined in the section above is presented. This study reports an offspring NOAEL of greater than or equal to 494 mg/kg bw/day (highest dose tested in this study). NICNAS concluded that there was no evidence indicating developmental toxicity for the chemicals in the kerosine group.	ECHA, 2020 NICNAS, 2016
Endocrine Disruption Hydrotreated light petroleum distillates are not identified in the European Commission (EC)'s report, "Towards the establishment of a priority list of substances for further evaluation of their role in endocrine disruption" as a substance of interest.	EC, 2000
Acute Toxicity (oral, dermal, inhalation) Kerosines are considered to have low acute oral, dermal and inhalation toxicity and do not meet the criteria for classification under the EU CLP Regulation (EC No. 1272/2008). The key acute **oral** study presented by ECHA reports a LD_{50} of > 5 000 mg/kg bw in male and female rats. The study was undertaken similar to OECD 420 guideline. Five rats per sex were given a single oral dose of 5 000 mg/kg bw of undiluted thermocracked kerosine and observed for 14 days. Additional studies reporting oral LD_{50} of > 5 000 mg/kg supported this conclusion. The key acute **dermal** study presented by ECHA reports a LD_{50} of > 2 000 mg/kg bw in male and female rabbits. The study was undertaken similar to OECD 402 guideline. Five rabbits per sex were dermally exposed to undiluted thermocraked kerosine for 24 hours to 10% of their body surface area at a dose of 2 000 mg/kg. Animals were then observed for 14 days. Additional studies reporting dermal LD_{50} of > 2 000 mg/kg bw supported this conclusion. The key acute **inhalation** study presented by ECHA reports a LC_{50} of > 5.28 mg/L in male and female rats. The study was undertaken similar to OECD 403 guideline. Five rats per sex were exposed to	ECHA, 2020

straight-run kerosene for 4 hours to their whole body at a single dose of 5.28 mg/L. The reported LC_{50} of > 5.28 mg/L is supported by additional studies.	
NICNAS report low acute **oral** toxicity based on animal studies, with an LD_{50} of > 2 000 mg/kg bw reported for rats. NICNAS report low acute **dermal** toxicity based on animal studies, with an LD_{50} of > 2 000 mg/kg bw reported for rats and rabbits. NICNAS report low acute **inhalation** toxicity based on animal studies, with an LC_{50} of > 5.28 and > 5.2 mg/L reported for rats.	NICNAS, 2016
NICNAS outlines that the kerosines group (including CAS RN 64742-47-8) are classified as hazardous, with a classification of Aspiration Hazard – Category 1; H304 (May be fatal if swallowed and enters airways) on Hazardous Chemical Information System (HCIS). NICNAS report that numerous cases of kerosine poisoning have been described in humans, particularly in children in areas where kerosine oil is used extensively. Although many signs of kerosine poisoning are asymptomatic, signs do include diarrhoea, nausea and vomiting (UK HP, 2007, cited by NICNAS 2016). Incidents of children surviving ingestion of up to 1700 mg/kg bw have been reported, with death from oral ingestion usually being associated with aspiration of vomit, rather than systemic toxicity (ATSDR, 1995; UK HPA, 2007, cited by NICNAS, 2016). NICNAS also report that acute exposure of humans to kerosine and kerosine-based fuels has been associated with a variety of effects including impaired central nervous system function, including irritability, restlessness, ataxia, drowsiness, convulsions, coma and death; these are generally considered to be secondary effects resulting from hypoxia (UK HPA, 2007, cited by NICNAS).	Safe Work Australia, 2020
Chronic/repeat dose toxicity (oral, dermal, inhalation) Kerosines were reported to not meet criteria for classification for repeat dose toxicity, under the EU CLP Regulation EC No. 1272/2008. NICNAS also report that repeated oral, dermal and inhalation exposure to the chemicals in the kerosine group are not considered to cause serious damage to health based on the available data. ECHA reports that a number of subacute and subchronic studies with kerosines and jet fuels were available to asses repeat repeat dose toxicity. These studies were reportedly undertaken in accordance with OECD Guidelines 410, 412, 413 and other non-guideline protocols. The key sub-chronic **oral** study reported a LOAEL of 1500 mg/kg/day and NOAEL of 750 mg/kg bw/day in rats for systemic effects. The sub-chronic **inhalation** NOAEC was reported to be 1 000 mg/m^3 in rats for both systemic and local effects. This was based on six well conducted studies on representative samples from this category. For CAS RN. 64742-47-8 (vapour), NICNAS report a NOAEC of 6 000 mg/m^3 (the highest dose tested) in a 90-day rat inhalation toxicity study, undertaken in accordance with OECD 413 guidelines (OECD, 2012c, cited by NICNAS, 2016).	ECHA, 2020 and NICNAS, 2016

The sub-acute to sub-chronic **dermal** NOAEL was reported to be 495 mg/kg bw/day in rats for systemic effects. This was based on one of 15 well conducted studies with representatives of the kerosine category, covering sub-acute and sub-chronicle exposure. A sub-chronic **dermal** LOAEL of 1 mg/cm^2 was reported for local effect in rats.	
Sensitisation of the skin or respiratory system Kerosines do not meet the criteria for classification as a **skin** sensitiser under EU CLP Regulation (EC No. 1272/2008), according to the information presented in ECHA. The key study cited by ECHA tested thermocracked kerosene in mineral oil on male young adult pig/Hartley guinea pigs using a modified Buehler technique. Under the test conditions, thermocracked kerosine was not considered a delayed contact sensitiser. This conclusion was supported by other studies. NICNAS also conclude that the chemicals in the kerosine group are not skin sensitisers. No data was available to assess **respiratory** sensitisation of kerosines.	ECHA, 2020 and NICNAS, 2016
Corrosion (irreversible)/irritation (reversible) effects on the skin or eye Kerosines are classified as **Skin** Irritation Category 2 (H315), irritating to the skin, as defined by EU CLP Regulation (EC No. 1272/2008), according to ECHA. ECHA reports that animal studies indicated kerosene may act as a skin irritant, but the degree of irritancy appears to be substance, dose-exposure-time and methodology dependent. The results of studies of kerosines and jet fuels ranged from essentially non-irritating after 4 hours of semi-occlusive exposure to severely irritating after 24 hours of occluded exposure. The same results are cited by NICNAS. A potential mechanism suggested for irritation and the following inflammatory reaction is that fuels may induce the production and release of proinflammatory factors such as cytokines. Based on the weight-of-evidence, the substance is classified as irritating. Kerosines do not meet the criteria for classification as an **eye** irritant, as defined by EU CLP Regulation (EU No. 1272/2008), based on lack of corneal, iridial and conjunctival irritation, according to ECHA. ECHA reports that several irritation animal studies undertaken on a variety of kerosines indicated that none of the kerosines and jet fuels tested were more than slightly irritating to the eyes. NICNAS also conclude that the kerosines group are not ocular irritants. NICNAS outlines that the kerosines group (including CAS RN 64742-47-8) are given the hazard statement AUH066 (Repeated exposure may cause skin dryness and cracking).	ECHA, 2020 NICNAS, 2016 Safe Work Australia, 2020

Physical Hazards	Reference
Flammable Potential Flammable. Flash point of 29°C to 70°C and an auto-flammability of 220°C to 250°C.	ECHA, 2020
Explosive Potential Non-explosive. There are no chemical groups associated with explosive properties in the molecule.	ECHA, 2020

Toxicity Values	Value	Reference
Human Toxicity Data		
High Chronic/Repeat Dose Toxicity		
LOAEC	NDF	
LOAEL	NDF	
Animal Toxicity Data		
Acute Toxicity		
LD_{50}		
Rat, oral	LD_{50} (male and female): > 5 000 mg/kg bw LD_{50}: > 2 000 mg/kg bw	Cited by ECHA, 2020 Cited by NICNAS, 2016
Rat, dermal	LD_{50}: > 2 000 mg/kg bw	Cited by NICNAS, 2016
Rabbit, dermal	LD_{50} (male and female): > 2 000 mg/kg bw LD_{50}: > 2 000 mg/kg bw	Cited by ECHA, 2020 Cited by NICNAS, 2016
LC_{50}		
Rat	LC_{50} (male and female): > 5.28 mg/L	Cited by ECHA, 2020 and NICNAS, 2016
High Chronic/Repeat Dose Toxicity		

LOAEL	LOAEL (rat, oral, subacute, developmental toxicity - decreased pub weight): 1 500 mg/kg bw/d LOAEL (rat, dermal, sub-chronic): 1 mg/cm^2	Cited by ECHA, 2020
NOAEL	NOAEL (rat, oral, systemic effects): > 750 mg/kg bw/day) NOAEL (rat, dermal, sub-chronic, systemic effects): > 495 mg/kg bw/day NOAEL (rat, oral, subacute, developmental toxicity - decreased pub weight): 1 000 mg/kg bw/d NOAEL (rat, dermal, reproductive and developmental toxicity): > 494 mg/kg bw/day	Cited by ECHA, 2020
NOAEC	NOAEC (rat, inhalation, systemic and local effects): 1 000 mg/m^3 (or 1 mg/L) NOAEC (rat, inhalation): 6 000 mg/m^3 (or 6 mg/L)	Cited by ECHA, 2020 Cited by NICNAS, 2016

Footnotes:
LD_{50} – lethal dose for 50% of experimental population
LC_{50} – lethal air concentration for 50% of experimental population
LOAEL – Lowest Observed Adverse Effect Level
LOAEC – Lowest Observed Adverse Effect Concentration
NDF – No data found within the limits of the search strategy

Human Health Toxicity Ranking		
	Hazard data	**Comment**
Hazard Band 4		
Carcinogenicity (IARC Group 1 or 2A)	No	
Mutagenicity/Genotoxicity (GHS Category 1A and 1B)	No	
Reproductive Toxicity/Developmental toxicity (GHS Category 1, 1A and 1B)	No	
Endocrine Disruption[1]	No	
Hazard Band 3		
Carcinogenicity (IARC Group 2B)	No	
Mutagenicity/Genotoxicity (GHS Category 2)	No	
Reproductive Toxicity/Developmental toxicity (GHS Category 2)	No	
Acute Toxicity (oral, dermal or inhalation) Very Toxic/Toxic • oral LD_{50} ≤ 300 mg/kg [2] • dermal LD_{50} ≤ 1000 mg/kg • inhalation LC_{50} ≤ 10 mg/L [3] (or mg/m^3) (vapour)	Yes (Aspiration hazard)	Classified as Aspiration Hazard – Category 1; H304 (May be fatal if swallowed and enters airways) Inhalation - LC_{50} (male and female): > 5.28 mg/L
High Chronic/repeat dose toxicity • oral LOAEL ≤ 10 mg/kg/d [2]; • dermal LOAEL ≤ 20 mg/kg/d; • inhalation LOAEC (6 h/d) ≤ 50 ppm/d for gases, ≤ 0.2 mg/L/d for vapours or ≤ 0.02 mg/L/d for dust/mists/fumes [3]	No	
Corrosive (irreversible effect)	No	
Respiratory sensitiser	NDF	

Human Health Toxicity Ranking		
	Hazard data	**Comment**
Hazard Band 2		
Harmful chronic/repeat dose toxicity • oral LOAEL > 10 mg/kg/d and ≤ 100 mg/kg/d • dermal LOAEL > 20 mg/kg/d and ≤ 200 mg/kg/d • inhalation (6-h/d) LOAEC > 50 mg/L ≤ 250 mg/L/d for gases, > 0.2 mg/L ≤ 1 .0 mg/L/d for vapours or > 0.02 mg/L ≤ 0.2 mg/L/d for dust/mists/fumes [3]	No	
Skin Sensitiser	No	
Hazard Band 1		
Acute Toxicity-Harmful • oral LD_{50} > 300 mg/kg ≤ 2000 mg/kg • dermal LD_{50} >1 000 mg/kg ≤ 2000 mg/kg; • inhalation LC_{50} (6 h/d) > 10 mg/L ≤ 20 mg/L for vapours) [3]	No	Inhalation - LC_{50} (male and female): > 5.28 mg/L
Irritant (reversible effect)	Yes	Classified as irritating to the skin. Hazard statement AUH066 (Repeated exposure may cause skin dryness and cracking).
Hazard Band 0 **All indicators outside criteria listed in Hazards 1-4**	-	
Physical Hazards		
Flammable potential	Yes	
Explosive potential	No	
Hazard Evaluation (highest band) not including physical hazards	3	
Data confidence (available points out of 12 parameters)	11/12	92%

* Based on IMAP Framework [NICNAS (2013) Inventory Multi-tiered Assessment and Prioritisation (IMAP) Framework. National Industrial Chemicals Notification and Assessment Scheme. Department of Health and Aging, Canberra].

"[1]Based on list of endocrine disrupting chemicals from the European Commission's Endocrine Disrupters website.

[2] milligrams per kilogram body mass (mg/kg) or milligrams per kilogram body mass per day (mg/kg/d)

[3] Based on GHS cut-offs for hazard classification. For chronic/repeat dose toxicity, GHS cut-offs are provided as guidance values (i.e. the dose/concentration at or below which significant health effects are observed)". (p 18, NICNAS 2013).

Human Health Guidelines		
Media	**Concentration (mg/m^3; mg/L; mg/kg)**	**Reference**
Occupational Exposure Limits		
Air (OEL)		
8-h TWA	NDF	
STEL	NDF	
Peak Limitation	NDF	
Environmental Exposure		
Air, ambient, residential	Total Petroleum Hydrocarbons (Aliphatic Low) – 630 µg/m^3 Total Petroleum Hydrocarbons (Aliphatic Medium) – 100 µg/m^3 Total Petroleum Hydrocarbons (Aromatic Low) – 31 µg/m^3 Total Petroleum Hydrocarbons (Aromatic Medium) – 3.1 µg/m^3	US EPA, 2019
Air, commercial/industrial	Total Petroleum Hydrocarbons (Aliphatic Low) – 2600 µg/m^3 Total Petroleum Hydrocarbons (Aliphatic Medium) – 440 µg/m^3 Total Petroleum Hydrocarbons (Aromatic Low) – 130 µg/m^3 Total Petroleum Hydrocarbons (Aromatic Medium) – 13 µg/m^3	US EPA, 2019

Water, potable	Total Petroleum Hydrocarbons (Aliphatic Low) – 1.3 mg/L Total Petroleum Hydrocarbons (Aliphatic Medium) – 0.1 mg/L Total Petroleum Hydrocarbons (Aromatic Low) – 0.033 mg/L Total Petroleum Hydrocarbons (Aromatic Medium) – 0.0055 mg/L	US EPA, 2019
Water, recreational	NDF	
Soil, residential	Total Petroleum Hydrocarbons (Aliphatic Low) – 520 mg/kg Total Petroleum Hydrocarbons (Aliphatic Medium) – 96 mg/kg Total Petroleum Hydrocarbons (Aromatic Low) - 82 mg/kg Total Petroleum Hydrocarbons (Aromatic Medium) – 97 mg/kg	US EPA, 2019
Soil, commercial/industrial	Total Petroleum Hydrocarbons (Aliphatic Low) – 2200 mg/kg Total Petroleum Hydrocarbons (Aliphatic Medium) – 440 mg/kg Total Petroleum Hydrocarbons (Aromatic Low) - 420 mg/kg Total Petroleum Hydrocarbons (Aromatic Medium) – 560 mg/kg	US EPA, 2019
Soil, protection of groundwater	Total Petroleum Hydrocarbons (Aliphatic Low) – 8.8 mg/kg Total Petroleum Hydrocarbons (Aliphatic Medium) – 1.5 mg/kg Total Petroleum Hydrocarbons (Aromatic Low) – 0.017 mg/kg Total Petroleum Hydrocarbons (Aromatic Medium) – 0.023 mg/kg	US EPA, 2019

Footnotes:

OEL = Occupational Exposure Limit

TWA = 8 h Time-Weighted Average

STEL = (15 min) Short-term Exposure Limit

Qualifying Summary Comments

Hydrotreated light petroleum distillate (CAS RN.: 64742-47-8) is part of the group of chemicals referred to as kerosines, Kerosines are the lighter end of a group of petroleum substances known as middle distillates, the heavier end being gas oils. Distillates (petroleum), hydrotreated light (CAS RN 64742-47-8) is identified as a complex combination of hydrocarbons obtained by treating a petroleum fraction with hydrogen in the presence of a catalyst. It consists of hydrocarbons having carbon numbers predominantly in the range of C_9 through to $C_{16,}$ and consists of unknown or variable compositions. The boiling range is approximately 150°C to 290°C. Kerosines are reported to have a density from 0.77 to 0.85 g/cm^3 at 15°C. They are considered flammable, with a flash point of 29°C to 70°C and an auto-flammability of 220°C to 250°C. Distillates (petroleum), hydrotreated light has reported commercial uses in Australia as an adhesive, binding agent, floatation agent, lubricant and solvent.

The NICNAS profile identifies that the toxicity of other petroleum substances is predominantly driven by the levels of either benzene and/or polycyclic aromatic compounds containing 3 – 7 fused-rings. Chemical mixtures in the kerosine group contain negligible levels of these constituents (AIP, 2010, cited by NICNAS, 2016). Distillates (petroleum), hydrotreated light has been ranked in Hazard Band 3, based on a classification of Aspiration Hazard – Category 1; H304 (May be fatal if swallowed and enters airways) (Safe Work Australia, 2020). In addition, Kerosines are classified as Skin Irritation Category 2 (H315), irritating to the skin, and have the hazard statement AUH066 (Repeated exposure may cause skin dryness and cracking). Other than these hazards, studies reported low acute and chronic toxicity via the oral, dermal and inhalation route.

References

European Chemicals Agency (ECHA), 2019. Registration Dossier for Distillates (petroleum), hydrotreated light. Available at https://echa.europa.eu/registration-dossier/-/registered-dossier/15375/1 Last modified 16 January 2020, accessed January 2020.

European Commission (EC), 2000. Towards the establishment of a priority list of substances for further evaluation of their role in endocrine disruption, preparation of a candidate list of substances as a basis for priority setting, Final Report (Incorporating corrigenda to final report dated 21 June 2000).

International Agency for Research on Cancer (IARC), 2019. Agents Classified by the IARC Monographs, Volumes 1–125, last updated 12 December 2019. Available at https://monographs.iarc.fr/agents-classified-by-the-iarc/, accessed January 2020.

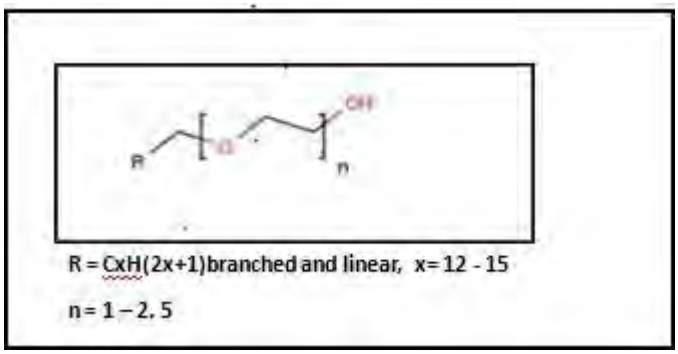
National Industrial Chemicals Notification and Assessment Scheme (NICNAS), 2016. Assessment Report for Kerosines: Human health tier II assessment. Dated 01 July 2016. Available at https://www.nicnas.gov.au/chemical-information/imap-assessments/imap-group-assessment-report?assessment_id=1810#cas-A_64742-47-8, accessed January 2020.

Safe Work Australia, 2020. Hazardous Chemical Information System (HCIS): Hazardous Chemical Details for CAS RN 64742-47-8. Available at: http://hcis.safeworkaustralia.gov.au/HazardousChemical/Details?chemicalID=1717, accessed January 2020.

U.S. Environmental Protection Agency (U.S. EPA), 2019. Regional Screening Levels (RSLs) – Generic Tables (Tables as of November 2019). Available at: https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables, accessed January 2020.

Created by:	MGT	Date: 31/01/2020
Reviewed by:	CLB	Date and Revision: 12/02/2020

https://golderassociates.sharepoint.com/sites/117999/project files/6 deliverables/report 014/appendix e - human health summaries/19133367_hh_64742-47-8_hyrdrotreated light petroleum distillate jan2020.docx

Name	Alcohols, C12-15, ethoxylated
Synonyms	(C12-C15) Alkyl alcohol ethoxylate
CAS number	68131-39-5
Molecular formula	-
Molecular structure	 (Source: ECHA, 2020)
Surrogate	Alcohol ethoxylates (AE) group of chemicals

Overview	References
Alcohols, C12-15, ethoxylated, belong to a large range of chemicals that exist as alcohol ethoxylates (AE). AE's are a widely used class of non-ionic surfactants. Nonionic surfactants are often used for wetting, detergency, foam stabilization, de-foaming, rheology modification, dispersion, and emulsification, or demulsification. They are widely used in laundry detergents and to a lesser extent in household cleaners, institutional and industrial cleaners, cosmetics, agriculture, and in textile, paper, oil and other process industries. The AE family is of the basic structure C_{x-y} AE_{n}. The subscript (x-y) following the 'C' indicates the range of carbon chain units. AEs with carbon unit range between C8 to C18 are most commonly used in household detergent products. AEs contain an ethylene oxide chain attached to the alcohol. The properties and behaviours of specific AE chemicals are dependent on the increase in carbon number and number of ethylene oxide units (indicated by sub script 'n' in formula above). For the purposes of this hazard profile, alcohols, C12-15, ethoxylated will be considered as part of the AE group.	HERA (2009)

Human Health Toxicity Summary	Reference
Carcinogenicity AEs have not been evaluated by the International Agency for Research on Cancer (IARC) as to their carcinogenicity. Toxicological data and information presented indicate that there is no evidence for AEs being carcinogenic. HERA reports studies were conducted using $C_{14\text{-}15}AE_7$ and $C_{12\text{-}13}AE_{6.5}$.	IARC (2020) HERA (2009)
Mutagenicity/Genotoxicity Alcohol ethoxylates are not classified as mutagenic or genotoxic substances. The HERA report cites studies assessing the potential of $C_{13\text{-}15}AE_7$ and $C_{12\text{-}14}AE_7$ to induce chromosome damage in Chinese hamster bone marrow cells. Although the studies were not completed in full compliance with GLP and OECD guidelines, the studies were judged by HERA to be scientifically reliable. It was reported that there was no evidence was found that $C_{13\text{-}15}AE_7$ or $C_{12\text{-}14}AE_7$ damages bone marrow chromosomes under the conditions of the experiments. $C_{14\text{-}15}AE_7$ was also administered orally to 5 male and female rats at doses of 250, 500 and 1,000 mg/kg in a GLP compliant study. Bone marrow smears were prepared 24 hours after and were processed for chromosome analysis. The test material did not show any potential for clastogenicity under the given test conditions. Two *in vivo* studies testing for chromosome damage with $C_{12\text{-}15}AE_3$ and $C_{12\text{-}14}AE_9$ in a mouse micronucleus test were also cited. No chromosome abnormalities were observed in these studies.	HERA (2009).
Reproductive Toxicity Alcohol ethoxylates are not classified as reproductive toxicants. In a two-generation study conducted in rats, the reproductive toxicity and developmental effects of $C_{14\text{-}15}AE_7$ were evaluated at dietary levels of 0.05%, 0.1% and 0.5%. No compound related differences were seen between control and treated rats with respect to fertility, gestation or viability indices**.** No treatment-related changes in behaviour or appearance were observed in the parental rats or pups throughout the study. The reproductive toxicity and developmental effects of $C_{12}AE_6$ was evaluated in a feeding study using a similar experimental design. Rats were exposed in a two-generation study to the compound at dose levels of 25, 50 or 250 mg/kg bw/d. No treatment related effects in the parents or pups on general behaviour, appearance or survival were observed. Fertility of treated groups was comparable with the controls.	HERA (2009)
Developmental Toxicity/Teratogenicity Two-generation developmental and teratogenicity study groups of rats of both sexes were fed $C_{14\text{-}15}AE_7$ in the diet at dosage levels of 0.05, 0.1 and 0.5%. No compound related differences were seen between control and treated rats with respect to fertility, gestation or viability indices and the NOAEL for reproduction was assessed to be greater than 0.5% which equals the dose of about 250 mg/kg bw/d. In another studie where the test compounds were administered orally, a 'no observed adverse effect level' (NOAEL) greater than 50 mg/kg bw/d could be estimated for developmental toxicity. At higher exposure levels a reduced pup body weight was observed in the second generation of rats tested. When applied dermally, no adverse effects on the growth and	HERA (2009)

development of the offspring was observed during two generations of rats tested. Following dermal exposure, the NOAEL can be assumed to be higher than the highest tested dose of 250 mg/kg bw/d.	
Endocrine Disruption AEs are not identified in the European Commission (EC)'s report, "*Towards the establishment of a priority list of substances for further evaluation of their role in endocrine disruption*" as a substance of interest.	EC (2000)
Acute Toxicity (oral, dermal, inhalation) HERA report that many studies investigating the acute toxicity of AEs have shown these compounds are of low oral, dermal and inhalational toxicity. The length of the alkyl chain did not exert any meaningful influence on acute toxicity. The degree of ethoxylation of the AE appear to be the only factor found to be of relevance in acute oral toxicity with the compounds with ethoxylate chains between 5 and 14 being more toxic by oral consumption than those with less than 4 or more than 21 ethoxy units. **Oral toxicity** Alcohol ethoxylates have been shown to have a low to moderate order of acute oral toxicity in the rat with LD_{50} values ranging between 0.6 to more than 10 g/kg. It was also found that in some studies data for male and female animals were evaluated separately. Females appear to be more sensitive to AEs than males. Safe Work Australia (2020) provide the following the hazard categories and hazard statements for human health: • Acute Toxicity – Category 4; H302 (Harmful if swallowed) **Inhalation Toxicity** HERA reviewed three studies and concluded that alcohol ethoxylates are of low acute inhalation toxicity to rats with LC_{50} values exceeding the saturated vapour concentration in air. Acute toxic thresholds were reached only when animals were exposed to the undiluted test chemical in the form of a respirable mist or aerosol. **Dermal toxicity** HERA conclude that alcohol ethoxylates have a low order of acute dermal toxicity and there was no relationship between compound structure and dermal toxicity. In a GLP-compliant study, five rats of each sex were given doses up to 2 g/kg. The acute dermal LD_{50} of $C_{12\text{-}15}AE_7$ was determined to be greater than 2 g/kg. The only signs of toxicity observed in both sexes were wet appearance of the fur and inflammation of the treated site.	HERA (2009) Safe Work Australia (2020)
Chronic/repeat dose toxicity (oral, dermal, inhalation) HERA (2009) reviewed a number of key studies that present a range of NOAELs, as follows: The repeated dose toxicity of 5 different AEs (i.e., $C_{12\text{-}15}AE_3$, $C_{12\text{-}14}AE_7$, $C_{12\text{-}15}AE_7$, $C_{12\text{-}15}AE_{11}$, $C_{16\text{-}20}AE_{18}$) was evaluated on the basis of a repeated dose 21-day oral toxicity assay. Three (3) rats per sex per dose and 6 animals of each sex in the control group were used in these investigations. On the	HERA (2009)

basis of observed increases in liver weight and hepatocytic hypertrophy, the NOAEL was equivalent to a dose of about 433 mg/kg bw/d for females and 579 mg/kg bw/d for males. The study methodology used was similar to the OECD method 407 with the exception that the exposure duration in the OECD protocol is at 28 days and that at least 5 animals per dose and sex are required.

In a 90-day oral feeding study, $C_{10}AE_5$ was fed to rats at doses of 125, 250 or 500 mg/kg bw/d. Clinical examinations did not indicate treatment-related effects, which were considered to be of biological significance. A NOAEL was established at 500 mg/kg bw/d under the assumption that the increased absolute and relative liver weights are of adaptive nature and not indicative of a toxic effect. Taking a more conservative approach, a NOAEL can be established at 250 mg/kg bw/d. Although the study was pre-GLP and not in full compliance with OECD guidelines, the study was judged by HEAR (2009) to be scientifically reliable.

$C_{12\text{-}15}AE_7$ and $C_{12\text{-}14}AE_7$ were tested in a 90-day dietary feeding study at dose levels of 0%, 0.0313%, 0.0625%, 0.125%, 0.25%, 0.5% and 1.0% active material in rats. NOAELs were established on the basis of hepatic histology at the 0.125% level, corresponding to a daily intake of $C_{12\text{-}15}AE_7$ of 102 mg/kg bw/d and of $C_{12\text{-}14}AE_7$ of 110 mg/kg bw/d. These studies were conducted pre-GLP and followed the principles of OECD guidelines.

In another 90-day study with $C_{14\text{-}15}AE_7$, the material was fed via the diet to three groups of young albino rats each consisting of 20 males and 20 females with control group consisting of an equal number of rats. The surfactant was incorporated in the diet at concentrations of 0.1%, 0.5% and 1%. During the in-life phase, standard haematological and biochemical parameters, and complete urinalyses were performed. As there were no treatment-related findings, the NOEL was established at the highest exposure level. The individual mean exposure for the high level males was 700 mg/kg bw/d of $C_{14\text{-}15}AE_7$ and for females was 785 mg/kg bw/d. This study followed the principles of OECD methodology, but was not compliant with GLP regulations.

In a further 90-day oral feeding study, $C_{14\text{-}15}AE_7$ was fed to Wistar rats at dietary concentrations of 0, 300, 1,000, 3,000, and 10,000 ppm of active ingredient. Significant treatment-related effects on body weight, food intake, organ weights, clinical chemistry and haematology were identified in one or both sexes fed with dietary concentrations of 3,000 and 10,000 ppm. Histopathologically, there were no compound-related effects at any dose level. No effects were observed on the organs of the reproductive system. Minor, but statistically significant changes in liver weight, kidney weights and plasma urea concentration were recorded in female rats in the 1,000 ppm group were not of toxicological significance. The NOEL for $C_{14\text{-}15}AE_7$ was established at a dietary level of 300 ppm (15 mg/kg/day).

Dermal

Dermal treatment of 10 rats per sex per group for 90-days with 1%, 10% and 25% $C_{9\text{-}11}AE_6$ did not result in any significant compound related effects. Scores for signs of irritation at the application site throughout the study were zero but at 10% and 25% dry and flaky skin was noted. Relative kidney weights were increased in both sexes at the 25% treatment level, but no histological lesions could be determined. As a result of the observation of the increases in relative kidney weight, the NOAEL was established at the 10% level. This exposure level reflects a dose of about 80 mg/kg bw/d. This study followed the principles of the OECD procedure 411 and was GLP compliant.

No treatment-related lesions were observed when $C_{12\text{-}13}AE_{6.5}$ was applied to the backs of ICR Swiss mice three times a week at dilutions of 0, 0.2, 1.0 or 5.0% for 18 months. The 5% level is

approximately equivalent to 270 mg/kg bw/d assuming that the mouse weight averages over the study was 75 g. No more detailed study information was available.	
Sensitisation of the skin or respiratory system Based on a weight-of-evidence approach and considering quality criteria in evaluating the studies, HERA conclude alcohol ethoxylates are not considered to be skin sensitizers. No data available to assess respiratory sensitisation. The majority of available guinea pig studies in which AEs were tested for skin sensitization properties demonstrated the absence of skin sensitization potential with both the Magnusson and Kligman and Buehler protocol.	HERA (2009), ECHA (2020)
Corrosion (irreversible and reversible)/irritation of the skin or eye HERA (2009) found that studies of skin and eye irritation potential show that the use of these AEs in household cleaning products is of low concern. When tested undiluted AEs were found to be slightly too severely irritating to skin in rabbits and rats and mildly to severely irritating to the rabbit eye. ECHA (2020) conclude that substance does not need to be classified for eye or skin irritation. Safe Work Australia (2020) provide the following the hazard categories and hazard statements for human health: • Eye damage – category 1; H318 (Causes serious eye damage) • Skin irritation – category 2; H315 (Causes skin irritation)	HERA (2009) ECHA (2020) Safe Work Australia (2020)

Physical Hazards	Reference
Flammable Potential Non flammable	ECHA (2020)
Explosive Potential Non explosive	ECHA (2020)

Toxicity Values	Value	Reference
Human Toxicity Data		
Acute Toxicity		
	NDF	
	NDF	
High Chronic/Repeat Dose Toxicity		
LOAEC	NDF	
LOAEL	NDF	
Animal Toxicity Data		
Acute Toxicity		
LD_{50}		
Rat, oral	0.6 g/kg to >10 g/kg	HERA (2009)
Rat, dermal	>2 g/kg ($C_{12\text{-}14}AE_3$ and $C_{12\text{-}15}AE_7$)	HERA (2009)
Rabbit, dermal	2 g/kg ($C_{12\text{-}14}AE_3$ and $C_{12\text{-}14}AE_6$)	HERA (2009)
LC_{50}		
Rat	Acute 4h-LC50>0.22 mg/L	HERA (2009)

	1.5 - 20.7 mg/L	
High Chronic/Repeat Dose Toxicity		
LOAEL	NOAEL = 15 mg/kg bw/d to >500 mg/kg bw/d	HERA (2009)
LOAEC	NDF	

Footnotes:
LD_{50} – lethal dose for 50% of experimental population
LC_{50} – lethal air concentration for 50% of experimental population
LOAEL – Lowest Observed Adverse Effect Level
LOAEC – Lowest Observed Adverse Effect Concentration
NDF – No data found within the limits of the search strategy

Human Health Toxicity Ranking*		
	Hazard data	**Comment**
Hazard Band 4		
Carcinogenicity (IARC Group 1 or 2A)	No	HERA (2009)
Mutagenicity/Genotoxicity (GHS Category 1A and 1B)	No	HERA (2009)
Reproductive Toxicity/Developmental toxicity (GHS Category 1, 1A and 1B)	No	HERA (2009)
Endocrine Disruption[1]	No	EC (2000)
Hazard Band 3		
Carcinogenicity (IARC Group 2B)	No	HERA (2009)
Mutagenicity/Genotoxicity (GHS Category 2)	No	HERA (2009)
Reproductive Toxicity/Developmental toxicity (GHS Category 2)	No	HERA (2009)
Acute Toxicity (oral, dermal or inhalation) Very Toxic/Toxic • oral LD_{50} ≤ 300 mg/kg [2] • dermal LD_{50} ≤ 1000 mg/kg • inhalation LC_{50} ≤ 10 mg/L [3] (or mg/m^3) (vapour)	No	HERA (2009)
High Chronic/repeat dose toxicity • oral LOAEL ≤ 10 mg/kg/d [2]; • dermal LOAEL ≤ 2 0 mg/kg/d; • inhalation LOAEC (6 h/d) ≤ 50 ppm/d for gases, ≤ 0.2 mg/L/d for vapours or ≤ 0.02 mg/L/d for dust/mists/fumes [3]	No (based on 10X elevation from NOAEL to LOAEL consistent with uncertainty factor applications).	Lowest NOAEL (oral) = 15 mg/kg bw/d
Corrosive (irreversible effect)	No	
Respiratory sensitiser	NDF	
Hazard Band 2		

Human Health Toxicity Ranking*		
	Hazard data	**Comment**
Harmful chronic/repeat dose toxicity • oral LOAEL > 10 mg/kg/d and ≤ 100 mg/kg/d • dermal LOAEL > 20 mg/kg/d and ≤ 200 mg/kg/d • inhalation (6-h/d) LOAEC > 50 mg/L ≤ 250 mg/L/d for gases, > 0.2 mg/L ≤ 1 .0 mg/L/d for vapours or > 0.02 mg/L ≤ 0.2 mg/L/d for dust/mists/fumes [3]	No (based on 10X elevation from NOAEL to LOAEL consistent with uncertainty factor applications).	Lowest NOAEL (oral) = 15 mg/kg bw/d.
Skin Sensitiser	No	ECHA (2020)
Hazard Band 1		
Acute Toxicity-Harmful • oral LD_{50} > 300 mg/kg ≤ 2000 mg/kg • dermal LD_{50} >1 000 mg/kg ≤ 2000 mg/kg; • inhalation LC_{50} (6 h/d) > 10 mg/L ≤ 20 mg/L for vapours) [3]	Yes	Oral LD50 = 0.6 g/kg to >10 g/kg
Irritant (reversible effect)	Yes	HERA (2009)
Hazard Band 0 **All indicators outside criteria listed in Hazards 1-4**		
Physical Hazards		
Flammable potential	No	ECHA (2020)
Explosive potential	No	ECHA (2020)
Hazard Evaluation (highest band) not including physical hazards	Hazard band 1	
Data confidence (available points out of 12 parameters)	11/12	92%

* Based on IMAP Framework [NICNAS (2013) Inventory Multi-tiered Assessment and Prioritisation (IMAP) Framework. National Industrial Chemicals Notification and Assessment Scheme. Department of Health and Aging, Canberra].

"[1] *Based on list of endocrine disrupting chemicals from the European Commission's Endocrine Disrupters website.*

[2] Based on list of neurotoxic chemicals from US Agency for Toxic Substances and Disease Registry (ATSDR).

[3] milligrams per kilogram body mass(mg/kg) or milligrams per kilogram body mas per day (mg/kg/d)

[4] Based on GHS cut-offs for hazard classification. For chronic/repeat dose toxicity, GHS cut-offs are provided as guidance values (i.e."*the dose/concentration at or below which significant health effects are observed*"). (p 18, NICNAS, 2013).

Human Health Guidelines		
Media	**Concentration (mg/m^3; mg/L; mg/kg)**	**Reference**
Occupational Exposure Limits		
Air (OEL)		
8-h TWA	NDF	
STEL	NDF	
Peak Limitation	NDF	
Environmental Exposure		
Air, ambient, residential	NDF	
Air, commercial/industrial	NDF	
Water, potable	NDF	
Water, recreational	NDF	
Soil, residential	NDF	
Soil, commercial/industrial	NDF	
Soil, protection of groundwater	NDF	

Footnotes:

OEL = Occupational Exposure Limit

TWA = 8 h Time-Weighted Average

STEL = (15 min) Short-term Exposure Limit

Qualifying Summary Comments

Alcohols, C10-16, ethoxylated, propoxylated is a fractional alcohol ethoxylate range which is part of a large range of chemicals that exist as alcohol ethoxylates (AE) and has been assessed as Hazard Band 1. It has been considered as part of the group of alcohol ethoxylates taking into consideration the carbon number and extent of ethoxylation where data were available. The Hazard Band 1 rating reflects a low order of acute toxicity and its associated irritant properties, the latter of greater concern for the occupational setting. Overall, alcohols, C10-16, ethoxylated, propoxylated, exhibit a lack of carcinogenic, genotoxic, reproductive and developmental toxicities with the latter only evidenced at maternally toxic doses. It is not considered a sensitiser.

References

EC (2000) European Commission Towards the establishment of a priority list of substances for further evaluation of their role in endocrine disruption, preparation of a candidate list of substances as a basis for priority setting, Final Report (Incorporating corrigenda to final report dated 21 June 2000).

European Chemicals Agency. Registered Chemical Substances Search. Available at http://echa.europa.eu/web/guest/information-on-chemicals/registered-substances. [Accessed 6 January 2020]

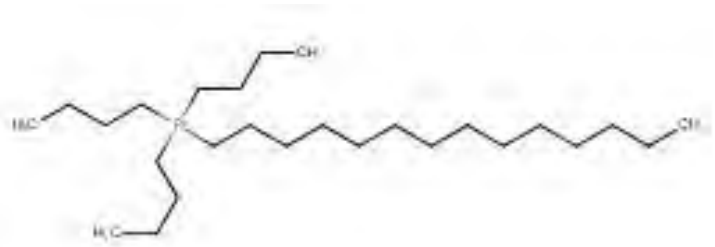
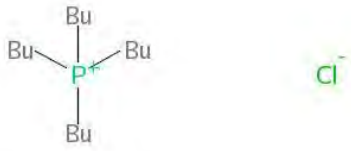
HERA (2009) Human and Environmental Risk Assessment (HERA) on Ingredients of Household Cleaning Products: Alcohol Ethoxylates Version 2.0. Available at http://www.heraproject.com & https://www.heraproject.com/files/34-F-09%20HERA%20AE%20Report%20Version%202%20-%203%20Sept%2009.pdf. [Accessed 7 January 2020]

IARC (2020) International Agency for Research on Cancer (IARC), 2020. Agents Classified by the *IARC Monographs*, Volumes 1–125. Available at https://monographs.iarc.fr/list-of-classifications & http://monographs.iarc.fr/ENG/Classification/ClassificationsCASOrder.pdf [Accessed 7 January 2020]

National Environment Protection (Assessment of Site Contamination) Amended Measure 2013 (No.1). *Schedule B1: Guidelines on Investigation Levels for soil and groundwater*. National Environment Protection Council, Commonwealth Government of Australia.

Safe Work Australia (2020) Hazardous Chemical Information System (HCIS) http://hcis.safeworkaustralia.gov.au/HazardousChemical/Details?chemicalID=100 Accessed February 2020.

Created by:	LPA	Date: 18/12/2019
Reviewed by:	CLB	Date and Revision: 20/01/20

Name	Tributyl tetradecyl phosphonium chloride
Synonyms	Tributyltetradecylphosphonium chloride
CAS number	81741-28-8
Molecular formula	$C_{26}H_{56}P.Cl$
Molecular structure	 (Source: ECHAa, 2020)
Surrogate	Name: Tetra-n-butyl phosphonium chloride; tetrabutylphosphonium chloride CAS RN: 2304-30-5 Basis for adoption: Limited information available for CAS 81741-28-8. U.S. EPA's Analog Identification Methodology (AIM) Tool software program identified Tetra-n-butyl phosphonium chloride as a read-across substance (U.S. EPA, 2020a).
Molecular formula (surrogate)	$C_{16}H_{36}P.Cl$
Molecular structure (surrogate)	 (Source: ECHAb, 2020)

Overview	References
Tetrabutylphosphonium chloride is an off-white waxy solid (at 20°C and 1013 hPa). It has a reported melting point of approximately 62°C - 64°C and will decompose upon boiling at approximately 345°C. Tetrabutylphosphonium chloride is considered completely miscible in water (at 25°C), has a vapour pressure of 0.018 Pa (at 25°C) and a relative density of 0.978 (at 20°C). It is considered non-flammable, non-explosive and non-oxidising.	ECHA, 2020b

Tetrabutylphosphonium chloride is registered for use in Scientific Research and Development. Tributyltetradecylphosphonium chloride is used as an active ingredient in pesticides and biocides and as an antimicrobial. Tetrabutylphosphonium chloride is reportedly not readily biodegradable in freshwater. The Log Kow was reported as -0.44 (at 23°C)	US EPA, 2020b

Human Health Toxicity Summary	Reference
Carcinogenicity Tributyltetradecylphosphonium chloride or Tetrabutylphosphonium chloride have not been evaluated by the International Agency for Research on Cancer (IARC) as to its carcinogenicity. There is data lacking for assessment of carcinogenicity.	IARC, 2020 ECHA, 2020b
Mutagenicity/Genotoxicity Tetrabutylphosphonium chloride was not classified for genotoxicity, based on CLP Regulation EC (No.) 1272/2008, based on available data according to ECHA. The key study cited by ECHA is an AMES test undertaken in accordance with OECD guideline 471 and GLP principles. The study reported all bacterial strains showed negative responses under the study conditions. Tetrabutylphosphonium chloride was determined to not be mutagenic in the Salmonella typhimurium reverse mutation assess and in the Escherichia coli reverse mutation assay with or without metabolic activation.	ECHA, 2020b
Reproductive Toxicity There is data lacking for assessment of reproductive toxicity.	ECHA, 2020b
Developmental Toxicity/Teratogenicity There is data lacking for assessment of developmental toxicity.	ECHAb, 2020b
Endocrine Disruption Tributyltetradecylphosphonium chloride or Tetrabutylphosphonium chloride are not identified in the European Commission (EC)'s report, "*Towards the establishment of a priority list of substances for further evaluation of their role in endocrine disruption*" as a substance of interest.	EC, 2000
Acute Toxicity (oral, dermal, inhalation) The acute **oral** toxicity of tetrabutylphosphonium chloride has been classified as Acute Toxicity 4 (H302: Harmful if swallowed), according to ECHA.	ECHA, 2020b

The key acute oral toxicity study cited by ECHA was undertaken on an analogue substance (Tetrabutylphosphonium Bromide) and was performed in accordance with OECD 423 guidelines and GLP principles. The study exposed female rats by gavage to 300 mg/kg bw and 2000 mg/kg bw. At the 2000 mg/kg dose, all animals were found dead on Day 1, and at the 300 mg/kg bw dose, no mortality occurred. The LD_{50} was established to be within the range of 300-2000 mg/kg bw, with a LD_{50} cut-off value of 500 mg/kg bw reported. The acute **dermal** toxicity of tetrabutylphosphonium chloride has been classified as Acute Toxicity 3 (H311: Toxic in contact with skin), according to ECHA. The key dermal toxicity study cited by ECHA was undertaken in accordance with OECD 402 Guideline and involved the application of tetrabutylphosphonium chloride to the skin of rabbits. Exposure included doses of 100, 200, 300 and 400 mg/kg undiluted compounds for 24 hours, with occlusive coverage. The LD_{50} for the undiluted compounds was reported as 225 mg/kg (male rabbits). The acute **inhalation** toxicity of tetrabutylphosphonium chloride has been classified as Acute Toxicity 1 (H330: Fatal if inhaled), according to ECHA. The key inhalation toxicity study cited by ECHA was undertaken in accordance with EPA OPPTS 870.130 guideline and GLP principles. Rats (one group of 5 males and 5 females) were exposed to tetrabutylphosphonium chloride aerosol in a nose only inhalation chamber for 4 hours at 0.05 mg/L (gravimetric chamber concentration of 0.053 mg/L). Within 3 days of exposure, 4 males and 2 females died, and 1 male and 2 females were euthanised for humane reasons. Based on these results, the inhalation LC_{50} 4 hour values was established to be <0.05 mg/L. Another key inhalation toxicity study was cited by ECHA, but it was outlined that this study could not be used for classification purposes. The study was undertaken in accordance with EPA OPPTS 870.130 guideline and GLP principles. Rats (male and female) were exposed to tetrabutylphosphonium chloride aerosol (50% in water) in a nose only inhalation chamber for 1 hour at 0.04 mg/L. All animals survived the exposure. The LC_{50} for 1 hr exposure was considered to be > 0.04 mg/L.	
Chronic/repeat dose toxicity (oral, dermal, inhalation) There is data lacking for the assessment of the chronic/repeat dose toxicity.	ECHA, 2020
Sensitisation of the skin or respiratory system Tetrabutylphosphonium chloride has been classified as **Skin** Sensitising Category 1B (H317: May cause an allergic skin reaction), according to ECHA. The key study cited by ECHA is a mouse local lymph node assay (LLNA) skin sensitisation study that concludes tetrabutylphosphonium bromide (considered a read-across substance) is sensitising to skin. The study was performed according to OECD Guideline 429, EU Method B.42 and GLP principles.	ECHA, 2020

There is data lacking for assessment of **respiratory** sensitisation.	
Corrosion (irreversible)/irritation (reversible) effects on the skin or eye Tetrabutylphosphonium chloride has been classified as **Skin** Corrosion Category 1C (H314: Causes severe skin burns and eye damage), according to ECHA. ECHA cites an in vitro membrane barrier test for skin corrosion using Corrositex®, undertaken in accordance to OECD Guideline 435 and in compliance with GLP principles. The study involved tetrabutylphosphonium chloride being topically applied on top of a bio-barrier. The ability of the chemical to then pass through the bio-barrier and elicit a colour change in the underlying liquid chemical system was evaluated. It was concluded that the results indicated a corrosive potential. Tetrabutylphosphonium chloride has been classified as **Eye** Damage Category 1 (H318: Causes serious eye damage), according to ECHA. ECHA outlines that an eye irritation study is not required, because classification is triggered as a result of the skin irritation study.	ECHA, 2020b

Physical Hazards	Reference
Flammable Potential Non-flammable. No flash point was observed up to 130°C in a closed cup experimental study.	ECHA, 2020
Explosive Potential Non-explosive. An experimental study was considered not warranted because the compound does not contain chemical groups present that are associated with explosive properties.	ECHA, 2020

Toxicity Values	Value	Reference
Human Toxicity Data		
High Chronic/Repeat Dose Toxicity		
LOAEC	NDF	
LOAEL	NDF	
Animal Toxicity Data		
Acute Toxicity		
LD_{50}		
Rat, oral	LD_{50} cut-off 500 mg/kg bw	Cited by ECHA, 2020
Rabbit, dermal	LD_{50} 225 mg/kg	Cited by ECHA, 2020
LC_{50}		
Rat	LC_{50} (4 hour) <0.05 mg/L.	Cited by ECHA, 2020
High Chronic/Repeat Dose Toxicity		
LOAEL	NDF	
LOAEC	NDF	

Footnotes:
LD_{50} – lethal dose for 50% of experimental population
LC_{50} – lethal air concentration for 50% of experimental population

LOAEL – Lowest Observed Adverse Effect Level
LOAEC – Lowest Observed Adverse Effect Concentration
NDF – No data found within the limits of the search strategy

Human Health Toxicity Ranking		
	Hazard data	**Comment**
Hazard Band 4		
Carcinogenicity (IARC Group 1 or 2A)	No	Based on IARC, 2020
Mutagenicity/Genotoxicity (GHS Category 1A and 1B)	No	
Reproductive Toxicity/Developmental toxicity (GHS Category 1, 1A and 1B)	NDF	
Endocrine Disruption[1]	No	
Hazard Band 3		
Carcinogenicity (IARC Group 2B)	No	
Mutagenicity/Genotoxicity (GHS Category 2)	No	
Reproductive Toxicity/Developmental toxicity (GHS Category 2)	NDF	
Acute Toxicity (oral, dermal or inhalation) Very Toxic/Toxic • oral LD_{50} ≤ 300 mg/kg [2] • dermal LD_{50} ≤ 1000 mg/kg • inhalation LC_{50} ≤ 10 mg/L [3] (or mg/m^3) (vapour)	Yes	Dermal LD_{50} 225 mg/kg Classified as toxic in contact with skin. Inhalation LC_{50} (4 hour) <0.05 mg/L. Classified as fatal if inhaled.
High Chronic/repeat dose toxicity • oral LOAEL ≤ 10 mg/kg/d [2]; • dermal LOAEL ≤ 2 0 mg/kg/d; • inhalation LOAEC (6 h/d) ≤ 50 ppm/d for gases, ≤ 0.2 mg/L/d for vapours or ≤ 0.02 mg/L/d for dust/mists/fumes [3]	NDF	
Corrosive (irreversible effect)	Yes	Classified as corrosive, causing skin burns and eye damage.

Human Health Toxicity Ranking		
	Hazard data	**Comment**
Respiratory sensitiser	NDF	
Hazard Band 2		
Harmful chronic/repeat dose toxicity • oral LOAEL > 10 mg/kg/d and ≤ 100 mg/kg/d • dermal LOAEL > 20 mg/kg/d and ≤ 200 mg/kg/d • inhalation (6-h/d) LOAEC > 50 mg/L ≤ 250 mg/L/d for gases, > 0.2 mg/L ≤ 1 .0 mg/L/d for vapours or > 0.02 mg/L ≤ 0.2 mg/L/d for dust/mists/fumes [3]	NDF	
Skin Sensitiser	Yes	Classified as may cause allergic skin reaction.
Hazard Band 1		
Acute Toxicity-Harmful • oral LD_{50} > 300 mg/kg ≤ 2000 mg/kg • dermal LD_{50} >1 000 mg/kg ≤ 2000 mg/kg; • inhalation LC_{50} (6 h/d) > 10 mg/L ≤ 20 mg/L for vapours) [3]	Yes	Oral LD_{50} cut-off 500 mg/kg bw Classified as harmful if swallowed.
Irritant (reversible effect)	No	Classified as corrosive.
Hazard Band 0 **All indicators outside criteria listed in Hazards 1-4**	1	
Physical Hazards		
Flammable potential	No	
Explosive potential	No	
Hazard Evaluation (highest band) not including physical hazards	3	Based on acute inhalation and dermal toxicity, and corrosive to skin and eyes.
Data confidence (available points out of 12 parameters)	9/12	75% Data based on surrogate compound

* Based on IMAP Framework [NICNAS (2013) Inventory Multi-tiered Assessment and Prioritisation (IMAP) Framework. National Industrial Chemicals Notification and Assessment Scheme. Department of Health and Aging, Canberra].

"[1]Based on list of endocrine disrupting chemicals from the European Commission's Endocrine Disrupters website.

[2] milligrams per kilogram body mass (mg/kg) or milligrams per kilogram body mass per day (mg/kg/d)

[3] Based on GHS cut-offs for hazard classification. For chronic/repeat dose toxicity, GHS cut-offs are provided as guidance values (i.e. the dose/concentration at or below which significant health effects are observed)". (p 18, NICNAS 2013).

Human Health Guidelines		
Media	**Concentration (mg/m^3; mg/L; mg/kg)**	**Reference**
Occupational Exposure Limits		
Air (OEL)		
8-h TWA	NDF	
STEL	NDF	
Peak Limitation	NDF	
Environmental Exposure		
Air, ambient, residential	NDF	
Air, commercial/industrial	NDF	
Water, potable	NDF	
Water, recreational	NDF	
Soil, residential	NDF	
Soil, commercial/industrial	NDF	

Soil, protection of groundwater	NDF	

Footnotes:

OEL = Occupational Exposure Limit

TWA = 8 h Time-Weighted Average

STEL = (15 min) Short-term Exposure Limit

Qualifying Summary Comments

Tetrabutylphosphonium chloride (CAS RN: 2304-30-5) has been adopted as a surrogate compound for assessment of Tributyltetradecylphosphonium chloride (CAS RN: 81741-28-8), as there is limited data available for tributyltetradecylphosphonium chloride. Tetrabutylphosphonium chloride is an off-white waxy solid (at 20°C and 1013 hPa). It has a reported melting point of approximately 62°C - 64°C and will decompose upon boiling at approximately 345°C. Tetrabutylphosphonium chloride is considered completely miscible in water (at 25°C), has a vapour pressure of 0.018 Pa (at 25°C) and a relative density of 0.978 (at 20°C). It is considered non-flammable, non-explosive and non-oxidising. Tetrabutylphosphonium chloride is registered for use in Scientific Research and Development. Tributyltetradecylphosphonium chloride is an active ingredient in pesticides and biocides and is used as an antimicrobial.

Tetrabutylphosphonium chloride has been ranked in Hazard Band 3, due to acute inhalation and dermal toxicity, and corrosivity to skin and eyes. It is considered fatal if inhaled, toxic following contact with the skin and harmful if shallowed. It is also considered corrosive to the skin and eyes and sensitising to the skin. Data is lacking for the assessment of the chronic toxicity, reproductive toxicity and respiratory sensitization potential of tetrabutylphosphonium chloride.

References

European Chemicals Agency (ECHA)a, 2020. Substance for Tributyltetradecylphosphonium chloride. Available at https://echa.europa.eu/substance-information/-/substanceinfo/100.072.531. Last modified 17/12/2019, accessed January 2020.

European Chemicals Agency (ECHA)b, 2019. Registration Dossier for Tetrabutylphosphonium chloride. Available at https://echa.europa.eu/registration-dossier/-/registered-dossier/27398/1. Last modified 03/02/2019, accessed January 2020.

European Commission (EC), 2000. Towards the establishment of a priority list of substances for further evaluation of their role in endocrine disruption, preparation of a candidate list of substances as a basis for priority setting, Final Report (Incorporating corrigenda to final report dated 21 June 2000).

International Agency for Research on Cancer (IARC), 2019. Agents Classified by the IARC Monographs, Volumes 1–125, last updated 12 December 2019. Available at https://monographs.iarc.fr/agents-classified-by-the-iarc/, accessed January 2020.

U.S. Environmental Protection Agency (U.S. EPA), 2020a. *Analog Identification Methodology (AIM) Tool software program*. Available at https://www.epa.gov/tsca-screening-tools/analog-identification-methodology-aim-tool, accessed January 2020.

U.S. Environmental Protection Agency (U.S. EPA), 2020b. *Chemistry Dashboard* Available at https://comptox.epa.gov/dashboard/dsstoxdb/results?search=DTXSID9034997#exposure, accessed January 2020.

Created by:	MGT	Date: 24/01/2020
Reviewed by:	CLB	Date and Revision: 28/01/2020

APPENDIX E

Chemical Information Sheets – Ecological Hazard Assessment

Project number: 12766600

ORGANIC

Name	Ethanol
Synonyms	
CAS Number	64-17-5
Molecular Formula	C2H6O

Physical Properties	Value	Reference
PhaseState:	Liquid	ECHA 2020
Molecular Weight (g/mol):	46.07	ECHA 2020
Melting Point (°C):	-114.14	ECHA 2020
Boiling Point (°C):	78.3	ECHA 2020
Density / Specific Gravity (g/cm3):	0.79	ECHA 2020
Vapour Pressure (mm Hg at 25°C):	5.93E+01	EPISUITE 2011 v4.1
Solubility (mg/L):	7.89E+05	ECHA 2020
Henry's Law Constant (atm m³/mole):	5.76E-06	EPISUITE 2011 v4.1
Organic carbon partition coefficient (Koc):	1.05	ECHA 2020
Log organic carbon partition coefficient (log Koc):	0.02	EPISUITE 2011 v4.1
Log octanol - water partition coefficient (log Kow):	-0.35	ECHA 2020

Persistance / Bioaccumulation	Value	Reference
Biowin 3 (Ultimate Survey Biodegradation):	3.2573	EPISUITE 2011 v4.1
Biowin 4 (Primary Biodegradation):	3.9107	EPISUITE 2011 v4.1
EPISUITE Ready Biodegradability:	Biodegrades fast	EPISUITE 2011 v4.1
Biowin 7 (Anaerobic Model Prediction):	0.9153	EPISUITE 2011 v4.1
Fugacity_Air: (%)	7.4	EPISUITE 2011 v4.1
Fugacity_Water: (%)	41	EPISUITE 2011 v4.1
Fugacity_Soil: (%)	52	EPISUITE 2011 v4.1
Fugacity_Sediment: (%)	0.0718	EPISUITE 2011 v4.1
Bioconcentration factor (BCF):	3.162	EPISUITE 2011 v4.1
Biotransformation half - life (Days):	0.02866	EPISUITE 2011 v4.1

GOLDER

Project number: 12766600 ORGANIC

Aquatic Ecotoxicological Data

Acute toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc mg/L**	**Reference**
Salmo gairdneri (Oncorhynchus mykiss)	Rainbow Trout	Fish LC50	MOR	Mortality	1	11200	ECHA 2020
Ceriodaphnia dubia	Water flea	Invertebrate LC50	MOR	Mortality/Immobilization	2	5012	ECHA 2020
Chlorella vulgaris	Green algae	Plant EC50	GRO	Growth	3	275	ECHA 2020

Chronic toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time**	**Conc mg/L**	**Reference**
Lemna gibba	Macrophyte	Plant NOEC	GRO	Growth	7	280	ECHA 2020
Daphnia magna	Water flea	Invertebrate NOEC	REP	Reproduction	10	9.6	ECHA 2020

Terrestrial Ecotoxicological Data

Acute Toxity Data							
Common Name	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc**	**Reference**	**Units**
Rat	Mammalian LD50	MOR	Mortality		2000	ECHA 2020	mg/kg
Guinea pig	Mammalian LD50	MOR	Mortality		5560	PubChem 2020	mg/kg
Mouse		MOR	Mortality		3450		
Mouse	Mammalian LD50	MOR	Mortality		3450	PubChem 2020	

Chronic toxicity data							
Common Name	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc**	**Reference**	**Units**
Earthworm	1	MOR	Mortality	14	134	ECOSAR 2012	mg/L

GOLDER

Project number: 12766600

ORGANIC

Created By:	Naomi Cooper	Date:	30/01/2020
Checked By:	Carolyn Brumley	Date:	31/01/2020

Project number: 12766600

ORGANIC

Name	Butyl alcohol
Synonyms	
CAS Number	71-36-3
Molecular Formula	C4H10O

Physical Properties	Value	Reference
PhaseState:	Liquid	ECHA 2020
Molecular Weight (g/mol):		0
Melting Point (°C):	-90.00	ECHA 2020
Boiling Point (°C):	119	ECHA 2020
Density / Specific Gravity (g/cm3):	0.81	ECHA 2020
Vapour Pressure (mm Hg at 25°C):	7.78E+00	EPISUITE 2011 v4.1
Solubility (mg/L):	6.60E+04	ECHA 2020
Henry's Law Constant (atm m³/mole):	9.99E-06	EPISUITE 2011 v4.1
Organic carbon partition coefficient (Koc):	3.47	EPISUITE 2011 v4.1
Log organic carbon partition coefficient (log Koc):	0.54	EPISUITE 2011 v4.1
Log octanol - water partition coefficient (log Kow):	1	ECHA 2020

Persistance / Bioaccumulation	Value	Reference
Biowin 3 (Ultimate Survey Biodegradation):	3.4937	EPISUITE 2011 v4.1
Biowin 4 (Primary Biodegradation):	4.1393	EPISUITE 2011 v4.1
EPISUITE Ready Biodegradability:	Biodegrades fast	EPISUITE 2011 v4.1
Biowin 7 (Anaerobic Model Prediction):	0.6495	EPISUITE 2011 v4.1
Fugacity_Air: (%)	4.56	EPISUITE 2011 v4.1
Fugacity_Water: (%)	40	EPISUITE 2011 v4.1
Fugacity_Soil: (%)	55	EPISUITE 2011 v4.1
Fugacity_Sediment: (%)	0.0747	EPISUITE 2011 v4.1
Bioconcentration factor (BCF):	3.162	EPISUITE 2011 v4.1
Biotransformation half - life (Days):	0.06816	EPISUITE 2011 v4.1

GOLDER

Project number: 12766600 ORGANIC

Aquatic Ecotoxicological Data

Acute toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc mg/L**	**Reference**
Pimephales promelas	Fathead minnow	Fish LC50	MOR	Mortality	4	1376	ECHA 2020
Daphnia magna	Water flea	Invertebrate EC50	MOR	Mortality/Immobilization	4	1328	ECHA 2020

Chronic toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time**	**Conc mg/L**	**Reference**
Daphnia magna	Water flea	Invertebrate NOEC	REP	Reproduction	21	4.1	ECHA 2020
Selenastrum capricornutum	Green algae	Plant NOEC	GRO	Growth	4	129	ECHA 2020

Terrestrial Ecotoxicological Data

Acute Toxity Data							
Common Name	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc**	**Reference**	**Units**
Rat	Mammalian LD50	MOR	Mortality		2292	ECHA 2020	mg/kg bw
Mouse	Mammalian LD50	MOR	Mortality		2680	ECHA 2020	mg/kg bw
Rabbit	Mammalian LD50	MOR	Mortality		3500	ECHA 2020	mg/kg bw
Earthworm	QSAR Earthworm LC50	MOR	Mortality	14	170	ECOSAR 2012	mg/L
Hamster	Mammalian LD50	MOR	Mortality		1200	ECHA 2020	mg/kg bw

Project number: 12766600

ORGANIC

Created By: Naomi Cooper Date: 31/01/2020

Checked By: Carolyn Brumley Date: 31/01/2020

Project number: 12766600 ORGANIC

Name	Amides, C18-unsaturated, N,N-bis(hydroxyethyl)
Synonyms	
CAS Number	93-83-4
Molecular Formula	C22H43NO3

Physical Properties	Value	Reference
PhaseState:	Liquid	ECHA 2020
Molecular Weight (g/mol):		0
Melting Point (°C):	-80.00	ECHA 2020
Boiling Point (°C):	300	ECHA 2012
Density / Specific Gravity (g/cm3):	0.97	ECHA 2020
Vapour Pressure (mm Hg at 25°C):	8.00E-07	ECHA 2020
Solubility (mg/L):	1.20E-01	ECHA 2020
Henry's Law Constant (atm m³/mole):	1.04E-11	EPISUITE 2011 v4.1
Organic carbon partition coefficient (Koc):	1,448.00	EPISUITE 2011 v4.1
Log organic carbon partition coefficient (log Koc):	3.16	EPISUITE 2011 v4.1
Log octanol - water partition coefficient (log Kow):	6	ECHA 2020

Persistance / Bioaccumulation	Value	Reference
Biowin 3 (Ultimate Survey Biodegradation):	2.9465	EPISUITE 2011 v4.1
Biowin 4 (Primary Biodegradation):	4.0479	EPISUITE 2011 v4.1
EPISUITE Ready Biodegradability:	Biodegrades fast	EPISUITE 2011 v4.1
Biowin 7 (Anaerobic Model Prediction):	0.4572	EPISUITE 2011 v4.1
Fugacity_Air: (%)	0.102	EPISUITE 2011 v4.1
Fugacity_Water: (%)	24	EPISUITE 2011 v4.1
Fugacity_Soil: (%)	75	EPISUITE 2011 v4.1
Fugacity_Sediment: (%)	1.14	EPISUITE 2011 v4.1
Bioconcentration factor (BCF):	99.66	EPISUITE 2011 v4.1
Biotransformation half - life (Days):	0.2725	EPISUITE 2011 v4.1

Project number: 12766600 ORGANIC

Aquatic Ecotoxicological Data

Acute toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc mg/L**	**Reference**
Danio rerio	Zebrafish	Fish LC50	MOR	Mortality	4	5.1	ECHA 2020
Daphnia magna	Water flea	Invertebrate EC50	MOR	Mortality/Immobilization	1	3.3	ECHA 2020
Desmodesmus subspicatus	Green algae	Plant EC50	GRO	Growth	3	18.6	ECHA 2020

Chronic toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time**	**Conc mg/L**	**Reference**
Oncorhynchus mykiss	Rainbow trout	Fish NOEC	MOR	Mortality	28	0.26	ECHA 2020
Daphnia magna	Water flea	Invertebrate NOEC	MOR/REP	Mortality and reproduction	21	0.07	ECHA 2020
Oncorhynchus mykiss	Rainbow trout	Fish LOEC	MOR	Mortality	28	0.83	ECHA 2020
Daphnia magna	Water flea	Invertebrate LOEC	MOR	Mortality	21	0.24	ECHA 2020

Terrestrial Ecotoxicological Data

Acute Toxity Data							
Common Name	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc**	**Reference**	**Units**
Rat	Mammalian LD50	MOR	Mortality		10000	ECHA 2020	mg/kg/bw

Created By: Naomi Cooper Date: 30/01/2020

Checked By: Carolyn Brumley Date: 31/01/2020

Project number: 12766600 ORGANIC

Name	Triethanol amine
Synonyms	
CAS Number	102-71-6
Molecular Formula	C6H15NO3

Physical Properties	Value	Reference
PhaseState:	Liquid	PubChem 2020
Molecular Weight (g/mol):	149.19	PubChem 2020
Melting Point (°C):	21.50	PubChem 2020
Boiling Point (°C):	350	PubChem 2020
Density / Specific Gravity (g/cm3):	1.12	PubChem 2020
Vapour Pressure (mm Hg at 25°C):	3.59E-06	PubChem 2020
Solubility (mg/L):	1.00E+06	EPISUITE 2011 v4.1
Henry's Law Constant (atm m³/mole):	7.05E-13	EPISUITE 2011 v4.1
Organic carbon partition coefficient (Koc):	10.00	PubChem 2020
Log organic carbon partition coefficient (log Koc):	1.00	PubChem 2020
Log octanol - water partition coefficient (log Kow):	-1	PubChem 2020

Persistance / Bioaccumulation	Value	Reference
Biowin 3 (Ultimate Survey Biodegradation):	3.0946	EPISUITE 2011 v4.1
Biowin 4 (Primary Biodegradation):	3.7328	EPISUITE 2011 v4.1
EPISUITE Ready Biodegradability:	Biodegrades fast	EPISUITE 2011 v4.1
Biowin 7 (Anaerobic Model Prediction):	0.3155	EPISUITE 2011 v4.1
Fugacity_Air: (%)	0.0000161	EPISUITE 2011 v4.1
Fugacity_Water: (%)	31	EPISUITE 2011 v4.1
Fugacity_Soil: (%)	69	EPISUITE 2011 v4.1
Fugacity_Sediment: (%)	0.0688	EPISUITE 2011 v4.1
Bioconcentration factor (BCF):	3.9	PubChem 2020
Biotransformation half - life (Days):	0.0008924	EPISUITE 2011 v4.1

GOLDER

Project number: 12766600 ORGANIC

Aquatic Ecotoxicological Data

Acute toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc mg/L**	**Reference**
Scenedesmus subspicatus	Green algae	Plant EC50	GRO	Growth	2	470	ECOTOX 2020
Ceriodaphnia dubia	Water flea	Invertebrate EC50	IMB	Immobilization	2	610	ECOTOX 2020
Pimephales promelas	Fathead minnow	Fish LC50	MOR	Mortality	4	11800	ECOTOX 2020

Chronic toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time**	**Conc mg/L**	**Reference**
Scenedesmus quadricauda	Green algae	Plant LOEC	GRO	Growth		1.8	ECOTOX 2020
Daphnia magna	Water flea	Invertebrate NOEC	REP	Reproduction	21	16	ECOTOX 2020

Terrestrial Ecotoxicological Data

Acute Toxity Data							
Common Name	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc**	**Reference**	**Units**
Mouse	Mammalian LD50	MOR	Mortality		5846	PubChem 2020	mg/kg
Rat	Mammalian LD50	MOR	Mortality		4920	PubChem 2020	mg/kg
Guinea Pig	Mammalian LD50	MOR	Mortality		2200	PubChem 2020	mg/kg
Rabbit	Mammalian LD50	MOR	Mortality		2200	PubChem 2020	mg/kg

Created By: Naomi Cooper Date: 9/01/2020

GOLDER

Project number: 12766600

ORGANIC

Checked By: Carolyn Brumley

Date: 17/01/2020

GOLDER

Project number: 12766600 ORGANIC

Name	Ethylene glycol
Synonyms	
CAS Number	107-21-1
Molecular Formula	C2H6O2

Physical Properties	Value	Reference
PhaseState:	Liquid	ECHA 2020
Molecular Weight (g/mol):	62.068	ATSDR 2010
Melting Point (°C):	-13.00	ECHA 2020
Boiling Point (°C):	197.4	ECHA 2020
Density / Specific Gravity (g/cm3):	1.11	ECHA 2020
Vapour Pressure (mm Hg at 25°C):	8.90E-02	ATSDR 2010
Solubility (mg/L):	1.00E+06	ECHA 2020
Henry's Law Constant (atm m^3/mole):	6.00E-08	ATSDR 2010
Organic carbon partition coefficient (Koc):	1.00	EPISUITE 2011 v4.1
Log organic carbon partition coefficient (log Koc):	0.00	EPISUITE 2011 v4.1
Log octanol - water partition coefficient (log Kow):	-1.36	ECHA 2020

Persistance / Bioaccumulation	Value	Reference
Biowin 3 (Ultimate Survey Biodegradation):	3.3891	EPISUITE 2011 v4.1
Biowin 4 (Primary Biodegradation):	4.0171	EPISUITE 2011 v4.1
EPISUITE Ready Biodegradability:	Biodegrades fast	EPISUITE 2011 v4.1
Biowin 7 (Anaerobic Model Prediction):	1.1563	EPISUITE 2011 v4.1
Fugacity_Air: (%)	1.44	EPISUITE 2011 v4.1
Fugacity_Water: (%)	36	EPISUITE 2011 v4.1
Fugacity_Soil: (%)	62	EPISUITE 2011 v4.1
Fugacity_Sediment: (%)	0.0638	EPISUITE 2011 v4.1
Bioconcentration factor (BCF):	3.162	EPISUITE 2011 v4.1
Biotransformation half - life (Days):	0.0065	EPISUITE 2011 v4.1

Project number: 12766600 ORGANIC

Aquatic Ecotoxicological Data

Acute toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc mg/L**	**Reference**
Pimephales promelas	Fathead minnow	Fish LC50	MOR	Mortality	4	16	ECOTOX 2020
Daphnia magna	Water flea	Invertebrate EC50	MOR	Mortality	2	6900	ECOTOX 2020

Chronic toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time**	**Conc mg/L**	**Reference**
Ceriodaphnia magna	Water flea	Fish MATC	MOR	Mortality	7	4.2	ECOTOX 2020
Pimephales promelas	Fathead minnow	Fish NOEC	GRO	Growth	7	<3330	ECOTOX 2020
Ceriodaphnia dubia	Water flea	Invertebrate NOEC	REP	Reproduction	7	<3330	ECOTOX 2020

Terrestrial Ecotoxicological Data

Acute Toxity Data							
Common Name	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc**	**Reference**	**Units**
Rat	Mammalian LD50	MOR	Mortality		4000	ATSDR 2010	mg/kg day
Earthworm	QSAR Earthworm LC50	MOR	Mortality	14	232	ECOSAR 2012	mg/L

Created By: Naomi Cooper Date: 3/02/2020

Checked By: Carolyn Brumley Date: 3/02/2020

Project number: 12766600

ORGANIC

Name	Glutaraldehyde
Synonyms	
CAS Number	111-30-8
Molecular Formula	C5H8O2

Physical Properties	Value	Reference
PhaseState:	Liquid	ECHA 2019
Molecular Weight (g/mol):		0
Melting Point (°C):	-33.00	ECHA 2019
Boiling Point (°C):	101.5	ECHA 2019
Density / Specific Gravity (g/cm3):	1.13	ECHA 2019
Vapour Pressure (mm Hg at 25°C):	6.00E-01	EPISUITE 2011 v4.1
Solubility (mg/L):	1.67E+05	EPISUITE 2011 v4.1
Henry's Law Constant (atm m³/mole):	1.10E-07	EPISUITE 2011 v4.1
Organic carbon partition coefficient (Koc):	1.00	EPISUITE 2011 v4.1
Log organic carbon partition coefficient (log Koc):	0.00	EPISUITE 2011 v4.1
Log octanol - water partition coefficient (log Kow):	-0.36	ECHA 2019

Persistance / Bioaccumulation	Value	Reference
Biowin 3 (Ultimate Survey Biodegradation):	3.0226	EPISUITE 2011 v4.1
Biowin 4 (Primary Biodegradation):	4.0966	EPISUITE 2011 v4.1
EPISUITE Ready Biodegradability:	Biodegrades fast	EPISUITE 2011 v4.1
Biowin 7 (Anaerobic Model Prediction):	1.1592	EPISUITE 2011 v4.1
Fugacity_Air: (%)	0.395	EPISUITE 2011 v4.1
Fugacity_Water: (%)	40	EPISUITE 2011 v4.1
Fugacity_Soil: (%)	59	EPISUITE 2011 v4.1
Fugacity_Sediment: (%)	0.0755	EPISUITE 2011 v4.1
Bioconcentration factor (BCF):	3.162	EPISUITE 2011 v4.1
Biotransformation half - life (Days):	0.05197	EPISUITE 2011 v4.1

GOLDER

Project number: 12766600 ORGANIC

Aquatic Ecotoxicological Data

Acute toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc mg/L**	**Reference**
Pimephales promelas	Fathead minnow	Fish LC50	MOR	Mortality	4	5.4	ECOTOX 2020
Daphnia magna	Water flea	Invertebrate EC50	MOR	Mortality/Immobilization	2	0.75	ECOTOX 2020
Scenedesmus subspicatus	Green algae	Plant EC50	GRO	Growth	3	0.375	ECHA 2019

Chronic toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time**	**Conc mg/L**	**Reference**
Oncorhynchus mykiss	Rainbow trout	Fish NOEC	MOR/GRO	Mortality/growth	97	1.6	ECHA 2019
Oncorhynchus mykiss	Rainbow trout	Fish LOEC	MOR/GRO	Mortality/growth	97	5	ECHA 2019
Daphnia magna	Water flea	Invertebrate NOEC	REP	Reproduction	21	5	ECHA 2019
Pseudokirchneriella subcapitata	Algae	Plant NOEC	GRO	Growth	4	0.042	ECOTOX 2020

Terrestrial Ecotoxicological Data

Acute Toxity Data							
Common Name	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc**	**Reference**	**Units**
Rat	Mammalian LD50	MOR	Mortality		77	ECHA 2019	mg/kg bw
Mouse	Mammalian LD50	MOR	Mortality		27	ECHA 2019	mg/kg bw
Rabbit	Mammalian LD50	MOR	Mortality		133	ECHA 2019	mg/kg bw
Earthworm	QSAR Earthworm LC50	MOR	Mortality	14	170	ECHA 2019	mg/kg soil dw

Project number: 12766600

ORGANIC

Created By:	Naomi Cooper	Date:	31/01/2020
Checked By:	Carolyn Brumley	Date:	31/01/2020

GOLDER

Project number: 12766600 ORGANIC

Name	Diethanolamine
Synonyms	
CAS Number	111-42-2
Molecular Formula	C4H11NO2

Physical Properties	Value	Reference
PhaseState:	Viscous liquid or deliquescent prisms	PubChem 2020
Molecular Weight (g/mol):	105.14	PubChem 2020
Melting Point (°C):	27.90	PubChem 2020
Boiling Point (°C):	268.8	PubChem 2020
Density / Specific Gravity (g/cm3):	1.10	ECHA 2020
Vapour Pressure (mm Hg at 25°C):	2.80E-04	PubChem 2020
Solubility (mg/L):	1.00E+06	PubChem 2020
Henry's Law Constant (atm m³/mole):	3.90E-11	PubChem 2020
Organic carbon partition coefficient (Koc):	3.97	PubChem 2020
Log organic carbon partition coefficient (log Koc):	0.60	PubChem 2020
Log octanol - water partition coefficient (log Kow):	-1.43	PubChem 2020

Persistance / Bioaccumulation	Value	Reference
Biowin 3 (Ultimate Survey Biodegradation):	3.3112	EPISUITE 2011 v4.1
Biowin 4 (Primary Biodegradation):	3.9982	EPISUITE 2011 v4.1
EPISUITE Ready Biodegradability:	Biodegrades fast	EPISUITE 2011 v4.1
Biowin 7 (Anaerobic Model Prediction):	1.3829	EPISUITE 2011 v4.1
Fugacity_Air: (%)	0.00135	EPISUITE 2011 v4.1
Fugacity_Water: (%)	34	EPISUITE 2011 v4.1
Fugacity_Soil: (%)	66	EPISUITE 2011 v4.1
Fugacity_Sediment: (%)	0.0593	EPISUITE 2011 v4.1
Bioconcentration factor (BCF):	3	PubChem 2020
Biotransformation half - life (Days):	0.01362	EPISUITE 2011 v4.1

GOLDER

Project number: 12766600

ORGANIC

Aquatic Ecotoxicological Data

Acute toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc mg/L**	**Reference**
Oncorhynchus mykiss	Rainbow trout	Fish LC50	Mortality	Mortality	6	460	ECHA 2020
Daphnia magna	Water flea	Invertebrate LC50	Mortality	Mortality	4	1	ECOTOX 2020
Pseudokirchneriella subcapitata	Green algae	Plant EC50	GRO	Growth	3	9.5	ECHA 2020

Chronic toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time**	**Conc mg/L**	**Reference**
Daphnia magna	Water flea	Invertebrate NOEC	Reproduction	Reproduction	21	1.05	ECHA 2020
Pseudokirchneriella subcapitata	Green algae	Plant NOEC	Growth	Population changes	7	10	ECOTOX 2020
Pseudokirchneriella subcapitata	Green algae	Plant LOEC	Growth	Population changes	7	100	ECOTOX 2020

Terrestrial Ecotoxicological Data

Acute Toxity Data							
Common Name	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc**	**Reference**	**Units**
Rat	Mammalian LD50	MOR	Mortality		1100	ECHA 2020	mg/kg bw
Earthworm	QSAR Earthworm LC50	MOR	Mortality	35	>1000	ECHA 2020	mg/kg soil dw
Earthworm	QSAR Earthworm LC50	REP	Reproduction	63	776	ECHA 2020	mg/kg soil dw

Created By: Naomi Cooper Date: 9/01/2020

Checked By: Carolyn Brumley Date: 17/01/2020

Project number: 12766600 ORGANIC

Name	Tetra-n-butyl phosphonium chloride
Synonyms	
CAS Number	2304-30-5
Molecular Formula	C16H36P.Cl

Physical Properties	Value	Reference
PhaseState:	Solid	ECHA 2019
Molecular Weight (g/mol):		0
Melting Point (℃):	62.75	ECHA 2019
Boiling Point (℃):	344.8	ECHA 2019
Density / Specific Gravity(g/cm3):	0.98	ECHA 2019
Vapour Pressure (mm Hg at 25℃):	5.20E-04	EPISUITE 2011 v4.1
Solubility (mg/L):	8.43E-02	EPISUITE 2011 v4.1
Henry's Law Constant (atm m³/mole):	1.54E-02	EPISUITE 2011 v4.1
Organic carbon partition coefficient (Koc):	78,830.00	EPISUITE 2011 v4.1
Log organic carbon partition coefficient (log Koc):	4.90	EPISUITE 2011 v4.1
Log octanol - water partition coefficient (log Kow):	-0.44	ECHA 2019

Persistance / Bioaccumulation	Value	Reference
Biowin 3 (Ultimate Survey Biodegradation):	3.8170	EPISUITE 2011 v4.1
Biowin 4 (Primary Biodegradation):	4.5483	EPISUITE 2011 v4.1
EPISUITE Ready Biodegradability:	Biodegrades fast	EPISUITE 2011 v4.1
Biowin 7 (Anaerobic Model Prediction):	-0.4412	EPISUITE 2011 v4.1
Fugacity_Air: (%)	8.16	EPISUITE 2011 v4.1
Fugacity_Water: (%)	24	EPISUITE 2011 v4.1
Fugacity_Soil: (%)	60	EPISUITE 2011 v4.1
Fugacity_Sediment: (%)	8.12	EPISUITE 2011 v4.1
Bioconcentration factor (BCF):	286.4	EPISUITE 2011 v4.1
Biotransformation half - life (Days):	13.87	EPISUITE 2011 v4.1

Project number: 12766600

ORGANIC

Aquatic Ecotoxicological Data

Acute toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc mg/L**	**Reference**
Pimephales promelas	Fathead minnow	Fish LC50	MOR	Mortality	4	>100	ECHA 2019
Ceriodaphnia dubia	Water flea	Invertebrate EC50	MOR	Mortality/Immobilization	2	1.5	ECHA 2019
Pseudokirchneriella subcapitata	Green algae	Plant EC50	GRO	Growth	3	2.84	ECHA 2019

Terrestrial Ecotoxicological Data

Acute Toxity Data							
Common Name	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc**	**Reference**	**Units**
Rat	Mammalian LD50	MOR	Mortality		300	ECHA 2019	mg/kg bw
Earthworm	QSAR Earthworm LC50	MOR	Mortality	14	162	ECOSAR 2012	mg/L

Created By: Naomi Cooper Date: 31/01/2020

Checked By: Carolyn Brumley Date: 31/01/2020

Project number: 127666004

INORGANIC

Name	Sodium bisulfite
Synonyms	Monosodium sulfite, sodium sulhydrate, sodium hydrogen sulphite
CAS Number	7631-90-5
Molecular Formula	NaHSO3

Physical Properties	Value	Reference
PhaseState:	Solid	ECHA 2020
Molecular Weight (g/mol):		
Melting Point (°C):		
Boiling Point (°C):		
Solubility (mg/L):	724,000.00	ECHA 2020

Other Relevant Factors	Value	Reference
Reactivity		
Species:		
Reaction type:		
pH / Acidity		
acid / alkaline		
pH (10% solution)		

Sodium bisulfite is highly reactive (oxidation). Exposure potential is therefore limited.

GOLDER

Project number: 127666004 INORGANIC

Aquatic Ecotoxicological Data

Acute toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc mg/L**	**Reference**
Ceriodaphnia dubia	Water flea	Invertebrate LC50	MOR	Mortality	2	1.94	ECOTOX 2020
Pimephales promelas	Fathead minnow	Fish LC50	MOR	Mortality	4	26.2	ECOTOX 2020
	Green algae	Plant EC50	GRO	Growth	3	36.8	ECHA 2020

Chronic toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time**	**Conc mg/L**	**Reference**
Danio rerio	Zebrafish	Fish NOEC	MOR	Mortality	34	200.5	ECHA 2020
Daphnia magna	Water flea	Invertebrate NOEC	REP	Reproduction	21	8.41	ECHA 2020

Terrestrial Ecotoxicological Data

Acute Toxity Data							
Common Name	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc**	**Reference**	**Units**
Rat	Mammalian LD50	MOR	Mortality		1420	ECHA 2020	mg/kg bw

Created By: Naomi Cooper Date: 3/02/2020

Checked By Carolyn Brumley Date: 3/02/2020

GOLDER

Project number: 12766600 ORGANIC

Name	Guar gum
Synonyms	
CAS Number	9000-30-0
Molecular Formula	C10H14N5Na2O12P3

Physical Properties	Value	Reference
PhaseState:	Solid	
Molecular Weight (g/mol):	535.2	PubChem 2020
Melting Point (°C):		
Boiling Point (°C):		
Density / Specific Gravity (Enter Unit):		
Vapour Pressure (mm Hg at 25°C):		
Solubility (mg/L):	1.00E+00	PubChem 2020
Henry's Law Constant (atm m³/mole):		
Organic carbon partition coefficient (Koc):		
Log organic carbon partition coefficient (log Koc):		
Log octanol - water partition coefficient (log Kow):		

Persistance / Bioaccumulation	Value	Reference
Biowin 3 (Ultimate Survey Biodegradation):		
Biowin 4 (Primary Biodegradation):		
EPISUITE Ready Biodegradability:		
Biowin 7 (Anaerobic Model Prediction):		
Fugacity_Air: (%)		
Fugacity_Water: (%)		
Fugacity_Soil: (%)		
Fugacity_Sediment: (%)		
Bioconcentration factor (BCF):		
Biotransformation half - life (Days):		

Notes: Solubility is < 1mg/L at 18.9oC (66oF)

Project number: 12766600 ORGANIC

Aquatic Ecotoxicological Data

Acute toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc mg/L**	**Reference**
Daphnia magna	Water flea	Invertebrate LC50	MOR	Mortality	4	<6.2	ECOTOX 2020
Oncorhynchus mykiss	Rainbow trout	Fish LC50	MOR	Mortality	4	218	ECOTOX 2020

Terrestrial Ecotoxicological Data

Acute Toxity Data							
Common Name	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc**	**Reference**	**Units**
Rat	Mammalian LD50	MOR	Mortality		7060	FR 2011	mg/kg bw

Created By: Naomi Cooper Date: 3/02/2020

Checked By: Carolyn Brumley Date: 3/02/2020

Project number: 12766600

ORGANIC

Name	Sodium Polyacrylate
Synonyms	
CAS Number	9003-04-7
Molecular Formula	(C3H4O2)x-x-Na

Physical Properties	Value	Reference
PhaseState:		
Molecular Weight (g/mol):	4500	HERA 2014
Melting Point (°C):		
Boiling Point (°C):		
Density / Specific Gravity (g/cm3):	1.10	ChemIDplus 2020
Vapour Pressure (mm Hg at 25°C):		
Solubility (mg/L):	4.00E+05	HERA 2014
Henry's Law Constant (atm m³/mole):		
Organic carbon partition coefficient (Koc):		
Log organic carbon partition coefficient (log Koc):		
Log octanol - water partition coefficient (log Kow):		

Persistance / Bioaccumulation	Value	Reference
Biowin 3 (Ultimate Survey Biodegradation):		
Biowin 4 (Primary Biodegradation):		
EPISUITE Ready Biodegradability:		
Biowin 7 (Anaerobic Model Prediction):		
Fugacity_Air: (%)		
Fugacity_Water: (%)		
Fugacity_Soil: (%)		
Fugacity_Sediment: (%)		
Bioconcentration factor (BCF):		
Biotransformation half - life (Days):		

GOLDER

Project number: 12766600

ORGANIC

Aquatic Ecotoxicological Data

Acute toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc mg/L**	**Reference**
Danio rerio	Zebrafish	Fish LC50	MOR	Mortality	4	>200	HERA 2014
Daphnia magna	Water flea	Invertebrate EC50	MOR	Mortality/Immobilization	2	>200	HERA 2014
Selenastrum capricornutum	Green algae	Plant EC50	GRO	Growth	3	40	HERA 2014

Chronic toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time**	**Conc mg/L**	**Reference**
Pimephales promelas	Fathead minnow	Fish NOEC	GRO	Growth	32	56	HERA 2014
Daphnia magna	Water flea	Invertebrate NOEC	REP	Reproduction	21	5.6	HERA 2014
Scenedesmus subspicatus	Green algae	Plant NOEC	GRO	Growth	4	32.8	HERA 2014

Terrestrial Ecotoxicological Data

Acute Toxity Data							
Common Name	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc**	**Reference**	**Units**
Earthworm	QSAR worms	MOR	Mortality	14	1000	HERA 2014	mg/kg
Rat	Mammalian LD50	MOR	Mortality		>1000	HERA 2014	mg/kg
Rat	Mammalian LD50	MOR	Mortality	28	1136	HERA 2014	mg/kg/bw/d

Created By: Naomi Cooper Date: 30/01/2020

Checked By: Carolyn Brumley Date: 31/01/2020

GOLDER

Project number: 127666004

INORGANIC

Name	Disodium Octaborate Tetrahydrate
Synonyms	Boric acid - disodium salt, boron sodium oxide, disodium octoborate
CAS Number	12008-41-2
Molecular Formula	B8Na2O13

Physical Properties	Value	Reference
PhaseState:	Crystalline powder	PubChem 2020
Molecular Weight (g/mol):	340.5	PubChem 2020
Melting Point (°C):	1,000.00	PubChem 2020
Boiling Point (°C):		
Solubility (mg/L):	224,000.00	ECHA 2020

Other Relevant Factors	Value	Reference
Reactivity		
Species:		
Reaction type:		
pH / Acidity		
acid / alkaline		
pH (10% solution)		

GOLDER

Project number: 127666004 INORGANIC

Aquatic Ecotoxicological Data

Acute toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc mg/L**	**Reference**
Pimephales promelas	Fathead minnow	Fish LC50	Mortality	Mortality	4	79.7	ECHA 2020
-	Water flea	Invertebrate LC50	Mortality	Mortality	2	64	ECHA 2020
Pseudokirchneriella subcapitata	Algae	Plant EC50	Growth	Growth	3	52.4	ECHA 2020

Chronic toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time**	**Conc mg/L**	**Reference**
Ictalurus punctatus	Channel catfish	Fish NOEC	Mortality	Mortality	9	17.3	ECHA 2020
Daphnia magna	Water flea	Invertebrate NOEC	Mortality	Mortality	21	10.8	ECHA 2020
Spirodella polyrrhiza	Duckweed	Plant NOEC	Growth	Growth	10	6.5	ECHA 2020
Spirodella polyrrhiza	Duckweed	Plant LOEC	Growth	Frond number	10	3.6	ECHA 2020

Terrestrial Ecotoxicological Data

Acute Toxity Data							
Common Name	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc**	**Reference**	**Units**
Rat	Mammalian LD50	Mortality	Mortality		2550	ECHA 2020	mg/kg

Chronic toxicity data							
Common Name	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc**	**Reference**	**Units**
Earthworm	1	Mortality	Mortality		315	ECHA 2020	mg/kg

Created By: Naomi Cooper Date: 9/01/2020

Checked By Carolyn Brumley Date: 17/01/2020

GOLDER

Project number: 12766600 ORGANIC

Name	Fatty acids, tall-oil, ethoxylated
Synonyms	
CAS Number	61791-00-2
Molecular Formula	C(18-50)H(34-98)O(3-8)

Physical Properties	Value	Reference
PhaseState:	Liquid	ECHA 2018
Molecular Weight (g/mol):		0
Melting Point (°C):	-85.00	ECHA 2018
Boiling Point (°C):	172	ECHA 2018
Density / Specific Gravity (g/cm3):	0.96	ECHA 2018
Vapour Pressure (mm Hg at 25°C):	3.79E-14	EPISUITE 2011 v4.1
Solubility (mg/L):	1.87E-02	EPISUITE 2011 v4.1
Henry's Law Constant (atm m³/mole):	4.06E-14	EPISUITE 2011 v4.1
Organic carbon partition coefficient (Koc):	3,321.00	EPISUITE 2011 v4.1
Log organic carbon partition coefficient (log Koc):	3.52	EPISUITE 2011 v4.1
Log octanol - water partition coefficient (log Kow):	5.94	ECHA 2018

Persistance / Bioaccumulation	Value	Reference
Biowin 3 (Ultimate Survey Biodegradation):	2.6520	EPISUITE 2011 v4.1
Biowin 4 (Primary Biodegradation):	3.7109	EPISUITE 2011 v4.1
EPISUITE Ready Biodegradability:	Does not biodegrade fast	EPISUITE 2011 v4.1
Biowin 7 (Anaerobic Model Prediction):	0.1911	EPISUITE 2011 v4.1
Fugacity_Air: (%)	0.00000413	EPISUITE 2011 v4.1
Fugacity_Water: (%)	11	EPISUITE 2011 v4.1
Fugacity_Soil: (%)	87	EPISUITE 2011 v4.1
Fugacity_Sediment: (%)	2.02	EPISUITE 2011 v4.1
Bioconcentration factor (BCF):	164	EPISUITE 2011 v4.1
Biotransformation half - life (Days):	0.1547	EPISUITE 2011 v4.1

Project number: 12766600

ORGANIC

Aquatic Ecotoxicological Data

Acute toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc mg/L**	**Reference**
Danio rerio	Zebrafish	Fish LC50	MOR	Mortality	4	>100	ECHA 2018
Daphnia magna	Water flea	Invertebrate EC50	MOR	Mortality/Immobilisation	2	12.41	ECHA 2018
Pseudokirchneriella subcapitata	Green algae	Plant EC50	GRO	Growth	3	39.7	ECHA 2018

Terrestrial Ecotoxicological Data

Acute Toxity Data							
Common Name	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc**	**Reference**	**Units**
Rat	Mammalian LD50	MOR	Mortality		10000	ECHA 2018	mg/kg
Earthworm	QSAR Earthworm LC50	MOR	Mortality	14	351	ECOSAR 2012	mg/L

Created By: Naomi Cooper Date: 30/01/2020

Checked By: Carolyn Brumley Date: 31/01/2020

Project number: 12766600 ORGANIC

Name	Hydrotreated light petroleum distillate
Synonyms	
CAS Number	64742-47-8
Molecular Formula	Complex combination of hydrocarbons

Physical Properties	Value	Reference
PhaseState:	Liquid	ECHA 2020
Molecular Weight (g/mol):		0
Melting Point (°C):	-9.60	EPISUITE 2011 v4.1
Boiling Point (°C):	216.3	EPISUITE 2011 v4.1
Density / Specific Gravity ():		
Vapour Pressure (mm Hg at 25°C):	2.36E-01	EPISUITE 2011 v4.1
Solubility (mg/L):	3.70E-03	EPISUITE 2011 v4.1
Henry's Law Constant (atm m³/mole):	9.35E+00	EPISUITE 2011 v4.1
Organic carbon partition coefficient (Koc):	4,818.00	EPISUITE 2011 v4.1
Log organic carbon partition coefficient (log Koc):	3.68	EPISUITE 2011 v4.1
Log octanol - water partition coefficient (log Kow):	6.1	EPISUITE 2011 v4.1

Persistance / Bioaccumulation	Value	Reference
Biowin 3 (Ultimate Survey Biodegradation):	3.4194	EPISUITE 2011 v4.1
Biowin 4 (Primary Biodegradation):	4.1401	EPISUITE 2011 v4.1
EPISUITE Ready Biodegradability:	Biodegrades fast	EPISUITE 2011 v4.1
Biowin 7 (Anaerobic Model Prediction):	0.3014	EPISUITE 2011 v4.1
Fugacity_Air: (%)	22.4	EPISUITE 2011 v4.1
Fugacity_Water: (%)	69	EPISUITE 2011 v4.1
Fugacity_Soil: (%)	3	EPISUITE 2011 v4.1
Fugacity_Sediment: (%)	6.15	EPISUITE 2011 v4.1
Bioconcentration factor (BCF):	207.7	EPISUITE 2011 v4.1
Biotransformation half - life (Days):	5.026	EPISUITE 2011 v4.1

GOLDER

Project number: 12766600 ORGANIC

Aquatic Ecotoxicological Data

Acute toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc mg/L**	**Reference**
Oncorhynchus mykiss	Rainbow trout	Fish LC50	MOR	Mortality	4	2	ECHA 2020
Daphnia magna	Water flea	Invertebrate LC50	MOR	Mortality/Immobilization	2	1.4	ECHA 2020
Raphidocelis subcapitata	Green algae	Plant EC50	GRO	Growth	3	1	ECHA 2020

Chronic toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time**	**Conc mg/L**	**Reference**
Daphnia magna	Water flea	Invertebrate NOEC	REP	Reproduction	21	0.48	ECHA 2020
Selenastrum capricornutum	Green algae	Plant NOEC	GRO	Growth	4	0.4	ECHA 2020
Daphnia magna	Water flea	Invertebrate LOEC	REP	Reproduction	21	1.2	ECHA 2020

Terrestrial Ecotoxicological Data

Acute Toxity Data							
Common Name	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc**	**Reference**	**Units**
Rat	Mammalian LD50	MOR	Mortality		>5000	ECHA 2020	mg/kg/bw
Earthworm	QSAR Earthworm LC50	MOR	Mortality	14	108	ECOSAR 2012	mg/L

Created By: Naomi Cooper Date: 30/01/2020

Checked By: Carolyn Brumley Date: 30/01/2020

Project number: 12766600

ORGANIC

Name	Alcohols C12-C15 ethoxylated
Synonyms	
CAS Number	68131-39-5
Molecular Formula	Cx-yAEn

Physical Properties	Value	Reference
PhaseState:	Liquid	ECHA 2020
Molecular Weight (g/mol):		0
Melting Point (°C):	7.22	ECHA 2020
Boiling Point (°C):	271	ECHA 2020
Density / Specific Gravity (g/cm3):	0.93	ECHA 2020
Vapour Pressure (mm Hg at 25°C):	7.54E-11	EPISUITE 2011 v4.1
Solubility (mg/L):	7.00E+00	ECHA 2020
Henry's Law Constant (atm m³/mole):	5.51E-14	EPISUITE 2011 v4.1
Organic carbon partition coefficient (Koc):	150.40	EPISUITE 2011 v4.1
Log organic carbon partition coefficient (log Koc):	2.18	EPISUITE 2011 v4.1
Log octanol - water partition coefficient (log Kow):	5.06	ECHA 2020

Persistance / Bioaccumulation	Value	Reference
Biowin 3 (Ultimate Survey Biodegradation):	2.7156	EPISUITE 2011 v4.1
Biowin 4 (Primary Biodegradation):	3.6109	EPISUITE 2011 v4.1
EPISUITE Ready Biodegradability:	Does not biodegrade fast	EPISUITE 2011 v4.1
Biowin 7 (Anaerobic Model Prediction):	-0.1689	EPISUITE 2011 v4.1
Fugacity_Air: (%)	0.0000000217	EPISUITE 2011 v4.1
Fugacity_Water: (%)	15	EPISUITE 2011 v4.1
Fugacity_Soil: (%)	84	EPISUITE 2011 v4.1
Fugacity_Sediment: (%)	0.143	EPISUITE 2011 v4.1
Bioconcentration factor (BCF):	81.07	EPISUITE 2011 v4.1
Biotransformation half - life (Days):	0.1392	EPISUITE 2011 v4.1

Project number: 12766600

ORGANIC

Aquatic Ecotoxicological Data

Acute toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc mg/L**	**Reference**
Oncorhynchus mykiss	Rainbow trout	Fish LC50	MOR	Mortality	4	1.03	ECOTOX 2020
Daphnia magna	Water flea	Invertebrate EC50	MOR	Mortality/Immobilization	2	0.14	ECHA 2020
	Green algae	Plant EC50	GRO	Growth	3	0.75	ECHA 2020

Chronic toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time**	**Conc mg/L**	**Reference**
Pimephales promelas	Fathead minnow	Fish NOEC	MOR	Mortality	10	0.11	ECHA 2020
	Water flea	Invertebrate NOEC	REP	Reproduction	21	0.77	ECHA 2020
Pseudokirchneriella subcapitata	Green algae	Plant NOEC	GRO	Growth	4	1	ECOTOX 2020
Daphnia magna	Water flea	Invertebrate LOEC	REP	Reproduction	21	0.187	ECOTOX 2020
Pseudokirchneriella subcapitata	Green algae	Plant LOEC	GRO	Growth	4	0.6	ECOTOX 2020
Lepomis macrochirus	Bluegill sunfish	Fish NOEC	MOR	Mortality	10	0.16	ECHA 2020

Terrestrial Ecotoxicological Data

Acute Toxity Data							
Common Name	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc**	**Reference**	**Units**
Rat	Mammalian LD50	MOR	Mortality		>5000	ECHA 2020	mg/kg bw
Earthworms	QSAR Earthworm LC50	MOR	Mortality		>1000	ECHA 2020	mg/kg soil dw

Created By: Naomi Cooper Date: 30/01/2020

Checked By: Carolyn Brumley Date: 31/01/2020

GOLDER

Project number: 12766600 ORGANIC

Name	Reaction products of monoethanolamine and boric acid
Synonyms	
CAS Number	94095-04-2
Molecular Formula	C2H7NO.BH3O3

Physical Properties	Value	Reference
PhaseState:	Liquid	ECHA 2020
Molecular Weight (g/mol):		0
Melting Point (°C):		
Boiling Point (°C):		
Density / Specific Gravity (g/cm3):	1.25	ECHA 2020
Vapour Pressure (mm Hg at 25°C):	0.00E+00	ECHA 2020
Solubility (mg/L):	2.50E+03	ECHA 2020
Henry's Law Constant (atm m^3/mole):		
Organic carbon partition coefficient (Koc):	18.20	ECHA 2020
Log organic carbon partition coefficient (log Koc):	1.26	Calculated
Log octanol - water partition coefficient (log Kow):	-1.1	ECHA 2020

Persistance / Bioaccumulation	Value	Reference
Biowin 3 (Ultimate Survey Biodegradation):		
Biowin 4 (Primary Biodegradation):		
EPISUITE Ready Biodegradability:		
Biowin 7 (Anaerobic Model Prediction):		
Fugacity_Air: (%)		
Fugacity_Water: (%)		
Fugacity_Soil: (%)		
Fugacity_Sediment: (%)		
Bioconcentration factor (BCF):		
Biotransformation half - life (Days):		

GOLDER

Project number: 12766600

ORGANIC

Aquatic Ecotoxicological Data

Acute toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc mg/L**	**Reference**
Danio rerio	Zebrafish	Fish LC50	MOR	Mortality	4	>100	ECHA 2020
Daphnia magna	Water flea	Invertebrate EC50	MOR	Mortality/Immobilization	2	423	ECHA 2020
Pseudokirchneriella subcapitata	Green algae	Plant EC50	GRO	Growth	3	26	ECHA 2020

Terrestrial Ecotoxicological Data

Acute Toxity Data							
Common Name	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc**	**Reference**	**Units**
Rat	Mammalian LD50	MOR	Mortality		2000	ECHA 2020	mg/kg bw

Created By: Naomi Cooper Date: 3/02/2020

Checked By: Carolyn Brumley Date: 3/02/2020

Project number: 127666004

ORGANIC

Name	Acetic Acid
Synonyms	Glacial Acetic Acid, ethanoic acid
CAS Number	64-19-7
Molecular Formula	C2-H4-O2

Physical Properties	Value	Reference
PhaseState:	Liquid	MSDS, 2010
Molecular Weight (g/mol):	60.05	HSDB 2011
Melting Point (°C):	16.60	HSDB 2011
Boiling Point (°C):	117.9	HSDB 2011
Density / Specific Gravity (at 20oC):	1.05	HSDB 2011
Vapour Pressure (mm Hg at 25°C):	15.7	HSDB 2011
Solubility (mg/L):	475,900.00	EPISUITE 2011 v4.0
Henry's Law Constant (atm m3/mol):	0.0000001	HSDB 2011
Organic carbon partition coefficient (Koc):	1.00	EPISUITE 2011 v4.0
Log organic carbon partition coefficient (log Koc):	0.00	EPISUITE 2011 v4.0
Log octanol - water partition coefficient (log Kow):	-1.70E-01	HSDB 2011

Persistance / Bioaccumulation	Value	Reference
Biowin 3 (Ultimate Survey Biodegradation):	3.4311	EPISUITE 2011 v4.0
Biowin 4 (Primary Biodegradation):	4.1467	EPISUITE 2011 v4.0
EPISUITE Ready Biodegradability:	Biodegrades fast	EPISUITE 2011 v4.0
Biowin 7 (Anaerobic Model Prediction):	0.9433	EPISUITE 2011 v4.0
Fugacity_Air: (%)	2.66	EPISUITE 2011 v4.0
Fugacity_Water: (%)	35	EPISUITE 2011 v4.0
Fugacity_Soil: (%)	62	EPISUITE 2011 v4.0
Fugacity_Sediment: (%)	0.0619	EPISUITE 2011 v4.0
Bioconcentration factor (BCF):	3.2	HSDB 2011
Biotransformation half - life (Days):	0.0762	EPISUITE 2011 v4.0

Project number: 127666004

ORGANIC

Aquatic Ecotoxicological Data

Acute toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc mg/L**	**Reference**
Branchiura sowerbyi	Oligochaete	Invertebrate LC50	Mortality	Mortality	1	14.9	ECOTOX 2012
Cyprinus carpio	Common carp	Fish LC50	Mortality	Mortality	2	49	ECOTOX 2012

Chronic toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc mg/L**	**Reference**
Navicula seminulum	Diatom	Plant EC50	Population	Population growth	4	73.4	ECOTOX 2012

Terrestrial Ecotoxicological Data

SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc**	**Reference**
	Rabbit	Mammalian LD50	Mortality	Mortality		600 mg/kg/bw	IUCLID 2012
	Earth worm	QSAR Earthworm LC50	Mortality	Mortality	14	1649 mg/L	ECOSAR 2012

Created By: Lisa Brookes Date: 31/07/2012

Checked By: Kirsten Broadgate Date: 31/08/2012

Project number: 127666004

ORGANIC

Name	Alcohols, C12-16, ethoxylated
Synonyms	NA
CAS Number	68551-12-2
Molecular Formula	

Physical Properties	Value	Reference
PhaseState:		
Molecular Weight (g/mol):		
Melting Point (°C):		
Boiling Point (°C):		
Density / Specific Gravity:		
Vapour Pressure (mm Hg at 25°C):		
Solubility (atm m³/mole):	0.01	HERA 2009
Henry's Law Constant:		
Organic carbon partition coefficient (Koc):		
Log organic carbon partition coefficient (log Koc):	6.65	HERA 2009
Log octanol - water partition coefficient (log Kow):		

Persistance / Bioaccumulation	Value	Reference
Biowin 3 (Ultimate Survey Biodegradation) (Enter		
Biowin 4 (Primary Biodegradation) (Enter Unit):		
EPISUITE Ready Biodegradability:		
Biowin 7 (Anaerobic Model Prediction):		
Fugacity_Air: (%)		
Fugacity_Water: (%)		
Fugacity_Soil: (%)		
Fugacity_Sediment: (%)		
Bioconcentration factor (BCF):	387.5	HERA 2009
Biotransformation half - life (Days):		

Project number: 127666004

ORGANIC

Aquatic Ecotoxicological Data

Acute toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc mg/L**	**Reference**
Scenedesmus subspicatus	Algae	Plant EC50	Population	Growth	3	0.05	HERA 2009
Scenedesmus subspicatus	Algae	Plant EC50	Population	Growth	3	0.035	HERA 2009
Daphnia magna	Water flea	Invertebrate NOEC			2	1	HERA 2009
Daphnia magna	Water flea	Invertebrate LC50			2	0.29	HERA 2009

Chronic toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc mg/L**	**Reference**
Selenastrum capriconutum	Algae	Plant NOEC	Population	Growth	3	0.5	HERA 2009

Created By: Lisa Brookes Date: 31/07/2012

Checked By: Kirsten Broadgate Date: 31/08/2012

Name	Aluminium oxide
Synonyms	Alumina, aluminium sesquioxide, aluminium trioxide
CAS Number	1344-28-1
Molecular Formula	Al2O3

Physical Properties	Value	Reference
PhaseState:	White crystalline powder	HSDB 2012
Molecular Weight (g/mol):	101.961	HSDB 2012
Melting Point (°C):	2,030.00	HSDB 2012
Boiling Point (°C):	3000	HSDB 2012
Solubility (mg/L):	0.98	IUCLID 2012

Other Relevant Factors	Value	Reference
Reactivity		
Species:		
Reaction type:	Hazardour reactivity and incompatabilities with strong acids, strong bases, chlorine trifluoride, ethylene oxide, halogenated hydrocarbon, oxygen difluoride, sodium nitrate, vinyl compounds.	HSDB 2012
pH / Acidity		
acid / alkaline		
pH (10% solution)		

Project number: 127666004

INORGANIC

Terrestrial Ecotoxicological Data

SpeciesName	Common Name	Endpoint	Effect	Effect Measure	Test Time (Days)	Conc	Reference
	Rat	Mammalian LD50	Mortality	Mortality		>2000 mg/kg	ECHA 2012

Created By: Lisa Brookes Date: 31/07/2012

Checked By: Kirsten Broadgate Date: 31/08/2012

Project number: 127666004

ORGANIC

Name	Amine oxides, cocoalkyldimethyl
Synonyms	Amines, coco alkyldimethyl, noxide; coco alkyldimethylamine oxide
CAS Number	61788-90-7
Molecular Formula	C14H31N01

Physical Properties	Value	Reference
PhaseState:	Solid	HSDB 2012
Molecular Weight (g/mol):	229.41	EPISUITE 2011 v4.1
Melting Point (°C):	167.95	EPISUITE 2011 v4.1
Boiling Point (°C):	426.62	EPISUITE 2011 v4.1
Density / Specific Gravity (Enter Unit):		
Vapour Pressure (mm Hg at 25°C):	0.000000157	EPISUITE 2011 v4.1
Solubility (atm m³/mole):	3.13	EPISUITE 2011 v4.1
Henry's Law Constant:	0.0000000000661	EPISUITE 2011 v4.1
Organic carbon partition coefficient (Koc):	7,988.00	EPISUITE 2011 v4.1
Log organic carbon partition coefficient (log Koc):	3.90	Calculated
Log octanol - water partition coefficient (log Kow):	4.67E+00	EPISUITE 2011 v4.1

Persistance / Bioaccumulation	Value	Reference
Biowin 3 (Ultimate Survey Biodegradation) (weeks)	2.9905	EPISUITE 2011 v4.1
Biowin 4 (Primary Biodegradation) (days):	3.7858	EPISUITE 2011 v4.1
EPISUITE Ready Biodegradability:	Biodegrades fast	EPISUITE 2011 v4.1
Biowin 7 (Anaerobic Model Prediction):	0.1278	EPISUITE 2011 v4.1
Fugacity_Air: (%)	0.00136	EPISUITE 2011 v4.1
Fugacity_Water: (%)	32	EPISUITE 2011 v4.1
Fugacity_Soil: (%)	81	EPISUITE 2011 v4.1
Fugacity_Sediment: (%)	3.66	EPISUITE 2011 v4.1
Bioconcentration factor (BCF):	23.77	EPISUITE 2011 v4.1
Biotransformation half - life (Days):	2.22	EPISUITE 2011 v4.1

Project number: 127666004

ORGANIC

Aquatic Ecotoxicological Data

Acute toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc mg/L**	**Reference**
	Daphnid	Invertebrate LC50	Mortality	Mortality	2	0.126	ECOSAR 2012
	Fish	Fish LC50	Mortality	Mortality	4	0.749	ECOSAR 2012

Chronic toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc mg/L**	**Reference**
	Green algae	Plant EC50	Population	Population, general	4	0.056	ECOSAR 2012

Terrestrial Ecotoxicological Data

SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc**	**Reference**
	Rat	Mammalian LD50	Mortality	Mortality		846 mg AO/kg bw	INCHEM 2012

Created By: Lisa Brookes Date: 31/07/2012

Checked By: Kirsten Broadgate Date: 31/08/2012

Project number: 127666004

ORGANIC

Name	Benzaldehyde
Synonyms	Artificial almond oil, benze carboxablehyde, benzoic aldehyde
CAS Number	100-52-7
Molecular Formula	C7H60

Physical Properties	Value	Reference
PhaseState:	Colourless to yellow liquid	HSDB 2012
Molecular Weight (g/mol):	106.2	HSDB 2012
Melting Point (°C):	-26.00	HSDB 2012
Boiling Point (°C):	179.2	HSDB 2012
Density / Specific Gravity (at 15oC):	1.04	HSDB 2012
Vapour Pressure (mm Hg at 25°C):	0.127	HSDB 2012
Solubility (atm m³/mole):	6.95	HSDB 2012
Henry's Law Constant:	0.000026	HSDB 2012
Organic carbon partition coefficient (Koc):	34.00	HSDB 2012
Log organic carbon partition coefficient (log Koc):	1.53	Calculated
Log octanol - water partition coefficient (log Kow):	1.48E+00	HSDB 2012

Persistance / Bioaccumulation	Value	Reference
Biowin 3 (Ultimate Survey Biodegradation) (weeks)	3.009	EPISUITE 2011 v4.1
Biowin 4 (Primary Biodegradation) (days):	3.8982	EPISUITE 2011 v4.1
EPISUITE Ready Biodegradability:	Biodegrades fast	EPISUITE 2011 v4.1
Biowin 7 (Anaerobic Model Prediction):	0.6997	EPISUITE 2011 v4.1
Fugacity_Air: (%)	2.72	EPISUITE 2011 v4.1
Fugacity_Water: (%)	39	EPISUITE 2011 v4.1
Fugacity_Soil: (%)	58	EPISUITE 2011 v4.1
Fugacity_Sediment: (%)	0.09	EPISUITE 2011 v4.1
Bioconcentration factor (BCF):	2.7	HSDB 2012
Biotransformation half - life (Days):	0.156	EPISUITE 2011 v4.1

Project number: 127666004

ORGANIC

Aquatic Ecotoxicological Data

Acute toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc mg/L**	**Reference**
Lepomis macrochirus	Bluegill	Fish LC50	Mortality	Mortality	4	1.07	ECOTOX 2012
Daphnia magna	Water flea	Invertebrate LC50	Mortality	Mortality	2	9	ECOTOX 2012

Chronic toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc mg/L**	**Reference**
Pimephales promelas	Fathead minnow	Fish NOEC	Growth	Growth, general	7	0.22	ECOTOX 2012
Pimephales promelas	Fathead minnow	Fish MATC	Population	Biomass	7	0.310	ECOTOX 2012

Terrestrial Ecotoxicological Data

SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc**	**Reference**
	Mouse	Mammalian LD50	Mortality	Mortality		27.8 mg/kg bw	INCHEM 2012

Created By: Lisa Brookes Date: 31/07/2012

Checked By: Kirsten Broadgate Date: 31/08/2012

Project number: 127666004

INORGANIC

Name	Chlorous Acid, Sodium Salt
Synonyms	Sodium chlorite, alcide LD,
CAS Number	7758-19-2
Molecular Formula	ClHO2.Na

Physical Properties	Value	Reference
PhaseState:	White crystals or crystalline powder	HSDB 2012
Molecular Weight (g/mol):	90.44	HSDB 2012
Melting Point (°C):		
Boiling Point (°C):		
Solubility (mg/L):	64,000.00	HSDB 2012

Other Relevant Factors	Value	Reference
Reactivity		
Species:		
Reaction type:		
pH / Acidity		
acid / alkaline		
pH (10% solution)		

Aquatic Ecotoxicological Data

Acute toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc mg/L**	**Reference**
Daphnia magna	Water flea	Invertebrate LC50	Intoxication	Immobilised	2	0.025	ECOTOX 2012
Ptychocheilus oregonesis	Northern Squawfish	Fish LC50	Mortality	Mortality	4	0.08	ECOTOX 2012

Chronic toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc mg/L**	**Reference**
Pseudokirchneriellea subcapitata	Green algae	Plant EC50	Population	Population growth rate	4	0.904	ECOTOX 2012
Pseudokirchneriella subcapitata	Green algae	Plant NOEC	Population	Population growth rate	4	0.0904	ECOTOX 2012
Oncorhynchus mykiss	Rainbow trout	Fish NOEC	Growth	Weight	20	2.3	ECOTOX 2012
Oncorhynchus mykiss	Rainbow trout	Fish MATC	Growth	Length	20	6.6	ECOTOX 2012

Project number: 127666004

INORGANIC

Terrestrial Ecotoxicological Data

SpeciesName	Common Name	Endpoint	Effect	Effect Measure	Test Time (Days)	Conc	Reference
	Rat	Mammalian LD50	Mortality	Mortality		165 mg/kg/bw	IUCLID 2012

Created By: Lisa Brookes Date: 31/07/2012

Checked By: Kirsten Broadgate Date: 31/08/2012

Project number: 127666004

ORGANIC

Name	Cinnamaldehyde
Synonyms	2 - propenal, 3 - phenyl; cinnamic alderhyde
CAS Number	104-55-2
Molecular Formula	C9H80

Physical Properties	Value	Reference
PhaseState:	Yellowish oily liquid	HSDB 2012
Molecular Weight (g/mol):	132.15	HSDB 2012
Melting Point (°C):	-7.50	HSDB 2012
Boiling Point (°C):	253	HSDB 2012
Density / Specific Gravity (Enter Unit):	1.05	HSDB 2012
Vapour Pressure (mm Hg at 25°C):	0.0289	HSDB 2012
Solubility (atm m³/mole):	1,420.00	HSDB 2012
Henry's Law Constant:	0.0000035	HSDB 2012
Organic carbon partition coefficient (Koc):	37.00	HSDB 2012
Log organic carbon partition coefficient (log Koc):	1.57	Calculated
Log octanol - water partition coefficient (log Kow):	1.90E+00	HSDB 2012

Persistance / Bioaccumulation	Value	Reference
Biowin 3 (Ultimate Survey Biodegradation) (weeks)	2.9514	EPISUITE 2011 v4.1
Biowin 4 (Primary Biodegradation) (days):	3.8586	EPISUITE 2011 v4.1
EPISUITE Ready Biodegradability:	Biodegrades fast	EPISUITE 2011 v4.1
Biowin 7 (Anaerobic Model Prediction):	0.5526	EPISUITE 2011 v4.1
Fugacity_Air: (%)	0.527	EPISUITE 2011 v4.1
Fugacity_Water: (%)	32	EPISUITE 2011 v4.1
Fugacity_Soil: (%)	68	EPISUITE 2011 v4.1
Fugacity_Sediment: (%)	0.107	EPISUITE 2011 v4.1
Bioconcentration factor (BCF):	8.33	HSDB 2012
Biotransformation half - life (Days):	0.2389	EPISUITE 2011 v4.1

Project number: 127666004

ORGANIC

Aquatic Ecotoxicological Data

Acute toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc mg/L**	**Reference**
	Fish	Fish LC50	Mortality	Mortality	4	0.201	ECOTOX 2012
	Daphnid	Invertebrate LC50	Mortality	Mortality	2	88.3	ECOTOX 2012

Chronic toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc mg/L**	**Reference**
	Green algae	Plant EC50	Population	Population changes, general	4	53.5	ECOTOX 2012

Terrestrial Ecotoxicological Data

SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc**	**Reference**
	Mouse	Mammalian LD50	Mortality	Mortality		200 mg/kg	HSDB 2012

Created By: Lisa Brookes Date: 31/07/2012

Checked By: Kirsten Broadgate Date: 31/08/2012

Project number: 127666004

ORGANIC

Name	Citric Acid
Synonyms	2-Hydroxytricarballylic acid; 2-Hydroxy-1,2,3-propanetricarboxylic acid
CAS Number	77-92-9
Molecular Formula	C6H8O7

Physical Properties	Value	Reference
PhaseState:	Colourless, translucent crystals or powder	HSDB 2011
Molecular Weight (g/mol):	192.12	HSDB 2011
Melting Point (°C):	153.00	HSDB 2011
Boiling Point (°C):		
Density / Specific Gravity (at 20oC):	1.67	HSDB 2011
Vapour Pressure (mm Hg at 25°C):	0.000000017	HSDB 2011
Solubility (mg/L):	383,000.00	HSDB 2011
Henry's Law Constant (atm m3/mol):	0.000000000000043	HSDB 2011
Organic carbon partition coefficient (Koc):	3.10	HSDB 2011
Log organic carbon partition coefficient (log Koc):	1.00	EPISUITE 2011 v4.0
Log octanol - water partition coefficient (log Kow):	-1.64E+00	EPISUITE 2011 v4.0

Persistance / Bioaccumulation	Value	Reference
Biowin 3 (Ultimate Survey Biodegradation):	3.6563	EPISUITE 2011 v4.0
Biowin 4 (Primary Biodegradation):	4.5738	EPISUITE 2011 v4.0
EPISUITE Ready Biodegradability:	Biodegrades fast	EPISUITE 2011 v4.0
Biowin 7 (Anaerobic Model Prediction):	1.1142	EPISUITE 2011 v4.0
Fugacity_Air: (%)	0.0000995	EPISUITE 2011 v4.0
Fugacity_Water: (%)	28	EPISUITE 2011 v4.0
Fugacity_Soil: (%)	72	EPISUITE 2011 v4.0
Fugacity_Sediment: (%)	0.0592	EPISUITE 2011 v4.0
Bioconcentration factor (BCF):	3.2	HSDB 2011
Biotransformation half - life (Days):	0.02	EPISUITE 2011 v4.0

Project number: 127666004

ORGANIC

Aquatic Ecotoxicological Data

Acute toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc mg/L**	**Reference**
Leuciscus idus ssp. Melanotus	Carp	Fish LC50	Mortality	Mortality	2	440	ECOTOX 2012

Terrestrial Ecotoxicological Data

SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc**	**Reference**
	Rat	Mammalian LD50	Mortality	Mortality		3000 mg/kg/bw	IUCLID 2012
	Earthworm	QSAR Earthworm LC50	Mortality	Mortality		8030 mg/L	ECOSAR 2012

Created By: Chelsea Papadopoulos Date: 16/08/2012

Checked By: Kirsten Broadgate Date: 31/08/2012

Project number: 127666004

ORGANIC

Name	Diethylene Glycol
Synonyms	Ethanol, 2,2 oxybis; digycol; carbitol; 2,2 oxybisethanol;DEG
CAS Number	111-46-6
Molecular Formula	C34H62O6

Physical Properties	Value	Reference
PhaseState:	Odourless, colourless viscous, hygroscopic liquid	IPCS 2007
Molecular Weight (g/mol):	106.2	IPCS 2007
Melting Point (°C):	-6.50	IPCS 2007
Boiling Point (°C):	245	IPCS 2007
Density / Specific Gravity:	1.12	IPCS 2007
Vapour Pressure (mm Hg at 25°C):	0.0057	HSDB 2012
Solubility (mg/L):	1,000,000.00	RAIS 2009
Henry's Law Constant (atm m3/mol):	0.000000002	HSDB 2012
Organic carbon partition coefficient (Koc):	1.00	HSDB 2012
Log organic carbon partition coefficient (log Koc):	0.00	Calculated
Log octanol - water partition coefficient (log Kow):	-1.47E+00	HSDB 2012

Persistance / Bioaccumulation	Value	Reference
Biowin 3 (Ultimate Survey Biodegradation):	3.2759	EPISUITE 2011 v4.1
Biowin 4 (Primary Biodegradation):	3.9438	EPISUITE 2011 v4.1
EPISUITE Ready Biodegradability:	Biodegrades fast	EPISUITE 2011 v4.1
Biowin 7 (Anaerobic Model Prediction):	0.9483	EPISUITE 2011 v4.1
Fugacity_Air: (%)	0.0677	EPISUITE 2011 v4.1
Fugacity_Water: (%)	34	EPISUITE 2011 v4.1
Fugacity_Soil: (%)	66	EPISUITE 2011 v4.1
Fugacity_Sediment: (%)	0.0599	EPISUITE 2011 v4.1
Bioconcentration factor (BCF):	3	HSDB 2012
Biotransformation half - life (Days):	0.004877	EPISUITE 2011 v4.1

Project number: 127666004

ORGANIC

Aquatic Ecotoxicological Data

Acute toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc mg/L**	**Reference**
Carassius auratus	Goldfish	Fish LC50	Mortality	Mortality	1	5000	ECOTOX 2012
Daphnia magna	Water flea	Invertebrate LC50	Mortality Mortality	Mortality	1	10000	ECOTOX 2012

Terrestrial Ecotoxicological Data

SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc**	**Reference**
	Cat	Mammalian LD50	Mortality	Mortality		3300 mg/kg bw	HSDB 2012
	Earthworm	QSAR Earthworm LC50	Mortality	Mortality	14	422.923 mg/L	ECOSAR 2012

Created By: Lisa Brookes Date: 31/07/2012

Checked By: Kirsten Broadgate Date: 31/08/2012

Name	Hydrochloric Acid
Synonyms	Anhydrous hydrochloric acid, chlorohydric acid, dilute hydrochloric acid, hydrochloric acid gas, muriatic acid
CAS Number	7647-01-0
Molecular Formula	HCl

Physical Properties	Value	Reference
PhaseState:	Liquid	Merck, 1996
Molecular Weight (g/mol):	36.46	HSDB 2011
Melting Point (°C):	-114.22	HSDB 2011
Boiling Point (°C):	-85.05	HSDB 2011
Solubility (mg/L):	825,000.00	IUCLID 2000a

Other Relevant Factors	Value	Reference
Reactivity		
Species:		
Reaction type:		
pH / Acidity		
acid / alkaline		
pH (10% solution)		

Aquatic Ecotoxicological Data

Acute toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc mg/L**	**Reference**
Gambusia affinis	Western Mosquito fish	Fish LC50	Mortality	Mortality	1	282	ECOTOX 2012

Chronic toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc mg/L**	**Reference**
Lemna minor	Duckweed	Plant EC50	Growth	Weight	10	182.3	ECOTOX 2012

Project number: 127666004

INORGANIC

Terrestrial Ecotoxicological Data

SpeciesName	Common Name	Endpoint	Effect	Effect Measure	Test Time (Days)	Conc	Reference
	Rat	Mammalian LD50	Mortality	Mortality		50 mg/kg/bw	INCHEM 2012

Created By: Chelsea Papadopoulos Date: 16/08/2012

Checked By: Carolyn Brumley Date: 31/08/2012

Name	Iron oxide
Synonyms	Ferric oxide, anhydrous ferric oxide, iron (III) oxide, diiron trioxide, iron trioxide, ferric sesquioxide
CAS Number	1309-37-1
Molecular Formula	Fe2O3

Physical Properties	Value	Reference
PhaseState:	Reddish brown hexagonal crystals	HSDB 2012
Molecular Weight (g/mol):	159.69	16
Melting Point (°C):	1,565.00	IUCLID 2012
Boiling Point (°C):		
Solubility (mg/L):	0.00	IUCLID 2012

Other Relevant Factors	Value	Reference
Reactivity		
Species:		
Reaction type:	Violent reaction when heated with powdered aluminum, calcium disilicide, magnesium, metal acetylides (e.g., calcium acetylide + iron (III) chloride (on ignition), cesium acetylide (incandescent reaction when warmed), rubidium acetylide).	HSDB 2012
pH / Acidity		
acid / alkaline	pH 5-6 at 100 g/l at 20oC	IUCLID 2012
pH (10% solution)		

Aquatic Ecotoxicological Data

Acute toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc mg/L**	**Reference**
Cloeon dipterum	Mayfly	Invertebrate LC50	Mortality	Mortality	1	40	ECOSAR 2012

Project number: 127666004

INORGANIC

Terrestrial Ecotoxicological Data

SpeciesName	Common Name	Endpoint	Effect	Effect Measure	Test Time (Days)	Conc	Reference
	Rat	Mammalian LD50	Mortality	Mortality		>10000 mg/kg	HSDB 2012

Created By: Lisa Brookes Date: 31/07/2012

Checked By: Carolyn Brumley Date: 31/08/2012

Project number: 127666004

ORGANIC

Name	Methanol
Synonyms	Methyl alcohol; carbinol; wood spirit; wood alcohol
CAS Number	67-56-1
Molecular Formula	CH4O

Physical Properties	Value	Reference
PhaseState:	Colourless liquid	HSDB 2011
Molecular Weight (g/mol):	32.04	HSDB 2011
Melting Point (°C):	-97.80	HSDB 2011
Boiling Point (°C):	64.7	HSDB 2011
Density / Specific Gravity (at 25 degrees):	0.79	HSDB 2011
Vapour Pressure (mm Hg at 25°C):	127	HSDB 2011
Solubility (mg/L):	1,000,000.00	EPISUITE 2011 v4.0
Henry's Law Constant (atm m3/mol):	0.00000455	HSDB 2011
Organic carbon partition coefficient (Koc):	1.00	HSDB 2011
Log organic carbon partition coefficient (log Koc):	0.00	EPISUITE 2011 v4.0
Log octanol - water partition coefficient (log Kow):	-7.70E-01	HSDB 2011

Persistance / Bioaccumulation	Value	Reference
Biowin 3 (Ultimate Survey Biodegradation):	3.2883	EPISUITE 2011 v4.0
Biowin 4 (Primary Biodegradation):	3.931	EPISUITE 2011 v4.0
EPISUITE Ready Biodegradability:	Biodegrades fast	EPISUITE 2011 v4.0
Biowin 7 (Anaerobic Model Prediction):	0.8893	EPISUITE 2011 v4.0
Fugacity_Air: (%)	10.3	EPISUITE 2011 v4.0
Fugacity_Water: (%)	39	EPISUITE 2011 v4.0
Fugacity_Soil: (%)	50	EPISUITE 2011 v4.0
Fugacity_Sediment: (%)	0.0695	EPISUITE 2011 v4.0
Bioconcentration factor (BCF):	10	HSDB 2011
Biotransformation half - life (Days):	0.021	EPISUITE 2011 v4.0

Project number: 127666004

ORGANIC

Aquatic Ecotoxicological Data

Acute toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc mg/L**	**Reference**
Anodonta imbecillis	Mussel	Invertebrate LC50	Mortality	Mortality	2	37.02	ECOTOX 2012
Pimephales promelas	Fathead Minnow	Fish LC50	Mortality	Mortality	4	>100	ECOTOX 2012

Chronic toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc mg/L**	**Reference**
Oreochromis mossambicus	Mozambique Tilapia	Fish NOEC	Reproduction	Fecundity	90	23.75	ECOTOX 2012
Algae	Algae	Plant NOEC	Population	Abundance	90	23.75	ECOTOX 2012
Oreochromis mossambicus	Mozambique Tilapia	Fish LOEC	Reproduction	Fecundity	90	47.49	ECOTOX 2012
Algae	Algae	Plant LOEC	Popoulation	Abundance	90	47.49	ECOTOX 2012
Pseudokirchneriella subcapitata	Green algae	Plant EC50	Population	Population growth rate	2	>60.4	ECOTOX 2012

Terrestrial Ecotoxicological Data

SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc**	**Reference**
	Rat	Mammalian LD50	Mortality	Mortality		5628 mg/kg	HSDB 2012
	Earthworm	QSAR Earthworm LC50	Mortality	Mortality	14	104.45 mg/L	ECOSAR 2012

Created By: Chelsea Papadopoulos Date: 16/08/2012

Checked By: Carolyn Brumley Date: 31/08/2012

Name	Sodium Carbonate
Synonyms	Soda ash, Solvay soda, bisodium carbonate, carbonic acid, crystol carbonate, disodium carbonate, sodium carbonate
CAS Number	497-19-8
Molecular Formula	Na2Co3

Physical Properties	Value	Reference
PhaseState:	White powder	HSDB 2011
Molecular Weight (g/mol):	105.99	HSDB 2011
Melting Point (°C):	851.00	HSDB 2011
Boiling Point (°C):		
Solubility (mg/L):	215,000.00	IPCS, 2011

Other Relevant Factors	Value	Reference
Reactivity		
Species:		
Reaction type:		
pH / Acidity		
acid / alkaline		
pH (10% solution)		

Aquatic Ecotoxicological Data

Acute toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc mg/L**	**Reference**
Amphipoda	Scud Order	Invertebrate LC50	Mortality	Mortality	3	67	ECOTOX 2012
Poecilia latipinna	Sailfin Molly	Fish LC50	Mortality	Mortality	2.1	297	ECOTOX 2012
Ceriodaphnia dubia	Water flea	Invertebrate EC50	Intoxication	Immobilisation	2	199.82	ECOTOX 2012

Chronic toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc mg/L**	**Reference**
Navicula seminulum	Diatom	Plant EC50	Population	Population growth rate	4	242	ECOTOX 2012
Daphnia magna	Water flea	Invertebrate LC50	Intoxication	Immobilisation	4.2	265	ECOTOX 2012
Daphnia magna	Water flea	Invertebrate EC50	Intoxication	Immobilisation	4.2	524	ECOTOX 2012

Project number: 127666004

INORGANIC

Terrestrial Ecotoxicological Data

SpeciesName	Common Name	Endpoint	Effect	Effect Measure	Test Time (Days)	Conc	Reference
	Rat	Mammalian LD50	Mortality	Mortality		2800 mg/kg bw	INCHEM 2012
	Earthworm	QSAR Earthworm LC50	Mortality	Mortality	14	194.054 mg/L	ECOSAR 2012

Created By: Chelsea Papadopoulos Date: 16/08/2012

Checked By: Carolyn Brumley Date: 31/08/2012

Name	Sodium Chloride
Synonyms	Salt
CAS Number	7647-14-5
Molecular Formula	NaCl

Physical Properties	Value	Reference
PhaseState:	Colourless transparent crystals or white crystalline powder	HSDB 2011
Molecular Weight (g/mol):	58.44	HSDB 2011
Melting Point (°C):	801.00	HSDB 2011
Boiling Point (°C):		
Solubility (mg/L):	3,570,000.00	HSDB 2011

Other Relevant Factors	Value	Reference
Reactivity		
Species:		
Reaction type:		
pH / Acidity		
acid / alkaline		
pH (10% solution)		

Aquatic Ecotoxicological Data

Acute toxicity data

SpeciesName	Common Name	Endpoint	Effect	Effect Measure	Test Time (Days)	Conc mg/L	Reference
Ceriodaphnia dubia	Water flea	Invertebrate LC50	Mortality	Mortality	7	280	ECOTOX 2012
Daphnia magna	Water flea	Invertebrate EC50	Intoxication	Immobilisation	1	402.6	ECOTOX 2012
Morone saxatilis	Striped bass	Fish LC50	Mortality	Mortality	3	1000	ECOTOX 2012

Chronic toxicity data

SpeciesName	Common Name	Endpoint	Effect	Effect Measure	Test Time (Days)	Conc mg/L	Reference
Nitzschia linearis	Diatom	Plant LC	Population	Population growth	5	2430	ECOTOX 2012
Stenonema modestum	Mayfly	Invertebrate NOEC	Mortality	Mortality	14	2.7	ECOTOX 2012
Stenonema modestum	Mayfly	Invertebrate LOEC	Mortality	Mortality	14	3.5	ECOTOX 2011
Pimephales promelas	Fathead minnow	Fish MATC	Mortality	Survival	33	298	EPISUITE 2011 v4.1
Kirchneriella sp.	Green algae	Plant LOEC	Population	Population doubling time	91.32	1900	ECOTOX 2011

Project number: 127666004

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Terrestrial Ecotoxicological Data

SpeciesName	Common Name	Endpoint	Effect	Effect Measure	Test Time (Days)	Conc	Reference
	Rat	Mammalian LD50	Mortality	Mortality		3000 mg/kg bw	HSDB 2012

Created By: Chelsea Papadopoulos Date: 16/08/2012

Checked By: Carolyn Brummley Date: 31/08/2012

Name	Sodium Hydroxide
Synonyms	Sodium hydroxide
CAS Number	1310-73-2
Molecular Formula	NaOH

Physical Properties	Value	Reference
PhaseState:	White orthogonal crystals	HSDB 2011
Molecular Weight (g/mol):	40	HSDB 2011
Melting Point (°C):	323.00	HSDB 2011
Boiling Point (°C):	1388	HSDB 2011
Solubility (mg/L):	1,110,000.00	HSDB 2011

Other Relevant Factors	Value	Reference
Reactivity		
Species:	OH-/NaOH	HSDB 2011
Reaction type:	Acid/base	HSDB 2011
pH / Acidity		
acid / alkaline	Alkaline	HSDB 2011
pH (10% solution)	11	HSDB 2011

Aquatic Ecotoxicological Data

Acute toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc mg/L**	**Reference**
Ceriodaphnia dubia	Water flea	Invertebrate EC50	Intoxication	Immobilisation	2	40.38	ECOTOX 2011
Gambusia affinis	Western mosquitofish	Fish LC50	Mortality	Mortality	1	125	ECOTOX 2011

Project number: 127666004

INORGANIC

Created By: Lisa Brookes Date: 31/07/2012

Checked By: Kirsten Broadgate Date: 31/08/2012

Name	Sodium Iodide
Synonyms	Sodium monoiodide
CAS Number	7681-82-5
Molecular Formula	Na+I-

Physical Properties	Value	Reference
PhaseState:	Crystals	HSDB 2012
Molecular Weight (g/mol):	149.92	HSDB 2012
Melting Point (°C):	651.00	HSDB 2012
Boiling Point (°C):	1304	HSDB 2012
Solubility (mg/L):	184,000.00	HSDB 2012

Other Relevant Factors	Value	Reference
Reactivity		
Species:		
Reaction type:		
pH / Acidity		
acid / alkaline		
pH (10% solution)		

Aquatic Ecotoxicological Data

Acute toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc mg/L**	**Reference**
Daphnia magna	Water flea	Invertebrate LC50	Mortality	Mortality	2	0.17	ECOTOX 2011
Oncorhynchus mykiss	Rainbow trout	Fish LC50	Mortality	Mortality	4	860	ECOTOX 2011

Project number: 127666004

INORGANIC

Terrestrial Ecotoxicological Data

SpeciesName	Common Name	Endpoint	Effect	Effect Measure	Test Time (Days)	Conc	Reference
	Mouse	Mammalian LD50	Mortality	Mortality		1000 mg/kg bw	ECHA 2012

Created By: Lisa Brookes Date: 31/07/2012

Checked By: Kirsten Broadgate Date: 31/08/2012

Name	Titanium Dioxide
Synonyms	Titanium Peroxide, Titanium White, Titamium Oxide
CAS Number	13463-67-7
Molecular Formula	TiO2

Physical Properties	Value	Reference
PhaseState:	Colourless to white crystalline powder	IPCS 2002
Molecular Weight (g/mol):	79.9	IPCS 2002
Melting Point (°C):	1,855.00	IPCS 2002
Boiling Point (°C):	2500	IPCS 2002
Solubility (mg/L):		

Other Relevant Factors	Value	Reference
Reactivity		
Species:		
Reaction type:		
pH / Acidity		
acid / alkaline		
pH (10% solution)		

Aquatic Ecotoxicological Data

Acute toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc mg/L**	**Reference**
Ceriodaphnia dubia	Water flea	Invertebrate LC50	Mortality	Mortality	2	3	ECOTOX 2012
Danio rerio	Zebra danio	Fish LC50	Mortality	Mortality	2	10	ECOTOX 2012

Chronic toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc mg/L**	**Reference**
Chironomus riparius	Midge	Invertebrate NOEC	Growth	Biomass	4	1	ECOTOX 2012
Pseudokirchneriella subcapitata	Green algae	Plant NOEC	Growth	Growth rate	3	0.984	ECOTOX 2012
Pseudokirchneriella subcapitata	Green algae	Plant EC50	Growth	Growth rate	3	5.83	ECOTOX 2012

Project number: 127666004

INORGANIC

Terrestrial Ecotoxicological Data

SpeciesName	Common Name	Endpoint	Effect	Effect Measure	Test Time (Days)	Conc	Reference
	Rat	Mammalian LD50	Mortality	Mortality		>10000 mg/kg bw	IUCLID 2012
	Mouse	Mammalian LD50	Mortality	Mortality		>10000 mg/kg bw	IUCLID 2012

Created By: Lisa Brookes Date: 31/07/2012

Checked By: Carolyn Brumley Date: 31/08/2012

APPENDIX F

Flowback Fluid Analytical Results

Hydraulic Fracturing Fluid Laboratory Results, South Australia
Job # 127666004

Field Identification	Laboratory ID	Sample Comments	Inorganics: Alkalinity (Bicarbonate as CaCO3)	Inorganics: Alkalinity (Carbonate as CaCO3)	pH: pH (Lab)	Physico - Chemical: Total Dissolved Solids	Total Dissolved Solids @180°C	Bicarbonate Alkalinity (as CaCO3)	Carbonate Alkalinity (as CaCO3)	Hydroxide Alkalinity (as CaCO3)	Total Alkalinity (as CaCO3)
			mg/L	mg/L	pH_Units	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
EQL			1	1	0.01	10				1	1
ANZECC 2000 Freshwater 95%											
CCME (2008)											
NHMRC 2008											
NHMRC 2011							600				
DERM Queensland BTEX Standards [10]											
Adopted Criteria 1 [9]											
Adopted Criteria 2 [9]											
Verbruggen (2004)-Lab Filtered [1]											
Verbruggen (2004)-Total [2]											
Halliburton Fracturing Fluid											
Crosslink Gel	EM1210744	Fracturing fluids with distilled water	-	-	-	-	-	-	-	-	-
FR Water	EM1210744	Fracturing fluids with distilled water	10	<1	6.1	1040	-	-	-	<1	10
Site Water											
Tindilpie Pad Clean	EM1209245	Fracture fluid make up water from pond	1590	206	8.36	3610	-	-	-	<1	1790
Tindilpie Pad Pit Circ	EM1209245	Flare pit water prior to flowback	2230	16	8.52	5490	-	-	-	<1	2240
Fracturing Flowback Fluids											
Tildilpie Pad 4-9-2012 Sample1	EM1210360	Flowback water	2270	<1	7.5	11,900	-	-	-	<1	2270
Tildilpie Pad 4-9-2012 Sample2	EM1210360	Flowback water	2310	<1	7.49	11,700	-	-	-	<1	2310
TPPF-FPWPF _27/08/2012	EM1209924	Tindilpie Pad Pit Flowback - frac pit water post flowback	-	-	7.46	-	10,100	2150	<1	<1	2150

Field Identification	Metals: Arsenic	Arsenic (Filtered)	Barium	Barium (Filtered)	Beryllium	Beryllium (Filtered)	Boron	Boron (Filtered)	Cadmium	Cadmium (Filtered)	Chlorine	Chromium III + VI	Chromium III + VI (Filtered)	Cobalt	Cobalt (Filtered)	Copper	Copper (Filtered)	Iron	Iron (Filtered)	Lead
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
EQL		0.001		0.001		0.001		0.05		0.0001			0.001		0.001		0.001		0.05	
ANZECC 2000 Freshwater 95%							**0.37**	**0.37**	**0.0002**	**0.0002**	**0.003**					**0.0014**	**0.0014**			**0.0034**
CCME (2008)																				
NHMRC 2008	0.007	0.007	0.7	0.7			4	4	0.002	0.002		0.05	0.05			2	2			0.01
NHMRC 2011	0.01	0.01	2	2	0.06	0.06	4	4	0.002	0.002		0.05	0.05			2	2	0.3	0.3	0.01
DERM Queensland BTEX Standards [10]																				
Adopted Criteria 1 [9]																				
Adopted Criteria 2 [9]																				
Verbruggen (2004)-Lab Filtered [1]																				
Verbruggen (2004)-Total [2]																				
Halliburton Fracturing Fluid																				
Crosslink Gel	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
FR Water	-	<0.001	-	<0.001	-	<0.001	-	<0.05	-	<0.0001	-	-	<0.001	-	<0.001	-	**0.003**	-	<0.05	-
Site Water																				
Tindilpie Pad Clean	-	<0.001	-	1.97	-	<0.001	-	**4.74**	-	<0.0001	-	-	<0.001	-	<0.001	-	**0.002**	-	<0.05	-
Tindilpie Pad Pit Circ	-	0.02	-	6.13	-	<0.001	-	**55.5**	-	**0.0002**	-	-	<0.001	-	0.004	-	**0.189**	-	15.6	-
Fracturing Flowback Fluids																				
Tildilpie Pad 4-9-2012 Sample1	-	0.216	-	6.02	-	<0.001	-	**40.8**	-	0.0001	-	-	0.04	-	0.009	-	**0.048**	-	28.4	-
Tildilpie Pad 4-9-2012 Sample2	-	0.21	-	5.86	-	<0.001	-	**44.9**	-	0.0001	-	-	0.04	-	0.009	-	**0.061**	-	29.4	-
TPPF-FPWPF _27/08/2012	0.182	-	31.6	-	<0.001	-	**57.9**	-	0.0001	-	-	<0.001	-	0.006	-	**0.061**	-	15.6	-	**0.088**

Field Identification	Lead (Filtered)	Lithium	Lithium (Filtered)	Manganese	Manganese (Filtered)	Mercury	Mercury (Filtered)	Molybdenum	Molybdenum (Filtered)	Nickel	Nickel (Filtered)	Selenium	Selenium (Filtered)	Strontium	Strontium (Filtered)	Tin	Tin (Filtered)	Uranium
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
EQL	0.001		0.001		0.001		0.0001		0.001		0.001		0.01		0.001		0.001	
ANZECC 2000 Freshwater 95%	**0.0034**			**1.9**	**1.9**	**0.0006**	**0.0006**			**0.011**	**0.011**	**0.011**	**0.011**					
CCME (2008)																		
NHMRC 2008	0.01			0.5	0.5	0.001	0.001	0.05	0.05	0.02	0.02	0.01	0.01					0.02
NHMRC 2011	0.01			0.1	0.1	0.001	0.001	0.05	0.05	0.02	0.02	0.01	0.01					0.017
DERM Queensland BTEX Standards [10]																		
Adopted Criteria 1 [9]																		
Adopted Criteria 2 [9]																		
Verbruggen (2004)-Lab Filtered [1]																		
Verbruggen (2004)-Total [2]																		
Halliburton Fracturing Fluid																		
Crosslink Gel	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
FR Water	<0.001	-	<0.001	-	0.002	-	<0.0001	-	<0.001	-	<0.001	-	<0.01	-	0.008	-	<0.001	-
Site Water																		
Tindilpie Pad Clean	<0.001	-	0.447	-	0.004	-	0.0002	-	<0.001	-	<0.001	-	<0.01	-	0.626	-	<0.001	-
Tindilpie Pad Pit Circ	**0.091**	-	0.872	-	0.18	-	<0.0001	-	0.035	-	**0.028**	-	<0.01	-	1.29	-	<0.001	-
Fracturing Flowback Fluids																		
Tildilpie Pad 4-9-2012 Sample1	**0.068**	-	2.42	-	**3.62**	-	0.0002	-	0.023	-	**0.039**	-	<0.01	-	1.66	-	<0.001	-
Tildilpie Pad 4-9-2012 Sample2	**0.068**	-	2.54	-	**3.74**	-	0.0003	-	0.023	-	**0.038**	-	<0.01	-	1.67	-	<0.001	-
TPPF-FPWPF _27/08/2012	-	2.58	-	**2.68**	-	0.0005	-	0.02	-	**0.028**	-	<0.01	-	1.7	-	<0.001	-	<0.001

Notes

[1] The SRCeco is the concentration of a substance in the soil, sediment or (ground)water at which functions in these compartments will be seriously affected or are threatened to be negatively affected. This is assumed to occur when 50% of the species and/or 50% of the microbial and enzymatic processes are possibly affected, the HC50NOEC

[2] The total concentration refers to the sum of the concentrations in the dissolved phase and in particulate matter.

[3] The toxic unit approach specifies that the sum of the individual ratios of field measurement to SRC should be less than 1.

[4] These criteria may be ignored where lower carbon fractions are absent because solubility is so low that the internal concentration corresponding to the SRC will not be reached. In the toxic unit approach the contribution of this fraction cannot exceed the maximum unit value. If the maximum toxic unit value is zero, the contribution to toxicity is negligible.

[5] This criteria has been adopted from NHMRC (2011) base on Ethylbenzene

[6] This criteria has been adopted from NHMRC (2011) base on o-, p-, and m-xylene(s)

[7] Based on health and do not include evaluation of organoleptic properties

[8] Must also examine PAH's if Benzo(a)pyrene = 0.00001 mg/L (NHMRC 2011)

[9] Criteria values have been sourced from WHO (2005), NHMRC (2011) and TPHCWG (1997)

[10] Criteria values have been sourced from the Australian Drinking Water Guidelines (2011) and the Australia and New Zealand Environment Conservation Council (ANZECC) Guidelines for Fresh and Marine Water Quality (2000). The value for xylenes (m and p) was determined from the sum of the values for the individual isomers

Prepared by:	MER	13/11/2012
Checked by:	BMC	20/11/2012

Abbreviations:
< - less than laboratory limit of reporting
- - not analysed
LOR - Laboratory Limit of Reporting
EQL - Effective Quantitative Limit
ug/L - micrograms per litre
mg/L - miligrams per litre
TPH - Total Petroleum Hydrocarbons
PCB - Polychlorinated Biphenyls
OCP - Organochlorine Pesticides
OPP - Organophosphorus Pesticides
MAH - Monocyclic Aromatic Hydrocarbons
PAH - Polycyclic Aromatic Hydrocarbons
BTEX - benzene, toluene, ethylbenzene, xylenes
VOC - Volatile Organic Compounds
SVOC - Semi-Volatile Organic Compounds

Hydraulic Fracturing Fluid Laboratory Results, South Australia
Job # 127666004

Field Identification	Laboratory ID	Sample Comments	Uranium (Filtered)	Vanadium	Vanadium (Filtered)	Zinc	Zinc (Filtered)	SQP: Aluminium	Aluminium (Filtered)	Bromide	Hardness (as CaCO3)	NOx (as N)	Sodium Absorption Ratio	Sodium Absorption Ratio (Filtered)	Cyanide (free)	Cyanide (total)	Fluoride
			mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	-	-	mg/L	mg/L	mg/L
EQL			0.001		0.01		0.005		0.01	0.01	1			0.01	0.004	0.004	0.1
ANZECC 2000 Freshwater 95%						**0.008**	**0.008**	**0.055**	**0.055**								
CCME (2008)																	
NHMRC 2008			0.02														1.5
NHMRC 2011			0.017			3	3	0.2	0.2							0.08	1.5
DERM Queensland BTEX Standards [10]																	
Adopted Criteria 1 [9]																	
Adopted Criteria 2 [9]																	
Verbruggen (2004)-Lab Filtered [1]																	
Verbruggen (2004)-Total [2]																	
Halliburton Fracturing Fluid																	
Crosslink Gel	EM1210744	Fracturing fluids with distilled water	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
FR Water	EM1210744	Fracturing fluids with distilled water	<0.001	-	<0.01	-	0.006	-	<0.01	0.082	5	-	-	4.09	<0.004	<0.004	<0.1
Site Water																	
Tindilpie Pad Clean	EM1209245	Fracture fluid make up water from pond	<0.001	-	<0.01	-	**0.014**	-	0.01	6.24	24	-	-	113	<0.004	<0.004	3.2
Tindilpie Pad Pit Circ	EM1209245	Flare pit water prior to flowback	0.001	-	0.02	-	**0.141**	-	**0.42**	12	91	-	-	108	<0.004	<0.004	2.5
Fracturing Flowback Fluids																	
Tildilpie Pad 4-9-2012 Sample1	EM1210360	Flowback water	<0.001	-	0.02	-	**0.052**	-	**0.07**	22.4	174	-	-	112	0.007	0.008	2.4
Tildilpie Pad 4-9-2012 Sample2	EM1210360	Flowback water	<0.001	-	0.02	-	**0.058**	-	**0.07**	20.9	169	-	-	110	<0.004	<0.004	2
TPPF-FPWPF _27/08/2012	EM1209924	Tindilpie Pad Pit Flowback - frac pit water post flowback	-	0.02	-	**0.052**	-	**0.09**	-	16.7	135	<0.01	105	-	<0.004	<0.004	1.8

Field Identification	Major Anions & Cations: Calcium	Calcium (Filtered)	Magnesium	Magnesium (Filtered)	Potassium	Potassium (Filtered)	Sodium	Sodium (Filtered)	Ionic Balance	Total Anions	Total Cations	Chloride	Sulphate (as SO4)	Sulphate (as SO4) (Filtered)
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	%	meq/L	meq/L	mg/L	mg/L	mg/L
EQL		1		1		1		1	0.01	0.01	0.01	1		1
ANZECC 2000 Freshwater 95%														
CCME (2008)														
NHMRC 2008														
NHMRC 2011							180	180				250		
DERM Queensland BTEX Standards [10]														
Adopted Criteria 1 [9]														
Adopted Criteria 2 [9]														
Verbruggen (2004)-Lab Filtered [1]														
Verbruggen (2004)-Total [2]														
Halliburton Fracturing Fluid														
Crosslink Gel	-	-	-	-	-	-	-	-	-	-	-	-	-	-
FR Water	-	2	-	<1	-	<1	-	21	3.9	16.7	15.5	370	-	292
Site Water														
Tindilpie Pad Clean	-	8	-	1	-	38	-	1280	5.91	64.2	57.1	992	-	24
Tindilpie Pad Pit Circ	-	30	-	4	-	75	-	2370	5.29	96	107	1800	-	23
Fracturing Flowback Fluids														
Tildilpie Pad 4-9-2012 Sample1	-	50	-	12	-	140	-	3410	3.47	185	173	4910	-	60
Tildilpie Pad 4-9-2012 Sample2	-	48	-	12	-	135	-	3300	3.24	183	172	4810	-	56
TPPF-FPWPF _27/08/2012	41	-	8	-	83	-	2810	-	7.67	148	127	3710	22	-

Field Identification	Nutrients: Ammonia (as N)	Nitrate (as N)	Nitrite (as N)	Nitrogen (Total Oxidised)	Nitrogen (Total)	Phosphorus	Total Kjeldahl Nitrogen (as N)	Total Organic Carbon	OCP: 4,4-DDE	a-BHC	Aldrin	Aldrin + Dieldrin	b-BHC	d-BHC	DDD	DDE	DDT	DDT+DDE+DDD	Dieldrin	Endosulfan I	Endosulfan II	Endosulfan sulphate
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
EQL	0.01	0.01	0.01	0.01	0.1	0.01	0.1	1	0.002	0.002	0.002	0.004	0.002	0.002	0.002		0.004	0.004	0.002	0.002	0.002	0.002
ANZECC 2000 Freshwater 95%																	**0.00001**					
CCME (2008)																						
NHMRC 2008												0.0003										0.03
NHMRC 2011		50	3									0.0003										
DERM Queensland BTEX Standards [10]																						
Adopted Criteria 1 [9]																						
Adopted Criteria 2 [9]																						
Verbruggen (2004)-Lab Filtered [1]																						
Verbruggen (2004)-Total [2]																						
Halliburton Fracturing Fluid																						
Crosslink Gel	-	-	-	-	-	-	-	23,900	<0.002	<0.002	<0.002	<0.004	<0.002	<0.002	<0.002	-	**<0.004**	<0.004	<0.002	<0.002	<0.002	<0.002
FR Water	90.5	0.36	<0.01	0.36	185	1.42	185	608	<0.01	<0.01	<0.01	<0.02	<0.01	<0.01	<0.01	-	**<0.02**	<0.02	<0.01	<0.01	<0.01	<0.01
Site Water																						
Tindilpie Pad Clean	0.2	0.03	<0.01	0.03	3.6	1.38	3.6	<1	<0.002	<0.002	<0.002	<0.004	<0.002	<0.002	<0.002	-	**<0.004**	<0.008	<0.002	<0.002	<0.002	<0.002
Tindilpie Pad Pit Circ	23.4	0.01	0.46	0.47	182	1.39	182	1080	<0.02	<0.02	<0.02	<0.04	<0.02	<0.02	<0.02	-	**<0.04**	<0.08	<0.02	<0.02	<0.02	<0.02
Fracturing Flowback Fluids																						
Tildilpie Pad 4-9-2012 Sample1	90.8	<0.01	0.09	0.09	222	2.16	222	1930	<0.2	<0.2	<0.2	<0.4	<0.2	<0.2	<0.2	-	**<0.4**	<0.4	<0.2	<0.2	<0.2	<0.2
Tildilpie Pad 4-9-2012 Sample2	95.8	<0.01	0.1	0.1	271	2.5	271	1800	<0.2	<0.2	<0.2	<0.4	<0.2	<0.2	<0.2	-	**<0.4**	<0.4	<0.2	<0.2	<0.2	<0.2
TPPF-FPWPF _27/08/2012	55.4	<0.01	0.05	-	166	2.22	166	1320	-	<0.01	<0.01	<0.02	<0.01	<0.01	<0.01	<0.01	-	<0.02	<0.01	<0.01	<0.01	<0.01

Notes
[1] The SRCeco is the concentration of a substance in the soil, sediment or (ground)water at which functions in these compartn
[2] The total concentration refers to the sum of the concentrations in the dissolved phase and in particulate matter.
[3] The toxic unit approach specifies that the sum of the individual ratios of field measurement to SRC should be less than 1.
[4] These criteria may be ignored where lower carbon fractions are absent because solubility is so low that the internal concentı
[5] This criteria has been adopted from NHMRC (2011) base on Ethylbenzene
[6] This criteria has been adopted from NHMRC (2011) base on o-, p-, and m-xylene(s)
[7] Based on health and do not include evaluation of organoleptic properties
[8] Must also examine PAH's if Benzo(a)pyrene = 0.00001 mg/L (NHMRC 2011)
[9] Criteria values have been sourced from WHO (2005), NHMRC (2011) and TPHCWG (1997)
[10] Criteria values have been sourced from the Australian Drinking Water Guidelines (2011) and the Australia and New Zealar
Guidelines for Fresh and Marine Water Quality (2000). The value for xylenes (m and p) was determined from the sum of the va

Abbreviations:
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- - not analysed
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TPH - Total Petroleum Hydrocarbons
PCB - Polychlorinated Biphenyls
OCP - Organochlorine Pesticides
OPP - Organophosphorus Pesticides
MAH - Monocyclic Aromatic Hydrocarbons
PAH - Polycyclic Aromatic Hydrocarbons
BTEX - benzene, toluene, ethylbenzene, xylenes
VOC - Volatile Organic Compounds
SVOC - Semi-Volatile Organic Compounds

Golder Associates

Hydraulic Fracturing Fluid Laboratory Results, South Australia
Job # 127666004

Field Identification	Laboratory ID	Sample Comments	Endrin	g-BHC	Heptachlor	Heptachlor & heptachlor edpoxide (Sum)	Heptachlor epoxide	Hexachlorobenzene	OPP: Chlorfenvinphos	Chlorpyriphos	Chlorpyriphos-methyl	Diazinon	Dichlorvos	Dimethoate	Ethion	Fenthion	Malathion	Pirimphos-ethyl	Prothiofos
			mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
EQL			0.002	0.002	0.002		0.002	0.004	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
ANZECC 2000 Freshwater 95%			**0.00002**	**0.0002**	**0.00009**					**0.00001**		**0.00001**		**0.00015**			**0.00005**		
CCME (2008)																			
NHMRC 2008						0.0003	0.0003		0.005	0.01		0.003	0.001	0.05	0.003			0.0005	
NHMRC 2011						0.0003			0.002	0.01		0.004	0.005	0.007	0.004	0.007			
DERM Queensland BTEX Standards [10]																			
Adopted Criteria 1 [9]																			
Adopted Criteria 2 [9]																			
Verbruggen (2004)-Lab Filtered [1]																			
Verbruggen (2004)-Total [2]																			
Halliburton Fracturing Fluid																			
Crosslink Gel	EM1210744	Fracturing fluids with distilled water	<0.002	<0.002	<0.002	-	<0.002	<0.004	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
FR Water	EM1210744	Fracturing fluids with distilled water	<0.01	<0.01	<0.01	-	<0.01	<0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Site Water																			
Tindilpie Pad Clean	EM1209245	Fracture fluid make up water from pond	<0.002	<0.002	<0.002	-	<0.002	<0.004	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Tindilpie Pad Pit Circ	EM1209245	Flare pit water prior to flowback	<0.02	<0.02	<0.02	-	<0.02	<0.04	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Fracturing Flowback Fluids																			
Tildilpie Pad 4-9-2012 Sample1	EM1210360	Flowback water	<0.2	<0.2	<0.2	-	<0.2	<0.4	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Tildilpie Pad 4-9-2012 Sample2	EM1210360	Flowback water	<0.2	<0.2	<0.2	-	<0.2	<0.4	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
TPPF-FPWPF 27/08/2012	EM1209924	Tindilpie Pad Pit Flowback - frac pit water post flowback	<0.01	<0.01	-	<0.01	<0.01	<0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

Field Identification	Phenols: 2,4,5-Trichlorophenol	2,4,6-Trichlorophenol	2,4-Dichlorophenol	2,4-Dimethylphenol	2,6-Dichlorophenol	2-Chlorophenol	2-Methylphenol	2-Nitrophenol	3- & 4- Methylphenol	4-Chloro-3-methylphenol	Pentachlorophenol	Phenol
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
EQL	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.004	0.002	0.004	0.002
ANZECC 2000 Freshwater 95%		**0.02**	**0.16**			**0.49**					**0.01**	**0.32**
CCME (2008)												
NHMRC 2008		0.02	0.2			0.3					0.01	
NHMRC 2011		0.02	0.2			0.3					0.01	
DERM Queensland BTEX Standards [10]												
Adopted Criteria 1 [9]												
Adopted Criteria 2 [9]												
Verbruggen (2004)-Lab Filtered [1]												
Verbruggen (2004)-Total [2]												
Halliburton Fracturing Fluid												
Crosslink Gel	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.004	<0.002	<0.004	<0.002
FR Water	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.02	<0.01	<0.02	<0.01
Site Water												
Tindilpie Pad Clean	<0.002	<0.002	<0.002	0.006	<0.002	<0.002	<0.002	<0.002	<0.004	<0.002	<0.004	<0.002
Tindilpie Pad Pit Circ	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.04	<0.02	<0.04	0.088
Fracturing Flowback Fluids												
Tildilpie Pad 4-9-2012 Sample1	<0.2	<0.2	<0.2	1.25	<0.2	<0.2	1.78	<0.2	1.43	<0.2	<0.4	1.25
Tildilpie Pad 4-9-2012 Sample2	<0.2	<0.2	<0.2	0.779	<0.2	<0.2	1	<0.2	0.924	<0.2	<0.4	0.735
TPPF-FPWPF 27/08/2012	<0.01	<0.01	<0.01	0.337	<0.01	<0.01	0.503	<0.01	0.354	<0.01	<0.02	0.418

Field Identification	PAH: 2-(Acetylamino) fluorene	2-Chloronaphthalene	2-Methylnaphthalene	3-Methylcholanthrene	7,12-Dimethylbenz(a)anthracene	Acenaphthene	Acenaphthylene	Anthracene	Benz(a)anthracene	Benzo(a)pyrene	Benzo(b)&(k)fluoranthene	Benzo(g,h,i)perylene	Chrysene	Dibenz(a,h)anthracene
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
EQL	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.004	0.002	0.002	0.002
ANZECC 2000 Freshwater 95%														
CCME (2008)														
NHMRC 2008										0.00001				
NHMRC 2011										0.00001				
DERM Queensland BTEX Standards [10]														
Adopted Criteria 1 [9]														
Adopted Criteria 2 [9]														
Verbruggen (2004)-Lab Filtered [1]														
Verbruggen (2004)-Total [2]														
Halliburton Fracturing Fluid														
Crosslink Gel	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.004	<0.002	<0.002	<0.002
FR Water	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.02	<0.01	<0.01	<0.01
Site Water														
Tindilpie Pad Clean	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.004	<0.002	<0.002	<0.002
Tindilpie Pad Pit Circ	<0.02	<0.02	0.036	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.04	<0.02	<0.02	<0.02
Fracturing Flowback Fluids														
Tildilpie Pad 4-9-2012 Sample1	<0.2	<0.2	2.09	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.4	<0.2	<0.2	<0.2
Tildilpie Pad 4-9-2012 Sample2	<0.2	<0.2	0.872	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.4	<0.2	<0.2	<0.2
TPPF-FPWPF 27/08/2012	<0.01	<0.01	0.33	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.02	<0.01	<0.01	<0.01

Notes

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[2] The total concentration refers to the sum of the concentrations in the dissolved phase and in particulate matter.
[3] The toxic unit approach specifies that the sum of the individual ratios of field measurement to SRC should be less than 1.
[4] These criteria may be ignored where lower carbon fractions are absent because solubility is so low that the internal concent
[5] This criteria has been adopted from NHMRC (2011) base on Ethylbenzene
[6] This criteria has been adopted from NHMRC (2011) base on o-, p-, and m-xylene(s)
[7] Based on health and do not include evaluation of organoleptic properties
[8] Must also examine PAH's if Benzo(a)pyrene = 0.00001 mg/L (NHMRC 2011)
[9] Criteria values have been sourced from WHO (2005), NHMRC (2011) and TPHCWG (1997)
[10] Criteria values have been sourced from the Australian Drinking Water Guidelines (2011) and the Australia and New Zealar
Guidelines for Fresh and Marine Water Quality (2000). The value for xylenes (m and p) was determined from the sum of the va

Abbreviations:
< - less than laboratory limit of reporting
- - not analysed
LOR - Laboratory Limit of Reporting
EQL - Effective Quantitative Limit
ug/L - micrograms per litre
mg/L - miligrams per litre
TPH - Total Petroleum Hydrocarbons
PCB - Polychlorinated Biphenyls
OCP - Organochlorine Pesticides
OPP - Organophosphorus Pesticides
MAH - Monocyclic Aromatic Hydrocarbons
PAH - Polycyclic Aromatic Hydrocarbons
BTEX - benzene, toluene, ethylbenzene, xylenes
VOC - Volatile Organic Compounds
SVOC - Semi-Volatile Organic Compounds

Field Identification	Laboratory ID	Sample Comments	Fluoranthene	Fluorene	Indeno(1,2,3-c,d)pyrene	Naphthalene	Phenanthrene	Pyrene	PAH Total
			mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
EQL			0.002	0.002	0.002	0.002	0.002	0.002	0.002
ANZECC 2000 Freshwater 95%						**0.016**			
CCME (2008)									
NHMRC 2008									
NHMRC 2011									
DERM Queensland BTEX Standards [10]									
Adopted Criteria 1 [9]									
Adopted Criteria 2 [9]									
Verbruggen (2004)-Lab Filtered [1]									
Verbruggen (2004)-Total [2]									
Halliburton Fracturing Fluid									
Crosslink Gel	EM1210744	Fracturing fluids with distilled water	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
FR Water	EM1210744	Fracturing fluids with distilled water	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Site Water									
Tindilpie Pad Clean	EM1209245	Fracture fluid make up water from pond	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Tindilpie Pad Pit Circ	EM1209245	Flare pit water prior to flowback	<0.02	<0.02	<0.02	**<0.02**	<0.02	<0.02	<0.02
Fracturing Flowback Fluids									
Tildilpie Pad 4-9-2012 Sample1	EM1210360	Flowback water	<0.2	<0.2	<0.2	**1.2**	0.268	<0.2	1.47
Tildilpie Pad 4-9-2012 Sample2	EM1210360	Flowback water	<0.2	<0.2	<0.2	**0.573**	<0.2	<0.2	0.573
TPPF-FPWPF _27/08/2012	EM1209924	Tindilpie Pad Pit Flowback - frac pit water post flowback	<0.01	0.014	<0.01	**0.156**	0.032	<0.01	0.202

SVOCs

Field Identification	1,2,3-Trichlorobenzene	1,2-Dichlorobenzene	1,3-Dichlorobenzene	1,4-Dichlorobenzene	2-Picoline	3,3-Dichlorobenzidine	4-(Dimethylamino) azobenzene	4-Aminobiphenyl	4-Bromophenyl phenyl ether	4-Chlorophenyl phenyl ether	4-Nitroquinoline-n-oxide	Acetophenone	Bis(2-chloroethoxy) methane
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
EQL	0.005	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
ANZECC 2000 Freshwater 95%	**0.01**	**0.16**	**0.26**	**0.06**									
CCME (2008)													
NHMRC 2008		1.5		0.04									
NHMRC 2011	0.005	1.5		0.04									
DERM Queensland BTEX Standards [10]													
Adopted Criteria 1 [9]													
Adopted Criteria 2 [9]													
Verbruggen (2004)-Lab Filtered [1]													
Verbruggen (2004)-Total [2]													
Halliburton Fracturing Fluid													
Crosslink Gel	<0.005	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
FR Water	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Site Water													
Tindilpie Pad Clean	<0.005	<0.002	<0.002	<0.004	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Tindilpie Pad Pit Circ	<0.005	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Fracturing Flowback Fluids													
Tildilpie Pad 4-9-2012 Sample1	**<0.1**	**<0.2**	<0.2	**<0.2**	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Tildilpie Pad 4-9-2012 Sample2	**<0.1**	**<0.2**	<0.2	**<0.2**	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
TPPF-FPWPF _27/08/2012	**<0.1**	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

Field Identification	Bis(2-chloroethyl) ether	Bis(2-chloroisopropyl) ether	Dibenzofuran	Hexachlorocyclopentadiene	Hexachloropropene	Methapyrilene	n-Nitrosomorpholine	n-Nitrosopiperidine	n-Nitrosopyrrolidine	Pentachlorobenzene	Pentachloronitrobenzene	Phenacetin
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
EQL		0.002	0.002	0.01	0.002	0.002	0.002	0.002	0.004	0.002	0.002	0.002
ANZECC 2000 Freshwater 95%												
CCME (2008)												
NHMRC 2008												
NHMRC 2011												
DERM Queensland BTEX Standards [10]												
Adopted Criteria 1 [9]												
Adopted Criteria 2 [9]												
Verbruggen (2004)-Lab Filtered [1]												
Verbruggen (2004)-Total [2]												
Halliburton Fracturing Fluid												
Crosslink Gel	-	<0.002	<0.002	<0.01	<0.002	<0.002	<0.002	<0.002	<0.004	<0.002	<0.002	<0.002
FR Water	-	<0.01	<0.01	<0.05	<0.01	<0.01	<0.01	<0.01	<0.02	<0.01	<0.01	<0.01
Site Water												
Tindilpie Pad Clean	-	<0.002	<0.002	<0.01	<0.002	<0.002	<0.002	<0.002	<0.004	<0.002	<0.002	<0.002
Tindilpie Pad Pit Circ	-	<0.02	<0.02	<0.1	<0.02	<0.02	<0.02	<0.02	<0.04	<0.02	<0.02	<0.02
Fracturing Flowback Fluids												
Tildilpie Pad 4-9-2012 Sample1	-	<0.2	<0.2	<1	<0.2	<0.2	<0.2	<0.2	<0.4	<0.2	<0.2	<0.2
Tildilpie Pad 4-9-2012 Sample2	-	<0.2	<0.2	<1	<0.2	<0.2	<0.2	<0.2	<0.4	<0.2	<0.2	<0.2
TPPF-FPWPF _27/08/2012	<0.01	-	<0.01	<0.05	<0.01	<0.01	<0.01	<0.01	<0.02	<0.01	<0.01	<0.01

MAH

Field Identification	1,2,4-trimethylbenzene	1,3,5-Trimethylbenzene	Isopropylbenzene	n-Butylbenzene	n-Propylbenzene	p-Isopropyltoluene	sec-Butylbenzene	Benzene	Styrene	Ethylbenzene	tert-Butylbenzene	Toluene
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
EQL	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.001	0.005	0.002	0.005	0.002
ANZECC 2000 Freshwater 95%								**0.95**				
CCME (2008)												
NHMRC 2008								0.001	0.03	0.3		0.8
NHMRC 2011								0.001	0.004	0.003		0.025
DERM Queensland BTEX Standards [10]								0.001		0.08		0.18
Adopted Criteria 1 [9]												
Adopted Criteria 2 [9]												
Verbruggen (2004)-Lab Filtered [1]												
Verbruggen (2004)-Total [2]												
Halliburton Fracturing Fluid												
Crosslink Gel	<0.005	<0.005	<0.005	<0.005	<0.005	0.316	<0.005	<0.001	<0.005	<0.002	<0.005	0.013
FR Water	<0.01	<0.01	<0.01	<0.01	<0.01	1.45	<0.01	<0.01	<0.01	<0.01	<0.01	0.026
Site Water												
Tindilpie Pad Clean	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.002	<0.005	<0.002	<0.005	0.004
Tindilpie Pad Pit Circ	0.032	0.01	<0.005	<0.01	<0.005	0.11	<0.005	0.065	<0.005	0.011	<0.005	0.148
Fracturing Flowback Fluids												
Tildilpie Pad 4-9-2012 Sample1	4.02	2.48	0.313	0.586	0.985	4.19	0.114	**1.16**	<0.1	0.995	<0.1	7.7
Tildilpie Pad 4-9-2012 Sample2	2.18	1.34	0.182	0.288	0.488	1.83	<0.1	**1.12**	<0.1	0.571	<0.1	6.38
TPPF-FPWPF _27/08/2012	2.55	1.76	0.118	0.199	0.628	2.68	<0.1	0.848	<0.1	0.533	<0.1	5.32

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[6] This criteria has been adopted from NHMRC (2011) base on o-, p-, and m-xylene(s)

[7] Based on health and do not include evaluation of organoleptic properties

[8] Must also examine PAH's if Benzo(a)pyrene = 0.00001 mg/L (NHMRC 2011)

[9] Criteria values have been sourced from WHO (2005), NHMRC (2011) and TPHCWG (1997)

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OPP - Organophosphorus Pesticides
MAH - Monocyclic Aromatic Hydrocarbons
PAH - Polycyclic Aromatic Hydrocarbons
BTEX - benzene, toluene, ethylbenzene, xylenes
VOC - Volatile Organic Compounds
SVOC - Semi-Volatile Organic Compounds

Field Identification	Laboratory ID	Sample Comments	Xylene (o)	Xylenes (m & p)	1,1,1,2-Tetrachloroethane	1,1,1-Trichloroethane	1,1,2,2-Tetrachloroethane	1,1,2-Trichloroethane	1,1-Dichloroethane	1,1-Dichloroethene	1,1-Dichloropropene	1,2,3-Trichloropropane	1,2,4-Trichlorobenzene	1,2-Dibromo-3-chloropropane	1,2-Dibromoethane	1,2-Dichloroethane
					VOC											
			mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
EQL			0.002	0.002	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.002	0.005	0.005	0.005
ANZECC 2000 Freshwater 95%			**0.35**					**6.5**					**0.17**			
CCME (2008)																
NHMRC 2008										0.03						0.003
NHMRC 2011										0.03			0.005			0.003
DERM Queensland BTEX Standards [10]			0.35	0.275												
Adopted Criteria 1 [9]																
Adopted Criteria 2 [9]																
Verbruggen (2004)-Lab Filtered [1]																
Verbruggen (2004)-Total [2]																
Halliburton Fracturing Fluid																
Crosslink Gel	EM1210744	Fracturing fluids with distilled water	<0.002	0.017	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.002	<0.005	<0.005	<0.005
FR Water	EM1210744	Fracturing fluids with distilled water	<0.01	0.05	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Site Water																
Tindilpie Pad Clean	EM1209245	Fracture fluid make up water from pond	<0.002	<0.002	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.002	<0.005	<0.005	<0.005
Tindilpie Pad Pit Circ	EM1209245	Flare pit water prior to flowback	0.023	0.08	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.02	<0.005	<0.005	<0.005
Fracturing Flowback Fluids																
Tildilpie Pad 4-9-2012 Sample1	EM1210360	Flowback water	**2.48**	13	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	**<0.2**	<0.1	<0.1	<0.1
Tildilpie Pad 4-9-2012 Sample2	EM1210360	Flowback water	**1.63**	8.13	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	**<0.2**	<0.1	<0.1	<0.1
TPPF-FPWPF _ 27/08/2012	EM1209924	Tindilpie Pad Pit Flowback - frac pit water post flowback	**1.35**	7.21	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.01	<0.1	<0.1	<0.1

Field Identification	1,2-Dichloropropane	1,3-Dichloropropane	2,2-Dichloropropane	2-Chlorotoluene	2-Hexanone	4-Chlorotoluene	4-Methyl-2-pentanone	Bromobenzene	Bromodichloromethane	Bromoform	Bromomethane	Carbon disulfide	Carbon tetrachloride	Chlorobenzene
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
EQL	0.005	0.005	0.005	0.005	0.05	0.005	0.05	0.005	0.005	0.005	0.05	0.005	0.005	0.005
ANZECC 2000 Freshwater 95%														
CCME (2008)														
NHMRC 2008													0.003	0.3
NHMRC 2011									0.25	0.25			0.003	0.01
DERM Queensland BTEX Standards [10]														
Adopted Criteria 1 [9]														
Adopted Criteria 2 [9]														
Verbruggen (2004)-Lab Filtered [1]														
Verbruggen (2004)-Total [2]														
Halliburton Fracturing Fluid														
Crosslink Gel	<0.005	<0.005	<0.005	0.006	<0.05	<0.005	<0.05	<0.005	<0.005	<0.005	<0.05	<0.005	<0.005	<0.005
FR Water	<0.01	<0.01	<0.01	<0.01	<0.1	<0.01	<0.1	<0.01	<0.01	<0.01	<0.1	<0.01	<0.01	<0.01
Site Water														
Tindilpie Pad Clean	<0.005	<0.005	<0.005	<0.005	<0.05	<0.005	<0.05	<0.005	<0.005	<0.005	<0.05	<0.005	<0.005	<0.005
Tindilpie Pad Pit Circ	<0.005	<0.005	<0.005	<0.005	<0.05	<0.005	<0.05	<0.005	<0.005	<0.005	<0.05	<0.005	<0.005	<0.005
Fracturing Flowback Fluids														
Tildilpie Pad 4-9-2012 Sample1	<0.1	<0.1	<0.1	<0.1	<1	<0.1	<1	<0.1	<0.1	<0.1	<1	<0.1	<0.1	<0.1
Tildilpie Pad 4-9-2012 Sample2	<0.1	<0.1	<0.1	<0.1	<1	<0.1	<1	<0.1	<0.1	<0.1	<1	<0.1	<0.1	<0.1
TPPF-FPWPF _ 27/08/2012	<0.1	<0.1	<0.1	<0.1	<1	<0.1	<1	<0.1	<0.1	<0.1	<1	<0.1	<0.1	<0.1

Field Identification	Chlorodibromomethane	Chloroethane	Chloroform	Chloromethane	cis-1,2-Dichloroethene	cis-1,3-Dichloropropene	cis-1,4-Dichloro-2-butene	Dibromomethane	Dichlorodifluoromethane	Hexachlorobutadiene	Hexachloroethane	Iodomethane	Isobutanol
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
EQL	0.005	0.05	0.005	0.05	0.005	0.005	0.005	0.005	0.05	0.002	0.002	0.005	0.05
ANZECC 2000 Freshwater 95%											**0.36**		
CCME (2008)													
NHMRC 2008										0.0007			
NHMRC 2011	0.25		0.25							0.0007			
DERM Queensland BTEX Standards [10]													
Adopted Criteria 1 [9]													
Adopted Criteria 2 [9]													
Verbruggen (2004)-Lab Filtered [1]													
Verbruggen (2004)-Total [2]													
Halliburton Fracturing Fluid													
Crosslink Gel	<0.005	<0.05	<0.005	0.06	<0.005	<0.005	<0.005	<0.005	<0.05	<0.002	<0.002	0.019	<0.125
FR Water	<0.01	<0.1	<0.01	<0.1	<0.01	<0.01	<0.01	<0.01	<0.1	<0.01	<0.01	<0.01	<0.125
Site Water													
Tindilpie Pad Clean	<0.005	<0.05	<0.005	<0.05	<0.005	<0.005	<0.005	<0.005	<0.05	<0.002	<0.002	<0.005	<0.05
Tindilpie Pad Pit Circ	<0.005	<0.05	<0.005	<0.05	<0.005	<0.005	<0.005	<0.005	<0.05	<0.02	<0.02	<0.005	<0.05
Fracturing Flowback Fluids													
Tildilpie Pad 4-9-2012 Sample1	<0.1	<1	<0.1	<1	<0.1	<0.1	<0.1	<0.1	<1	<0.2	<0.2	<0.1	<0.25
Tildilpie Pad 4-9-2012 Sample2	<0.1	<1	<0.1	<1	<0.1	<0.1	<0.1	<0.1	<1	<0.2	<0.2	<0.1	<0.25
TPPF-FPWPF _ 27/08/2012	<0.1	<1	<0.1	<1	<0.1	<0.1	<0.1	<0.1	<1	<0.01	<0.01	<0.1	<0.25

Notes
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VOC - Volatile Organic Compounds
SVOC - Semi-Volatile Organic Compounds

Golder Associates

Hydraulic Fracturing Fluid Laboratory Results, South Australia
Job # 127666004

Field Identification	Laboratory ID	Sample Comments	Methyl Ethyl Ketone	Pentachloroethane	Tetrachloroethene	trans-1,2-dichloroethene	trans-1,3-dichloropropene	trans-1,4-Dichloro-2-butene	Trichloroethene	Trichlorofluoromethane	Vinyl acetate	Vinyl chloride
			mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
EQL			0.05	0.005	0.005	0.005	0.005	0.005	0.005	0.05	0.05	0.05
ANZECC 2000 Freshwater 95%												
CCME (2008)												
NHMRC 2008					0.05							0.0003
NHMRC 2011					0.05							0.0003
DERM Queensland BTEX Standards [10]												
Adopted Criteria 1 [9]												
Adopted Criteria 2 [9]												
Verbruggen (2004)-Lab Filtered [1]												
Verbruggen (2004)-Total [2]												
Halliburton Fracturing Fluid												
Crosslink Gel	EM1210744	Fracturing fluids with distilled water	0.05	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.05	<0.05	<0.05
FR Water	EM1210744	Fracturing fluids with distilled water	<0.1	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.1	<0.1	<0.1
Site Water												
Tindilpie Pad Clean	EM1209245	Fracture fluid make up water from pond	<0.05	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.05	<0.05	<0.05
Tindilpie Pad Pit Circ	EM1209245	Flare pit water prior to flowback	<0.05	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.05	<0.05	<0.05
Fracturing Flowback Fluids												
Tildilpie Pad 4-9-2012 Sample1	EM1210360	Flowback water	<1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<1	<1	<1
Tildilpie Pad 4-9-2012 Sample2	EM1210360	Flowback water	<1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<1	<1	<1
TPPF-FPWPF _ 27/08/2012	EM1209924	Tindilpie Pad Pit Flowback - frac pit water post flowback	<1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<1	<1	<1

Other - Group 1

Field Identification	1,3,5-Trinitrobenzene	1-Naphthylamine	2,4-Dinitrotoluene	2,6-Dinitrotoluene	3-Nitroaniline	4-Chloroaniline	4-Nitroaniline	Aniline	Azobenzene	Bis(2-ethylhexyl) phthalate	Butylbenzyl phthalate	Carbazole	Chlorobenzilate	Diethyl phthalate	Dimethyl phthalate	Di-n-butyl phthalate	Di-n-octyl phthalate	Nitrobenzene	n-Nitrosodiethylamine	n-Nitrosodi-n-butylamine	n-Nitrosodi-n-propylamine	n-Nitrosodiphenylamine & Diphenylamine	n-Nitrosomethylethylamine	Pronamide
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
EQL	0.002	0.002	0.004	0.004	0.004	0.002	0.002	0.002	0.002	0.005	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.004	0.002	0.002
ANZECC 2000 Freshwater 95%			**0.065**					**0.25**						**1**	**3.7**	**0.026**		**0.55**						
CCME (2008)																								
NHMRC 2008																								
NHMRC 2011																							0.0001	
DERM Queensland BTEX Standards [10]																								
Adopted Criteria 1 [9]																								
Adopted Criteria 2 [9]																								
Verbruggen (2004)-Lab Filtered [1]																								
Verbruggen (2004)-Total [2]																								
Halliburton Fracturing Fluid																								
Crosslink Gel	<0.002	<0.002	<0.004	<0.004	<0.004	<0.002	<0.002	<0.002	<0.002	<0.01	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.004	<0.002	<0.002
FR Water	<0.01	<0.01	<0.02	<0.02	<0.02	<0.01	<0.01	<0.01	<0.01	<0.05	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.02	<0.01	<0.01
Site Water																								
Tindilpie Pad Clean	<0.002	<0.002	<0.004	<0.004	<0.004	<0.002	<0.002	<0.002	<0.002	<0.01	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.004	<0.002	<0.002
Tindilpie Pad Pit Circ	<0.02	<0.02	<0.04	<0.04	<0.04	<0.02	<0.02	<0.02	<0.02	<0.1	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.04	<0.02	<0.02
Fracturing Flowback Fluids																								
Tildilpie Pad 4-9-2012 Sample1	<0.2	<0.2	**<0.4**	<0.4	<0.4	<0.2	<0.2	<0.2	<0.2	<1	<0.2	<0.2	<0.2	<0.2	<0.2	**<0.2**	<0.2	<0.2	<0.2	<0.2	<0.2	<0.4	<0.2	<0.2
Tildilpie Pad 4-9-2012 Sample2	<0.2	<0.2	**<0.4**	<0.4	<0.4	<0.2	<0.2	<0.2	<0.2	<1	<0.2	<0.2	<0.2	<0.2	<0.2	**<0.2**	<0.2	<0.2	<0.2	<0.2	<0.2	<0.4	<0.2	<0.2
TPPF-FPWPF _ 27/08/2012	<0.01	<0.01	<0.02	<0.02	<0.02	<0.01	<0.01	<0.01	<0.01	<0.05	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-	<0.01	<0.01

Field Identification	Aromatic >C10-C12	Aromatic >C12-C16	Aromatic >C10-C16 [7]	Aromatic >C16-C21	Aromatic >C21-C35 [4]	Aromatic >C16-C35 [7]	Aromatic >C10-C35 [8]	Aromatic >C5-C7	Aromatic >C7-C8	Aromatic >C8-C10	4.4`-DDT
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
EQL	0.05	0.05		0.05	0.05			0.005	0.005	0.005	
ANZECC 2000 Freshwater 95%											
CCME (2008)	*0.096*	*0.0554*								*0.14*	
NHMRC 2008											
NHMRC 2011											0.009
DERM Queensland BTEX Standards [10]											
Adopted Criteria 1 [9]			0.1			0.09		0.001	0.025	0.003	
Adopted Criteria 2 [9]										0.02	
Verbruggen (2004)-Lab Filtered [1]	0.6	0.26		0.071	0.0061			2.3	1.6	1	
Verbruggen (2004)-Total [2]	0.94	0.67		0.6	1.2			2.6	1.8	1.3	
Halliburton Fracturing Fluid											
Crosslink Gel	*1.64*	<0.05	1.64	<0.05	0.056	0.056	1.696	<0.005	0.012	0.018	-
FR Water	*5.2*	*0.41*	5.61	0.41	0.205	0.615	6.225	<0.01	0.023	0.047	-
Site Water											
Tindilpie Pad Clean	<0.05	<0.05	<0.05	<0.05	0.099	<0.05	<0.05	<0.005	<0.005	<0.005	-
Tindilpie Pad Pit Circ	*2.24*	*2.18*	4.42	2.86	0.871	3.731	8.151	0.07	0.164	*0.142*	-
Fracturing Flowback Fluids											
Tildilpie Pad 4-9-2012 Sample1	*6.05*	*14.9*	20.95	12.9	3.61	16.51	37.46	1.04	6.49	*17.9*	-
Tildilpie Pad 4-9-2012 Sample2	*7.07*	*14.8*	21.87	12.7	3.41	16.11	37.98	1	5.42	*10.4*	-
TPPF-FPWPF _ 27/08/2012	*4.1*	*3.66*	7.76	2.78	0.64	3.42	11.18	0.837	4.42	*10.1*	<0.02

Notes
[1] The SRCeco is the concentration of a substance in the soil, sediment or (ground)water at which functions in these compartn
[2] The total concentration refers to the sum of the concentrations in the dissolved phase and in particulate matter.
[3] The toxic unit approach specifies that the sum of the individual ratios of field measurement to SRC should be less than 1.
[4] These criteria may be ignored where lower carbon fractions are absent because solubility is so low that the internal concentı
[5] This criteria has been adopted from NHMRC (2011) base on Ethylbenzene
[6] This criteria has been adopted from NHMRC (2011) base on o-, p-, and m-xylene(s)
[7] Based on health and do not include evaluation of organoleptic properties
[8] Must also examine PAH's if Benzo(a)pyrene = 0.00001 mg/L (NHMRC 2011)
[9] Criteria values have been sourced from WHO (2005), NHMRC (2011) and TPHCWG (1997)
[10] Criteria values have been sourced from the Australian Drinking Water Guidelines (2011) and the Australia and New Zealar
Guidelines for Fresh and Marine Water Quality (2000). The value for xylenes (m and p) was determined from the sum of the va

Abbreviations:
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TPH - Total Petroleum Hydrocarbons
PCB - Polychlorinated Biphenyls
OCP - Organochlorine Pesticides
OPP - Organophosphorus Pesticides
MAH - Monocyclic Aromatic Hydrocarbons
PAH - Polycyclic Aromatic Hydrocarbons
BTEX - benzene, toluene, ethylbenzene, xylenes
VOC - Volatile Organic Compounds
SVOC - Semi-Volatile Organic Compounds

Hydraulic Fracturing Fluid Laboratory Results, South Australia
Job # 127666004

			Other - Group 2															Other - Group 3					Solvents				
			Aliphatic >C10-C12	Aliphatic >C12-C16 [4]	Aliphatic >C16-C21 [4]	Aliphatic >C21-C35	Aliphatic >C5-C8 [7]	Aliphatic >C6-C8	Aliphatic >C8-C10	Aliphatic >C8-16 [7]	Benzo(a)pyrene (TEQs)	Formaldehyde	Free Chlorine	Iodide	Reactive Phosphorus (as P)	Silica	n-Butanol	2-Fluorobiphenyl (surrogate)	2-methyl-5-nitroaniline	2-Nitroaniline	Anionic surfactants (as MBAS)	Non-ionic surfactants (as CTAS)	1-Butanol	1-Propanol	2-Propanol	Ethanol	Isophorone
			mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	%	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
EQL			0.05	0.05	0.05	0.05	0.02	0.02	0.02		0.002	0.1	0.02	0.01	0.01	0.1			0.002	0.004	0.1	5	0.05	0.05	0.05	0.05	0.002
ANZECC 2000 Freshwater 95%																										**1.4**	
CCME (2008)			*0.00118*	*0.000074*				*0.0465*	*0.0076*																		
NHMRC 2008														0.1													
NHMRC 2011												0.5		0.5		80											
DERM Queensland BTEX Standards [10]																											
Adopted Criteria 1 [9]										0.3																	
Adopted Criteria 2 [9]																											
Verbruggen (2004)-Lab Filtered [1]			0.0024	0.0013	0.071		0.33	0.074	0.0094																		
Verbruggen (2004)-Total [2]			0.16	1.7	0.6		0.42	0.17	0.094																		
Field Identification	**Laboratory ID**	**Sample Comments**																									
Halliburton Fracturing Fluid																											
Crosslink Gel	EM1210744	Fracturing fluids with distilled water	*0.85*	*<0.05*	<0.05	<0.05	0.038	<0.02	*0.155*	1.005	<0.002	-	-	-	-	-	-	-	<0.002	<0.004	-	-	<0.125	<0.125	4.15	0.163	<0.002
FR Water	EM1210744	Fracturing fluids with distilled water	*1.98*	*<0.05*	<0.05	<0.05	<0.2	*0.216*	*19.2*	21.18	<0.01	<0.1	0.26	<0.01	0.07	<0.1	-	-	<0.01	<0.02	<0.1	105	<0.125	<0.125	4.27	0.138	<0.01
Site Water																											
Tindilpie Pad Clean	EM1209245	Fracture fluid make up water from pond	*<0.05*	*<0.05*	0.132	0.264	<0.02	0.02	*<0.02*	<0.05	-	0.2	0.08	0.168	<0.01	83.8	-	-	<0.002	<0.004	0.5	<5	<0.05	<0.05	<0.05	<0.05	<0.002
Tindilpie Pad Pit Circ	EM1209245	Flare pit water prior to flowback	*1.34*	*10.1*	13.2	5.7	0.086	*0.162*	*0.688*	12.128	-	3.5	0.11	<0.02	0.08	92.6	-	-	<0.02	<0.04	0.1	7	<0.05	<0.05	3.34	0.492	<0.02
Fracturing Flowback Fluids																											
Tildilpie Pad 4-9-2012 Sample1	EM1210360	Flowback water	*18*	*53.6*	52.5	24.9	5.3	*71.4*	*103*	174.6	<0.2	4.6	<0.02	1.42	0.11	141	-	-	<0.2	<0.4	0.1	17	<0.25	24.9	3.95	**2.46**	<0.2
Tildilpie Pad 4-9-2012 Sample2	EM1210360	Flowback water	*19.3*	*54.2*	52.6	24.2	3.89	*22*	*47.1*	120.6	<0.2	4.8	<0.02	1.61	0.12	135	-	-	<0.2	<0.4	0.1	21	<0.25	25.6	4.07	**2.44**	<0.2
TPPF-FPWPF 27/08/2012	EM1209924	Tindilpie Pad Pit Flowback - frac pit water post flowback	*5.18*	*12.5*	11.6	4.75	3.44	*24.1*	*47.4*	65.08	<0.01	2.9	0.3	1.29	0.09	12.6	<0.25	-	<0.01	<0.02	0.1	<5	-	22.8	2.84	**1.36**	<0.01

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MAH - Monocyclic Aromatic Hydrocarbons
PAH - Polycyclic Aromatic Hydrocarbons
BTEX - benzene, toluene, ethylbenzene, xylenes
VOC - Volatile Organic Compounds
SVOC - Semi-Volatile Organic Compounds

CERTIFICATE OF ANALYSIS

Work Order	: **EM1209245**	Page	: 1 of 13
Client	: **SANTOS LTD**	Laboratory	: Environmental Division Melbourne
Contact	: MR BARRY RITCHIE	Contact	: Jodie Hancock
Address	: GROUND FLOOR SANTOS CENTRE 60 FLINDERS STREET ADELAIDE SA, AUSTRALIA 5001	Address	: 4 Westall Rd Springvale VIC Australia 3171
E-mail	: barry.ritchie@santos.com	E-mail	: Jodie.Hancock@alsenviro.com
Telephone	: +61 08 8116 5000	Telephone	: +61 7 3243 7128
Facsimile	: +61 08 8116 5050	Facsimile	: +61 7 3243 7218
Project	: HFRA Fluids Sampling - Extended Analysis	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Order number	: 879002/538		
C-O-C number	: ----	Date Samples Received	: 14-AUG-2012
Sampler	: TD / AJ	Issue Date	: 28-AUG-2012
Site	: ----		
		No. of samples received	: 2
Quote number	: EN/039/11	No. of samples analysed	: 2

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results
- Surrogate Control Limits

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting

- **ED009X - Iodide LOR raised for sample ID Tindilpie Pad Pit Circ due to matrix interferences.**
- **EG020F: Positive mercury results for EM1209245-001 have been confirmed by re-preparation and re-analysis.**
- **EK025G: Free cyanide was analysed by Free cyanide by Segmented Flow analyser Method (EK025SF).**
- **EK026G: Total cyanide was analysed by Total cyanide by Segmented Flow analyser Method (EK026SF).**
- **EP050: The MBAS reported is calculated as LAS, mol wt ___342____.**
- **EP071: Poor matrix spike recovery for sample EM1209245-002 due to sample heterogeneity. Insufficient sample available for re-extraction and analysis.**
- **EP074: Sample EM1209245-002 has LOR raised for n-Butylbenzene due to matrix interference.**
- **EP075: EM1209245-002 Particular sample required dilution prior to analysis due to matrix interferences. LOR values have been adjusted accordingly.**
- **EP075: LOR raised for 1,4-Dichlorobenzene due to laboratory background.**
- **EP075: Matrix spike not determined due to matrix interferences.**
- **EP075: 'Sum of PAH' is the sum of the USEPA 16 priority PAHs**
- **Ionic Balance out of acceptable limits due to analytes not quantified in this report.**
- **Ionic balances were calculated using: major anions - chloride, alkalinity and sulfate; and major cations - calcium, magnesium, potassium and sodium.**
- **MBAS, CTAS, Bromide & Iodide and Alchohols conducted by ALS Sydney, NATA accreditation no. 825, site no 10911.**
- **Samples were filtered through a 0.45um filter prior to the dissolved metals analysis.**

NATA Accredited Laboratory 825

Accredited for compliance with ISO/IEC 17025.

Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	Position	Accreditation Category
Dilani Fernando	Senior Inorganic Chemist	Melbourne Inorganics
Nancy Wang	Senior Semivolatile Instrument Chemist	Melbourne Organics
Nanthini Coilparampil	Laboratory Manager - Inorganics	Sydney Inorganics
Pabi Subba	Senior Organic Chemist	Sydney Organics
Sarah Millington	Senior Inorganic Chemist	Sydney Inorganics
Varsha Ho Wing	Non-Metals Team Leader	Melbourne Inorganics

Analytical Results

Sub-Matrix: **WATER**

Compound	CAS Number	LOR	Unit	Client sample ID	"Tindilpie Pad Clean" frac make up water from pond	"Tindilpie Pad Pit Circ" Pit water prior to flowback	----	----	----
				Client sampling date / time	13-AUG-2012 08:00	13-AUG-2012 07:30	----	----	----
					EM1209245-001	EM1209245-002	----	----	----
EA005: pH									
pH Value	----	0.01	pH Unit		8.36	8.52	----	----	----
EA006: Sodium Adsorption Ratio (SAR)									
Sodium Absorption Ratio	----	0.01	-		113	108	----	----	----
EA015: Total Dissolved Solids									
Total Dissolved Solids @180°C	GIS-210-010	10	mg/L		3610	5490	----	----	----
EA065: Total Hardness as CaCO3									
Total Hardness as CaCO3	----	1	mg/L		24	91	----	----	----
ED009: Anions									
Bromide	24959-67-9	0.010	mg/L		6.24	12.0	----	----	----
Iodide	20461-54-5	0.010	mg/L		0.168	<0.020	----	----	----
ED037P: Alkalinity by PC Titrator									
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L		<1	<1	----	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L		206	16	----	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L		1590	2230	----	----	----
Total Alkalinity as CaCO3	----	1	mg/L		1790	2240	----	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA									
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L		24	23	----	----	----
ED045G: Chloride Discrete analyser									
Chloride	16887-00-6	1	mg/L		992	1800	----	----	----
ED093F: Dissolved Major Cations									
Calcium	7440-70-2	1	mg/L		8	30	----	----	----
Magnesium	7439-95-4	1	mg/L		1	4	----	----	----
Sodium	7440-23-5	1	mg/L		1280	2370	----	----	----
Potassium	7440-09-7	1	mg/L		38	75	----	----	----
EG020F: Dissolved Metals by ICP-MS									
Aluminium	7429-90-5	0.01	mg/L		0.01	0.42	----	----	----
Arsenic	7440-38-2	0.001	mg/L		<0.001	0.020	----	----	----
Barium	7440-39-3	0.001	mg/L		1.97	6.13	----	----	----
Beryllium	7440-41-7	0.001	mg/L		<0.001	<0.001	----	----	----
Cadmium	7440-43-9	0.0001	mg/L		<0.0001	0.0002	----	----	----
Cobalt	7440-48-4	0.001	mg/L		<0.001	0.004	----	----	----
Chromium	7440-47-3	0.001	mg/L		<0.001	<0.001	----	----	----
Copper	7440-50-8	0.001	mg/L		0.002	0.189	----	----	----
Manganese	7439-96-5	0.001	mg/L		0.004	0.180	----	----	----

Analytical Results

Sub-Matrix: **WATER**

Compound	CAS Number	LOR	Unit	Client sample ID	"Tindilpie Pad Clean" frac make up water from pond	"Tindilpie Pad Pit Circ" Pit water prior to flowback	----	----	----
				Client sampling date / time	13-AUG-2012 08:00	13-AUG-2012 07:30	----	----	----
					EM1209245-001	EM1209245-002	----	----	----
EG020F: Dissolved Metals by ICP-MS - Continued									
Nickel	7440-02-0	0.001	mg/L		<0.001	**0.028**	----	----	----
Lead	7439-92-1	0.001	mg/L		<0.001	**0.091**	----	----	----
Vanadium	7440-62-2	0.01	mg/L		<0.01	**0.02**	----	----	----
Zinc	7440-66-6	0.005	mg/L		**0.014**	**0.141**	----	----	----
Lithium	7439-93-2	0.001	mg/L		**0.447**	**0.872**	----	----	----
Molybdenum	7439-98-7	0.001	mg/L		<0.001	**0.035**	----	----	----
Selenium	7782-49-2	0.01	mg/L		<0.01	<0.01	----	----	----
Strontium	7440-24-6	0.001	mg/L		**0.626**	**1.29**	----	----	----
Tin	7440-31-5	0.001	mg/L		<0.001	<0.001	----	----	----
Uranium	7440-61-1	0.001	mg/L		<0.001	**0.001**	----	----	----
Boron	7440-42-8	0.05	mg/L		**4.74**	**55.5**	----	----	----
Iron	7439-89-6	0.05	mg/L		<0.05	**15.6**	----	----	----
EG035F: Dissolved Mercury by FIMS									
Mercury	7439-97-6	0.0001	mg/L		**0.0002**	<0.0001	----	----	----
EG052F: Dissolved Silica by ICPAES									
Silica	7631-86-9	0.1	mg/L		**83.8**	**92.6**	----	----	----
EK011: Chlorine - Free									
Free Chlorine	----	0.02	mg/L		**0.08**	**0.11**	----	----	----
EK025G: Free cyanide by Discrete Analyser									
Free Cyanide	----	0.004	mg/L		<0.004	<0.004	----	----	----
EK026G: Total Cyanide By Discrete Analyser									
Total Cyanide	57-12-5	0.004	mg/L		<0.004	<0.004	----	----	----
EK040P: Fluoride by PC Titrator									
Fluoride	16984-48-8	0.1	mg/L		**3.2**	**2.5**	----	----	----
EK055G: Ammonia as N by Discrete Analyser									
Ammonia as N	7664-41-7	0.01	mg/L		**0.20**	**23.4**	----	----	----
EK057G: Nitrite as N by Discrete Analyser									
Nitrite as N	----	0.01	mg/L		<0.01	**0.46**	----	----	----
EK058G: Nitrate as N by Discrete Analyser									
Nitrate as N	14797-55-8	0.01	mg/L		**0.03**	**0.01**	----	----	----
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N	----	0.01	mg/L		**0.03**	**0.47**	----	----	----
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser									

Analytical Results

Sub-Matrix: **WATER**

Compound	CAS Number	LOR	Unit	Client sample ID	"Tindilpie Pad Clean" frac make up water from pond	"Tindilpie Pad Pit Circ" Pit water prior to flowback	----	----	----
				Client sampling date / time	13-AUG-2012 08:00	13-AUG-2012 07:30	----	----	----
					EM1209245-001	EM1209245-002	----	----	----
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser - Continued									
Total Kjeldahl Nitrogen as N	----	0.1	mg/L		**3.6**	**182**	----	----	----
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser									
^ **Total Nitrogen as N**	----	0.1	mg/L		**3.6**	**182**	----	----	----
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphorus as P	----	0.01	mg/L		**1.38**	**1.39**	----	----	----
EK071G: Reactive Phosphorus as P by discrete analyser									
Reactive Phosphorus as P	----	0.01	mg/L		<0.01	**0.08**	----	----	----
EN055: Ionic Balance									
Total Anions	----	0.01	meq/L		**64.2**	**96.0**	----	----	----
Total Cations	----	0.01	meq/L		**57.1**	**107**	----	----	----
Ionic Balance	----	0.01	%		**5.91**	**5.29**	----	----	----
EP005: Total Organic Carbon (TOC)									
Total Organic Carbon	----	1	mg/L		<1	**1080**	----	----	----
EP010: Formaldehyde									
Formaldehyde	50-00-0	0.1	mg/L		**0.2**	**3.5**	----	----	----
EP041A: Nonionic Surfactants									
Nonionic Surfactants as CTAS	----	5	mg/L		<5	**7**	----	----	----
EP050: Anionic Surfactants as MBAS									
Anionic Surfactants as MBAS	----	0.1	mg/L		**0.5**	**0.1**	----	----	----
EP074A: Monocyclic Aromatic Hydrocarbons									
Benzene	71-43-2	1	µg/L		**2**	**65**	----	----	----
Toluene	108-88-3	2	µg/L		**4**	**148**	----	----	----
Ethylbenzene	100-41-4	2	µg/L		<2	**11**	----	----	----
meta- & para-Xylene	108-38-3 106-42-3	2	µg/L		<2	**80**	----	----	----
Styrene	100-42-5	5	µg/L		<5	<5	----	----	----
ortho-Xylene	95-47-6	2	µg/L		<2	**23**	----	----	----
Isopropylbenzene	98-82-8	5	µg/L		<5	<5	----	----	----
n-Propylbenzene	103-65-1	5	µg/L		<5	<5	----	----	----
1.3.5-Trimethylbenzene	108-67-8	5	µg/L		<5	**10**	----	----	----
sec-Butylbenzene	135-98-8	5	µg/L		<5	<5	----	----	----
1.2.4-Trimethylbenzene	95-63-6	5	µg/L		<5	**32**	----	----	----
tert-Butylbenzene	98-06-6	5	µg/L		<5	<5	----	----	----
p-Isopropyltoluene	99-87-6	5	µg/L		<5	**110**	----	----	----
n-Butylbenzene	104-51-8	5	µg/L		<5	<10	----	----	----

Analytical Results

Sub-Matrix: **WATER**

Compound	CAS Number	LOR	Unit	Client sample ID	"Tindilpie Pad Clean" frac make up water from pond	"Tindilpie Pad Pit Circ" Pit water prior to flowback	----	----	----
				Client sampling date / time	13-AUG-2012 08:00	13-AUG-2012 07:30	----	----	----
					EM1209245-001	EM1209245-002	----	----	----
EP074A: Monocyclic Aromatic Hydrocarbons - Continued									
EP074B: Oxygenated Compounds									
Vinyl Acetate	108-05-4	50	µg/L		<50	<50	----	----	----
2-Butanone (MEK)	78-93-3	50	µg/L		<50	<50	----	----	----
4-Methyl-2-pentanone (MIBK)	108-10-1	50	µg/L		<50	<50	----	----	----
2-Hexanone (MBK)	591-78-6	50	µg/L		<50	<50	----	----	----
EP074C: Sulfonated Compounds									
Carbon disulfide	75-15-0	5	µg/L		<5	<5	----	----	----
EP074D: Fumigants									
2.2-Dichloropropane	594-20-7	5	µg/L		<5	<5	----	----	----
1.2-Dichloropropane	78-87-5	5	µg/L		<5	<5	----	----	----
cis-1.3-Dichloropropylene	10061-01-5	5	µg/L		<5	<5	----	----	----
trans-1.3-Dichloropropylene	10061-02-6	5	µg/L		<5	<5	----	----	----
1.2-Dibromoethane (EDB)	106-93-4	5	µg/L		<5	<5	----	----	----
EP074E: Halogenated Aliphatic Compounds									
Dichlorodifluoromethane	75-71-8	50	µg/L		<50	<50	----	----	----
Chloromethane	74-87-3	50	µg/L		<50	<50	----	----	----
Vinyl chloride	75-01-4	50	µg/L		<50	<50	----	----	----
Bromomethane	74-83-9	50	µg/L		<50	<50	----	----	----
Chloroethane	75-00-3	50	µg/L		<50	<50	----	----	----
Trichlorofluoromethane	75-69-4	50	µg/L		<50	<50	----	----	----
1.1-Dichloroethene	75-35-4	5	µg/L		<5	<5	----	----	----
Iodomethane	74-88-4	5	µg/L		<5	<5	----	----	----
trans-1.2-Dichloroethene	156-60-5	5	µg/L		<5	<5	----	----	----
1.1-Dichloroethane	75-34-3	5	µg/L		<5	<5	----	----	----
cis-1.2-Dichloroethene	156-59-2	5	µg/L		<5	<5	----	----	----
1.1.1-Trichloroethane	71-55-6	5	µg/L		<5	<5	----	----	----
1.1-Dichloropropylene	563-58-6	5	µg/L		<5	<5	----	----	----
Carbon Tetrachloride	56-23-5	5	µg/L		<5	<5	----	----	----
1.2-Dichloroethane	107-06-2	5	µg/L		<5	<5	----	----	----
Trichloroethene	79-01-6	5	µg/L		<5	<5	----	----	----
Dibromomethane	74-95-3	5	µg/L		<5	<5	----	----	----
1.1.2-Trichloroethane	79-00-5	5	µg/L		<5	<5	----	----	----
1.3-Dichloropropane	142-28-9	5	µg/L		<5	<5	----	----	----
Tetrachloroethene	127-18-4	5	µg/L		<5	<5	----	----	----

Analytical Results

Sub-Matrix: **WATER**

Compound	CAS Number	LOR	Unit	Client sample ID	"Tindilpie Pad Clean" frac make up water from pond	"Tindilpie Pad Pit Circ" Pit water prior to flowback	----	----	----
				Client sampling date / time	13-AUG-2012 08:00	13-AUG-2012 07:30	----	----	----
					EM1209245-001	EM1209245-002	----	----	----
EP074E: Halogenated Aliphatic Compounds - Continued									
1.1.1.2-Tetrachloroethane	630-20-6	5	µg/L		<5	<5	----	----	----
trans-1.4-Dichloro-2-butene	110-57-6	5	µg/L		<5	<5	----	----	----
cis-1.4-Dichloro-2-butene	1476-11-5	5	µg/L		<5	<5	----	----	----
1.1.2.2-Tetrachloroethane	79-34-5	5	µg/L		<5	<5	----	----	----
1.2.3-Trichloropropane	96-18-4	5	µg/L		<5	<5	----	----	----
Pentachloroethane	76-01-7	5	µg/L		<5	<5	----	----	----
1.2-Dibromo-3-chloropropane	96-12-8	5	µg/L		<5	<5	----	----	----
EP074F: Halogenated Aromatic Compounds									
Chlorobenzene	108-90-7	5	µg/L		<5	<5	----	----	----
Bromobenzene	108-86-1	5	µg/L		<5	<5	----	----	----
2-Chlorotoluene	95-49-8	5	µg/L		<5	<5	----	----	----
4-Chlorotoluene	106-43-4	5	µg/L		<5	<5	----	----	----
1.2.3-Trichlorobenzene	87-61-6	5	µg/L		<5	<5	----	----	----
EP074G: Trihalomethanes									
Chloroform	67-66-3	5	µg/L		<5	<5	----	----	----
Bromodichloromethane	75-27-4	5	µg/L		<5	<5	----	----	----
Dibromochloromethane	124-48-1	5	µg/L		<5	<5	----	----	----
Bromoform	75-25-2	5	µg/L		<5	<5	----	----	----
EP075A: Phenolic Compounds									
Phenol	108-95-2	2	µg/L		<2	**88**	----	----	----
2-Chlorophenol	95-57-8	2	µg/L		<2	<20	----	----	----
2-Methylphenol	95-48-7	2	µg/L		<2	<20	----	----	----
3- & 4-Methylphenol	1319-77-3	4	µg/L		<4	<40	----	----	----
2-Nitrophenol	88-75-5	2	µg/L		<2	<20	----	----	----
2.4-Dimethylphenol	105-67-9	2	µg/L		**6**	<20	----	----	----
2.4-Dichlorophenol	120-83-2	2	µg/L		<2	<20	----	----	----
2.6-Dichlorophenol	87-65-0	2	µg/L		<2	<20	----	----	----
4-Chloro-3-Methylphenol	59-50-7	2	µg/L		<2	<20	----	----	----
2.4.6-Trichlorophenol	88-06-2	2	µg/L		<2	<20	----	----	----
2.4.5-Trichlorophenol	95-95-4	2	µg/L		<2	<20	----	----	----
Pentachlorophenol	87-86-5	4	µg/L		<4	<40	----	----	----
EP075B: Polynuclear Aromatic Hydrocarbons									
Naphthalene	91-20-3	2	µg/L		<2	<20	----	----	----
2-Methylnaphthalene	91-57-6	2	µg/L		<2	**36**	----	----	----

Analytical Results

Sub-Matrix: **WATER**

Compound	CAS Number	LOR	Unit	Client sample ID	"Tindilpie Pad Clean" frac make up water from pond	"Tindilpie Pad Pit Circ" Pit water prior to flowback	----	----	----
				Client sampling date / time	13-AUG-2012 08:00	13-AUG-2012 07:30	----	----	----
					EM1209245-001	EM1209245-002	----	----	----
EP075B: Polynuclear Aromatic Hydrocarbons - Continued									
2-Chloronaphthalene	91-58-7	2	µg/L		<2	<20	----	----	----
Acenaphthylene	208-96-8	2	µg/L		<2	<20	----	----	----
Acenaphthene	83-32-9	2	µg/L		<2	<20	----	----	----
Fluorene	86-73-7	2	µg/L		<2	<20	----	----	----
Phenanthrene	85-01-8	2	µg/L		<2	<20	----	----	----
Anthracene	120-12-7	2	µg/L		<2	<20	----	----	----
Fluoranthene	206-44-0	2	µg/L		<2	<20	----	----	----
Pyrene	129-00-0	2	µg/L		<2	<20	----	----	----
N-2-Fluorenyl Acetamide	53-96-3	2	µg/L		<2	<20	----	----	----
Benz(a)anthracene	56-55-3	2	µg/L		<2	<20	----	----	----
Chrysene	218-01-9	2	µg/L		<2	<20	----	----	----
Benzo(b) & Benzo(k)fluoranthene	205-99-2 207-08-9	4	µg/L		<4	<40	----	----	----
7.12-Dimethylbenz(a)anthracene	57-97-6	2	µg/L		<2	<20	----	----	----
Benzo(a)pyrene	50-32-8	2	µg/L		<2	<20	----	----	----
3-Methylcholanthrene	56-49-5	2	µg/L		<2	<20	----	----	----
Indeno(1.2.3.cd)pyrene	193-39-5	2	µg/L		<2	<20	----	----	----
Dibenz(a.h)anthracene	53-70-3	2	µg/L		<2	<20	----	----	----
Benzo(g.h.i)perylene	191-24-2	2	µg/L		<2	<20	----	----	----
^ Sum of PAHs	----	2	µg/L		<2	<20	----	----	----
EP075C: Phthalate Esters									
Dimethyl phthalate	131-11-3	2	µg/L		<2	<20	----	----	----
Diethyl phthalate	84-66-2	2	µg/L		<2	<20	----	----	----
Di-n-butyl phthalate	84-74-2	2	µg/L		<2	<20	----	----	----
Butyl benzyl phthalate	85-68-7	2	µg/L		<2	<20	----	----	----
bis(2-ethylhexyl) phthalate	117-81-7	5	µg/L		<10	<100	----	----	----
Di-n-octylphthalate	117-84-0	2	µg/L		<2	<20	----	----	----
EP075D: Nitrosamines									
N-Nitrosomethylethylamine	10595-95-6	2	µg/L		<2	<20	----	----	----
N-Nitrosodiethylamine	55-18-5	2	µg/L		<2	<20	----	----	----
N-Nitrosopyrrolidine	930-55-2	4	µg/L		<4	<40	----	----	----
N-Nitrosomorpholine	59-89-2	2	µg/L		<2	<20	----	----	----
N-Nitrosodi-n-propylamine	621-64-7	2	µg/L		<2	<20	----	----	----
N-Nitrosopiperidine	100-75-4	2	µg/L		<2	<20	----	----	----
N-Nitrosodibutylamine	924-16-3	2	µg/L		<2	<20	----	----	----

Analytical Results

Sub-Matrix: **WATER**

Compound	CAS Number	LOR	Unit	Client sample ID	"Tindilpie Pad Clean" frac make up water from pond	"Tindilpie Pad Pit Circ" Pit water prior to flowback	----	----	----
				Client sampling date / time	13-AUG-2012 08:00	13-AUG-2012 07:30	----	----	----
					EM1209245-001	EM1209245-002	----	----	----
EP075D: Nitrosamines - Continued									
N-Nitrosodiphenyl & Diphenylamine	86-30-6 122-39-4	4	µg/L		<4	<40	----	----	----
Methapyrilene	91-80-5	2	µg/L		<2	<20	----	----	----
EP075E: Nitroaromatics and Ketones									
2-Picoline	109-06-8	2	µg/L		<2	<20	----	----	----
Acetophenone	98-86-2	2	µg/L		<2	<20	----	----	----
Nitrobenzene	98-95-3	2	µg/L		<2	<20	----	----	----
Isophorone	78-59-1	2	µg/L		<2	<20	----	----	----
2.6-Dinitrotoluene	606-20-2	4	µg/L		<4	<40	----	----	----
2.4-Dinitrotoluene	121-14-2	4	µg/L		<4	<40	----	----	----
1-Naphthylamine	134-32-7	2	µg/L		<2	<20	----	----	----
4-Nitroquinoline-N-oxide	56-57-5	2	µg/L		<2	<20	----	----	----
5-Nitro-o-toluidine	99-55-8	2	µg/L		<2	<20	----	----	----
Azobenzene	103-33-3	2	µg/L		<2	<20	----	----	----
1.3.5-Trinitrobenzene	99-35-4	2	µg/L		<2	<20	----	----	----
Phenacetin	62-44-2	2	µg/L		<2	<20	----	----	----
4-Aminobiphenyl	92-67-1	2	µg/L		<2	<20	----	----	----
Pentachloronitrobenzene	82-68-8	2	µg/L		<2	<20	----	----	----
Pronamide	23950-58-5	2	µg/L		<2	<20	----	----	----
Dimethylaminoazobenzene	60-11-7	2	µg/L		<2	<20	----	----	----
Chlorobenzilate	510-15-6	2	µg/L		<2	<20	----	----	----
EP075F: Haloethers									
Bis(2-chloroethyl) ether	111-44-4	2	µg/L		<2	<20	----	----	----
Bis(2-chloroethoxy) methane	111-91-1	2	µg/L		<2	<20	----	----	----
4-Chlorophenyl phenyl ether	7005-72-3	2	µg/L		<2	<20	----	----	----
4-Bromophenyl phenyl ether	101-55-3	2	µg/L		<2	<20	----	----	----
EP075G: Chlorinated Hydrocarbons									
1.3-Dichlorobenzene	541-73-1	2	µg/L		<2	<20	----	----	----
1.4-Dichlorobenzene	106-46-7	2	µg/L		<4	<20	----	----	----
1.2-Dichlorobenzene	95-50-1	2	µg/L		<2	<20	----	----	----
Hexachloroethane	67-72-1	2	µg/L		<2	<20	----	----	----
1.2.4-Trichlorobenzene	120-82-1	2	µg/L		<2	<20	----	----	----
Hexachloropropylene	1888-71-7	2	µg/L		<2	<20	----	----	----
Hexachlorobutadiene	87-68-3	2	µg/L		<2	<20	----	----	----

Analytical Results

Sub-Matrix: **WATER**

Compound	CAS Number	LOR	Unit	Client sample ID	"Tindilpie Pad Clean" frac make up water from pond	"Tindilpie Pad Pit Circ" Pit water prior to flowback	----	----	----
				Client sampling date / time	13-AUG-2012 08:00	13-AUG-2012 07:30	----	----	----
					EM1209245-001	EM1209245-002	----	----	----
EP075G: Chlorinated Hydrocarbons - Continued									
Hexachlorocyclopentadiene	77-47-4	10	µg/L		<10	<100	----	----	----
Pentachlorobenzene	608-93-5	2	µg/L		<2	<20	----	----	----
Hexachlorobenzene (HCB)	118-74-1	4	µg/L		<4	<40	----	----	----
EP075H: Anilines and Benzidines									
Aniline	62-53-3	2	µg/L		<2	<20	----	----	----
4-Chloroaniline	106-47-8	2	µg/L		<2	<20	----	----	----
2-Nitroaniline	88-74-4	4	µg/L		<4	<40	----	----	----
3-Nitroaniline	99-09-2	4	µg/L		<4	<40	----	----	----
Dibenzofuran	132-64-9	2	µg/L		<2	<20	----	----	----
4-Nitroaniline	100-01-6	2	µg/L		<2	<20	----	----	----
Carbazole	86-74-8	2	µg/L		<2	<20	----	----	----
3.3`-Dichlorobenzidine	91-94-1	2	µg/L		<2	<20	----	----	----
EP075I: Organochlorine Pesticides									
alpha-BHC	319-84-6	2	µg/L		<2	<20	----	----	----
beta-BHC	319-85-7	2	µg/L		<2	<20	----	----	----
gamma-BHC	58-89-9	2	µg/L		<2	<20	----	----	----
delta-BHC	319-86-8	2	µg/L		<2	<20	----	----	----
Heptachlor	76-44-8	2	µg/L		<2	<20	----	----	----
Aldrin	309-00-2	2	µg/L		<2	<20	----	----	----
Heptachlor epoxide	1024-57-3	2	µg/L		<2	<20	----	----	----
alpha-Endosulfan	959-98-8	2	µg/L		<2	<20	----	----	----
4.4`-DDE	72-55-9	2	µg/L		<2	<20	----	----	----
Dieldrin	60-57-1	2	µg/L		<2	<20	----	----	----
Endrin	72-20-8	2	µg/L		<2	<20	----	----	----
beta-Endosulfan	33213-65-9	2	µg/L		<2	<20	----	----	----
4.4`-DDD	72-54-8	2	µg/L		<2	<20	----	----	----
Endosulfan sulfate	1031-07-8	2	µg/L		<2	<20	----	----	----
4.4`-DDT	50-29-3	4	µg/L		<4	<40	----	----	----
EP075J: Organophosphorus Pesticides									
Dichlorvos	62-73-7	2	µg/L		<2	<20	----	----	----
Dimethoate	60-51-5	2	µg/L		<2	<20	----	----	----
Diazinon	333-41-5	2	µg/L		<2	<20	----	----	----
Chlorpyrifos-methyl	5598-13-0	2	µg/L		<2	<20	----	----	----
Malathion	121-75-5	2	µg/L		<2	<20	----	----	----

Analytical Results

Sub-Matrix: **WATER**

Compound	CAS Number	LOR	Unit	Client sample ID	"Tindilpie Pad Clean" frac make up water from pond	"Tindilpie Pad Pit Circ" Pit water prior to flowback	----	----	----
				Client sampling date / time	13-AUG-2012 08:00	13-AUG-2012 07:30	----	----	----
					EM1209245-001	EM1209245-002	----	----	----
EP075J: Organophosphorus Pesticides - Continued									
Fenthion	55-38-9	2	µg/L		<2	<20	----	----	----
Chlorpyrifos	2921-88-2	2	µg/L		<2	<20	----	----	----
Pirimphos-ethyl	23505-41-1	2	µg/L		<2	<20	----	----	----
Chlorfenvinphos	470-90-6	2	µg/L		<2	<20	----	----	----
Prothiofos	34643-46-4	2	µg/L		<2	<20	----	----	----
Ethion	563-12-2	2	µg/L		<2	<20	----	----	----
EP117: Alcohols									
Ethanol	64-17-5	50	µg/L		<50	**492**	----	----	----
Isopropanol	67-63-0	50	µg/L		<50	**3340**	----	----	----
n-Propanol	71-23-8	50	µg/L		<50	<50	----	----	----
Isobutanol	78-83-1	50	µg/L		<50	<50	----	----	----
n-Butanol	71-36-3	50	µg/L		<50	<50	----	----	----
RIVM Aliphatic Hydrocarbon Fractions									
Aliphatic >C5-C6	----	20	µg/L		<20	**86**	----	----	----
Aliphatic >C6-C8	TPHCWG-ALV2	20	µg/L		**20**	**162**	----	----	----
Aliphatic >C8-C10	TPHCWG-ALV3	20	µg/L		<20	**688**	----	----	----
Aliphatic >C10-C12	TPHCWG-ALE1	50	µg/L		<50	**1340**	----	----	----
Aliphatic >C12-C16	TPHCWG-ALE2	50	µg/L		<50	**10100**	----	----	----
Aliphatic >C16-C21	----	50	µg/L		**132**	**13200**	----	----	----
Aliphatic >C21-C35	----	50	µg/L		**264**	**5700**	----	----	----
RIVM Aromatic Hydrocarbon Fractions									
Aromatic >C5-C7	----	5	µg/L		<5	**70**	----	----	----
Aromatic >C7-C8	TPHCWG-ARV2	5	µg/L		<5	**164**	----	----	----
Aromatic >C8-C10	TPHCWG-ARV3	5	µg/L		<5	**142**	----	----	----
Aromatic >C10-C12	TPHCWG-ARE1	50	µg/L		<50	**2240**	----	----	----
Aromatic >C12-C16	TPHCWG-ARE2	50	µg/L		<50	**2180**	----	----	----
Aromatic >C16-C21	TPHCWG-ARE3	50	µg/L		<50	**2860**	----	----	----
Aromatic >C21-C35	TPHCWG-ARE4	50	µg/L		**99**	**871**	----	----	----
EP074S: VOC Surrogates									
1.2-Dichloroethane-D4	17060-07-0	0.1	%		**116**	**108**	----	----	----
Toluene-D8	2037-26-5	0.1	%		**117**	**124**	----	----	----
4-Bromofluorobenzene	460-00-4	0.1	%		**117**	**106**	----	----	----
EP075S: Acid Extractable Surrogates									
2-Fluorophenol	367-12-4	0.1	%		**33.3**	**Not Determined**	----	----	----

Analytical Results

Sub-Matrix: **WATER**

Compound	CAS Number	LOR	Unit	Client sample ID	"Tindilpie Pad Clean" frac make up water from pond	"Tindilpie Pad Pit Circ" Pit water prior to flowback	----	----	----
				Client sampling date / time	13-AUG-2012 08:00	13-AUG-2012 07:30	----	----	----
					EM1209245-001	EM1209245-002	----	----	----
EP075S: Acid Extractable Surrogates - Continued									
Phenol-d6	13127-88-3	0.1	%		**27.5**	**Not Determined**	----	----	----
2-Chlorophenol-D4	93951-73-6	0.1	%		**60.2**	**Not Determined**	----	----	----
2.4.6-Tribromophenol	118-79-6	0.1	%		**76.8**	**Not Determined**	----	----	----
EP075T: Base/Neutral Extractable Surrogates									
Nitrobenzene-D5	4165-60-0	0.1	%		**68.2**	**Not Determined**	----	----	----
1.2-Dichlorobenzene-D4	2199-69-1	0.1	%		**54.8**	**Not Determined**	----	----	----
2-Fluorobiphenyl	321-60-8	0.1	%		**71.9**	**Not Determined**	----	----	----
Anthracene-d10	1719-06-8	0.1	%		**83.8**	**Not Determined**	----	----	----
4-Terphenyl-d14	1718-51-0	0.1	%		**81.1**	**Not Determined**	----	----	----
EP079/EP070S:TPH Surrogates - semivolatile speciation									
2-Fluorobiphenyl	321-60-8	0.1	%		**98.1**	**94.1**	----	----	----
2-Bromonaphthalene	580-13-2	0.1	%		**98.0**	**103**	----	----	----

Surrogate Control Limits

Sub-Matrix: **WATER**		Recovery Limits (%)	
Compound	*CAS Number*	*Low*	*High*
EP074S: VOC Surrogates			
1.2-Dichloroethane-D4	17060-07-0	72	132
Toluene-D8	2037-26-5	74	128
4-Bromofluorobenzene	460-00-4	70	132
EP075S: Acid Extractable Surrogates			
2-Fluorophenol	367-12-4	10	83
Phenol-d6	13127-88-3	10	49
2-Chlorophenol-D4	93951-73-6	20.3	101
2.4.6-Tribromophenol	118-79-6	19.5	134
EP075T: Base/Neutral Extractable Surrogates			
Nitrobenzene-D5	4165-60-0	18.2	114
1.2-Dichlorobenzene-D4	2199-69-1	18.8	100
2-Fluorobiphenyl	321-60-8	25.3	122
Anthracene-d10	1719-06-8	35	137
4-Terphenyl-d14	1718-51-0	32	136
EP079/EP070S:TPH Surrogates - semivolatile speciation			
2-Fluorobiphenyl	321-60-8	77	127
2-Bromonaphthalene	580-13-2	67	123

ALS Laboratory Group
ANALYTICAL CHEMISTRY & TESTING SERVICES

Environmental Division

QUALITY CONTROL REPORT

Work Order	: **EM1209245**	Page	: 1 of 24
Client	: **SANTOS LTD**	Laboratory	: Environmental Division Melbourne
Contact	: MR BARRY RITCHIE	Contact	: Jodie Hancock
Address	: GROUND FLOOR SANTOS CENTRE 60 FLINDERS STREET ADELAIDE SA, AUSTRALIA 5001	Address	: 4 Westall Rd Springvale VIC Australia 3171
E-mail	: barry.ritchie@santos.com	E-mail	: Jodie.Hancock@alsenviro.com
Telephone	: +61 08 8116 5000	Telephone	: +61 7 3243 7128
Facsimile	: +61 08 8116 5050	Facsimile	: +61 7 3243 7218
Project	: HFRA Fluids Sampling - Extended Analysis	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Site	: ----		
C-O-C number	: ----	Date Samples Received	: 14-AUG-2012
Sampler	: TD / AJ	Issue Date	: 28-AUG-2012
Order number	: 879002/538		
		No. of samples received	: 2
Quote number	: EN/039/11	No. of samples analysed	: 2

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Method Blank (MB) and Laboratory Control Spike (LCS) Report; Recovery and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits

NATA Accredited Laboratory 825

Accredited for compliance with ISO/IEC 17025.

Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Dilani Fernando	Senior Inorganic Chemist	Melbourne Inorganics
Nancy Wang	Senior Semivolatile Instrument Chemist	Melbourne Organics
Nanthini Coilparampil	Laboratory Manager - Inorganics	Sydney Inorganics
Pabi Subba	Senior Organic Chemist	Sydney Organics
Sarah Millington	Senior Inorganic Chemist	Sydney Inorganics
Varsha Ho Wing	Non-Metals Team Leader	Melbourne Inorganics

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

Key : Anonymous = Refers to samples which are not specifically part of this work order but formed part of the QC process lot
CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
RPD = Relative Percentage Difference
# = Indicates failed QC

Laboratory Duplicate (DUP) Report

The quality control term Laboratory Duplicate refers to a randomly selected intralaboratory split. Laboratory duplicates provide information regarding method precision and sample heterogeneity. The permitted ranges for the Relative Percent Deviation (RPD) of Laboratory Duplicates are specified in ALS Method QWI-EN/38 and are dependent on the magnitude of results in comparison to the level of reporting: Result < 10 times LOR:- No Limit; Result between 10 and 20 times LOR:- 0% - 50%; Result > 20 times LOR:- 0% - 20%.

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
EA005: pH (QC Lot: 2450578)									
EM1209174-001	Anonymous	EA005: pH Value	----	0.01	pH Unit	7.96	7.95	0.1	0% - 20%
EM1209245-001	"Tindilpie Pad Clean" frac make up water from pond	EA005: pH Value	----	0.01	pH Unit	8.36	8.38	0.2	0% - 20%
EA015: Total Dissolved Solids (QC Lot: 2451186)									
EM1209209-001	Anonymous	EA015H: Total Dissolved Solids @180°C	GIS-210-010	10	mg/L	220	224	1.8	0% - 20%
EM1209268-003	Anonymous	EA015H: Total Dissolved Solids @180°C	GIS-210-010	10	mg/L	634	638	0.6	0% - 20%
ED009: Anions (QC Lot: 2451265)									
EM1209245-001	"Tindilpie Pad Clean" frac make up water from pond	ED009-X: Bromide	24959-67-9	0.010	mg/L	6.24	6.02	3.6	0% - 20%
		ED009-X: Iodide	20461-54-5	0.010	mg/L	0.168	0.195	14.9	0% - 50%
ES1219844-007	Anonymous	ED009-X: Bromide	24959-67-9	0.010	mg/L	0.163	0.193	16.8	0% - 50%
		ED009-X: Iodide	20461-54-5	0.010	mg/L	<0.010	<0.010	0.0	No Limit
ED037P: Alkalinity by PC Titrator (QC Lot: 2450243)									
EM1209245-001	"Tindilpie Pad Clean" frac make up water from pond	ED037-P: Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	206	226	9.5	0% - 20%
		ED037-P: Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	1590	1560	1.6	0% - 20%
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	1790	1790	0.3	0% - 20%
EM1209281-004	Anonymous	ED037-P: Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	90	91	0.0	0% - 20%
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	90	91	0.0	0% - 20%
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA (QC Lot: 2450176)									
EM1209245-002	"Tindilpie Pad Pit Circ" Pit water prior to flowback	ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	23	28	19.5	0% - 20%
ED045G: Chloride Discrete analyser (QC Lot: 2450175)									
EM1209245-001	"Tindilpie Pad Clean" frac make up water from pond	ED045G: Chloride	16887-00-6	1	mg/L	992	979	1.3	0% - 20%
ED093F: Dissolved Major Cations (QC Lot: 2450171)									
EM1209070-001	Anonymous	ED093F: Calcium	7440-70-2	1	mg/L	61	59	3.8	0% - 20%
		ED093F: Magnesium	7439-95-4	1	mg/L	20	19	0.0	0% - 50%
		ED093F: Sodium	7440-23-5	1	mg/L	148	139	5.8	0% - 20%
		ED093F: Potassium	7440-09-7	1	mg/L	8010	7690	4.0	0% - 20%
EM1209232-009	Anonymous	ED093F: Calcium	7440-70-2	1	mg/L	461	512	10.4	0% - 20%
		ED093F: Magnesium	7439-95-4	1	mg/L	253	277	9.2	0% - 20%

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
ED093F: Dissolved Major Cations (QC Lot: 2450171) - continued									
EM1209232-009	Anonymous	ED093F: Sodium	7440-23-5	1	mg/L	2720	2980	9.0	0% - 20%
		ED093F: Potassium	7440-09-7	1	mg/L	17	18	5.6	0% - 50%
ED093F: Dissolved Major Cations (QC Lot: 2450177)									
EM1209245-002	"Tindilpie Pad Pit Circ" Pit water prior to flowback	ED093F: Calcium	7440-70-2	1	mg/L	30	29	5.4	0% - 20%
		ED093F: Magnesium	7439-95-4	1	mg/L	4	4	0.0	No Limit
		ED093F: Sodium	7440-23-5	1	mg/L	2370	2250	5.2	0% - 20%
		ED093F: Potassium	7440-09-7	1	mg/L	75	69	7.6	0% - 20%
EG020F: Dissolved Metals by ICP-MS (QC Lot: 2451813)									
EM1209234-001	Anonymous	EG020A-F: Cadmium	7440-43-9	0.0001	mg/L	3.61	3.65	1.1	0% - 20%
		EG020A-F: Arsenic	7440-38-2	0.001	mg/L	0.072	0.072	0.0	0% - 20%
		EG020A-F: Beryllium	7440-41-7	0.001	mg/L	0.058	0.055	5.5	0% - 20%
		EG020A-F: Barium	7440-39-3	0.001	mg/L	0.077	0.076	1.6	0% - 20%
		EG020A-F: Chromium	7440-47-3	0.001	mg/L	0.055	0.051	7.4	0% - 20%
		EG020A-F: Cobalt	7440-48-4	0.001	mg/L	13.8	13.6	1.7	0% - 20%
		EG020A-F: Copper	7440-50-8	0.001	mg/L	14.9	14.9	0.4	0% - 20%
		EG020A-F: Lead	7439-92-1	0.001	mg/L	0.016	0.016	0.0	0% - 50%
		EG020A-F: Lithium	7439-93-2	0.001	mg/L	0.040	0.038	4.3	0% - 20%
		EG020A-F: Manganese	7439-96-5	0.001	mg/L	0.566	0.542	4.3	0% - 20%
		EG020A-F: Molybdenum	7439-98-7	0.001	mg/L	0.002	0.002	0.0	No Limit
		EG020A-F: Nickel	7440-02-0	0.001	mg/L	11.6	11.9	2.4	0% - 20%
		EG020A-F: Tin	7440-31-5	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-F: Zinc	7440-66-6	0.005	mg/L	140	150	6.7	0% - 20%
		EG020A-F: Aluminium	7429-90-5	0.01	mg/L	22.9	22.1	3.9	0% - 20%
		EG020A-F: Selenium	7782-49-2	0.01	mg/L	0.05	0.04	0.0	No Limit
		EG020A-F: Vanadium	7440-62-2	0.01	mg/L	1.04	1.01	3.3	0% - 20%
		EG020A-F: Boron	7440-42-8	0.05	mg/L	3.48	3.36	3.6	0% - 20%
		EG020A-F: Iron	7439-89-6	0.05	mg/L	183	175	4.5	0% - 20%
EM1209265-001	Anonymous	EG020A-F: Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	0.0	No Limit
		EG020A-F: Arsenic	7440-38-2	0.001	mg/L	0.002	0.001	0.0	No Limit
		EG020A-F: Beryllium	7440-41-7	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-F: Barium	7440-39-3	0.001	mg/L	0.018	0.013	30.5	0% - 50%
		EG020A-F: Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-F: Cobalt	7440-48-4	0.001	mg/L	0.003	0.003	0.0	No Limit
		EG020A-F: Copper	7440-50-8	0.001	mg/L	0.002	0.002	0.0	No Limit
		EG020A-F: Lead	7439-92-1	0.001	mg/L	0.005	0.005	0.0	No Limit
		EG020A-F: Lithium	7439-93-2	0.001	mg/L	0.003	0.002	0.0	No Limit
		EG020A-F: Manganese	7439-96-5	0.001	mg/L	0.305	0.299	1.9	0% - 20%
		EG020A-F: Molybdenum	7439-98-7	0.001	mg/L	0.017	0.017	0.0	0% - 50%

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
EG020F: Dissolved Metals by ICP-MS (QC Lot: 2451813) - continued									
EM1209265-001	Anonymous	EG020A-F: Nickel	7440-02-0	0.001	mg/L	0.033	0.031	6.4	0% - 20%
		EG020A-F: Tin	7440-31-5	0.001	mg/L	0.002	0.002	0.0	No Limit
		EG020A-F: Zinc	7440-66-6	0.005	mg/L	0.011	0.012	0.0	No Limit
		EG020A-F: Aluminium	7429-90-5	0.01	mg/L	0.06	0.06	0.0	No Limit
		EG020A-F: Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	0.0	No Limit
		EG020A-F: Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	0.0	No Limit
		EG020A-F: Boron	7440-42-8	0.05	mg/L	0.41	0.42	3.1	No Limit
		EG020A-F: Iron	7439-89-6	0.05	mg/L	0.25	0.18	29.5	No Limit
EG020F: Dissolved Metals by ICP-MS (QC Lot: 2451814)									
EM1209234-001	Anonymous	EG020B-F: Strontium	7440-24-6	0.001	mg/L	15.3	15.7	2.5	0% - 20%
		EG020B-F: Uranium	7440-61-1	0.001	mg/L	15.4	17.3	11.7	0% - 20%
EM1209271-001	Anonymous	EG020B-F: Strontium	7440-24-6	0.001	mg/L	0.568	0.579	1.9	0% - 20%
		EG020B-F: Uranium	7440-61-1	0.001	mg/L	<0.001	<0.001	0.0	No Limit
EG035F: Dissolved Mercury by FIMS (QC Lot: 2451815)									
EM1209245-001	"Tindilpie Pad Clean" frac make up water from pond	EG035F: Mercury	7439-97-6	0.0001	mg/L	0.0002	0.0003	0.0	No Limit
EM1209271-004	Anonymous	EG035F: Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	0.0	No Limit
EK025G: Free cyanide by Discrete Analyser (QC Lot: 2451312)									
EM1209245-001	"Tindilpie Pad Clean" frac make up water from pond	EK025G: Free Cyanide	----	0.004	mg/L	<0.004	<0.004	0.0	No Limit
EK026G: Total Cyanide By Discrete Analyser (QC Lot: 2450067)									
EB1220870-001	Anonymous	EK026G: Total Cyanide	57-12-5	0.004	mg/L	0.019	0.019	0.0	No Limit
EM1209210-032	Anonymous	EK026G: Total Cyanide	57-12-5	0.004	mg/L	0.007	<0.004	49.2	No Limit
EK040P: Fluoride by PC Titrator (QC Lot: 2450242)									
EM1209228-001	Anonymous	EK040P: Fluoride	16984-48-8	0.1	mg/L	0.2	0.2	0.0	No Limit
EK055G: Ammonia as N by Discrete Analyser (QC Lot: 2450475)									
EM1209245-001	"Tindilpie Pad Clean" frac make up water from pond	EK055G: Ammonia as N	7664-41-7	0.01	mg/L	0.20	0.19	0.0	0% - 50%
EM1209290-008	Anonymous	EK055G: Ammonia as N	7664-41-7	0.01	mg/L	0.10	0.14	30.0	0% - 50%
EK057G: Nitrite as N by Discrete Analyser (QC Lot: 2450172)									
EM1209229-001	Anonymous	EK057G: Nitrite as N	----	0.01	mg/L	<0.01	<0.01	0.0	No Limit
EM1209230-006	Anonymous	EK057G: Nitrite as N	----	0.01	mg/L	<0.01	<0.01	0.0	No Limit
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser (QC Lot: 2450473)									
EM1209168-001	Anonymous	EK059G: Nitrite + Nitrate as N	----	0.01	mg/L	0.02	0.02	0.0	No Limit
EM1209281-001	Anonymous	EK059G: Nitrite + Nitrate as N	----	0.01	mg/L	<0.01	<0.01	0.0	No Limit
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser (QC Lot: 2450356)									
EM1209230-001	Anonymous	EK061G: Total Kjeldahl Nitrogen as N	----	0.1	mg/L	0.8	1.0	19.2	0% - 50%
EM1209230-010	Anonymous	EK061G: Total Kjeldahl Nitrogen as N	----	0.1	mg/L	0.7	0.8	0.0	No Limit
EK067G: Total Phosphorus as P by Discrete Analyser (QC Lot: 2450357)									

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
EK067G: Total Phosphorus as P by Discrete Analyser (QC Lot: 2450357) - continued									
EM1209230-001	Anonymous	EK067G: Total Phosphorus as P	----	0.01	mg/L	0.18	0.15	15.6	0% - 50%
EM1209230-010	Anonymous	EK067G: Total Phosphorus as P	----	0.01	mg/L	0.14	0.14	0.0	0% - 50%
EK071G: Reactive Phosphorus as P by discrete analyser (QC Lot: 2450173)									
EM1209229-001	Anonymous	EK071G: Reactive Phosphorus as P	----	0.01	mg/L	<0.01	<0.01	0.0	No Limit
EP005: Total Organic Carbon (TOC) (QC Lot: 2450355)									
EM1209171-002	Anonymous	EP005: Total Organic Carbon	----	1	mg/L	27	28	3.6	0% - 20%
EM1209190-004	Anonymous	EP005: Total Organic Carbon	----	1	mg/L	11	11	0.0	0% - 50%
EP010: Formaldehyde (QC Lot: 2450192)									
EM1209245-002	"Tindilpie Pad Pit Circ" Pit water prior to flowback	EP010: Formaldehyde	50-00-0	0.1	mg/L	3.5	3.4	0.0	0% - 20%
EP041A: Nonionic Surfactants (QC Lot: 2457642)									
EM1209245-001	"Tindilpie Pad Clean" frac make up water from pond	EP041A: Nonionic Surfactants as CTAS	----	5	mg/L	<5	<5	0.0	No Limit
EP050: Anionic Surfactants as MBAS (QC Lot: 2455526)									
EM1209245-001	"Tindilpie Pad Clean" frac make up water from pond	EP050: Anionic Surfactants as MBAS		0.1	mg/L	0.5	0.5	0.0	No Limit
EP1206741-002	Anonymous	EP050: Anionic Surfactants as MBAS		0.1	mg/L	1.0	1.0	0.0	0% - 50%
EP074A: Monocyclic Aromatic Hydrocarbons (QC Lot: 2450015)									
EM1209245-001	"Tindilpie Pad Clean" frac make up water from pond	EP074: Benzene	71-43-2	1	µg/L	2	2	0.0	No Limit
		EP074: Toluene	108-88-3	2	µg/L	4	4	0.0	No Limit
		EP074: Ethylbenzene	100-41-4	2	µg/L	<2	<2	0.0	No Limit
		EP074: meta- & para-Xylene	108-38-3 106-42-3	2	µg/L	<2	<2	0.0	No Limit
		EP074: ortho-Xylene	95-47-6	2	µg/L	<2	<2	0.0	No Limit
		EP074: Styrene	100-42-5	5	µg/L	<5	<5	0.0	No Limit
		EP074: Isopropylbenzene	98-82-8	5	µg/L	<5	<5	0.0	No Limit
		EP074: n-Propylbenzene	103-65-1	5	µg/L	<5	<5	0.0	No Limit
		EP074: 1.3.5-Trimethylbenzene	108-67-8	5	µg/L	<5	<5	0.0	No Limit
		EP074: sec-Butylbenzene	135-98-8	5	µg/L	<5	<5	0.0	No Limit
		EP074: 1.2.4-Trimethylbenzene	95-63-6	5	µg/L	<5	<5	0.0	No Limit
		EP074: tert-Butylbenzene	98-06-6	5	µg/L	<5	<5	0.0	No Limit
		EP074: p-Isopropyltoluene	99-87-6	5	µg/L	<5	<5	0.0	No Limit
		EP074: n-Butylbenzene	104-51-8	5	µg/L	<5	<5	0.0	No Limit
EP074B: Oxygenated Compounds (QC Lot: 2450015)									
EM1209245-001	"Tindilpie Pad Clean" frac make up water from pond	EP074: Vinyl Acetate	108-05-4	50	µg/L	<50	<50	0.0	No Limit
		EP074: 2-Butanone (MEK)	78-93-3	50	µg/L	<50	<50	0.0	No Limit
		EP074: 4-Methyl-2-pentanone (MIBK)	108-10-1	50	µg/L	<50	<50	0.0	No Limit

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
EP074B: Oxygenated Compounds (QC Lot: 2450015) - continued									
EM1209245-001	"Tindilpie Pad Clean" frac make up water from pond	EP074: 2-Hexanone (MBK)	591-78-6	50	µg/L	<50	<50	0.0	No Limit
EP074C: Sulfonated Compounds (QC Lot: 2450015)									
EM1209245-001	"Tindilpie Pad Clean" frac make up water from pond	EP074: Carbon disulfide	75-15-0	5	µg/L	<5	<5	0.0	No Limit
EP074D: Fumigants (QC Lot: 2450015)									
EM1209245-001	"Tindilpie Pad Clean" frac make up water from pond	EP074: 2.2-Dichloropropane	594-20-7	5	µg/L	<5	<5	0.0	No Limit
		EP074: 1.2-Dichloropropane	78-87-5	5	µg/L	<5	<5	0.0	No Limit
		EP074: cis-1.3-Dichloropropylene	10061-01-5	5	µg/L	<5	<5	0.0	No Limit
		EP074: trans-1.3-Dichloropropylene	10061-02-6	5	µg/L	<5	<5	0.0	No Limit
		EP074: 1.2-Dibromoethane (EDB)	106-93-4	5	µg/L	<5	<5	0.0	No Limit
EP074E: Halogenated Aliphatic Compounds (QC Lot: 2450015)									
EM1209245-001	"Tindilpie Pad Clean" frac make up water from pond	EP074: 1.1-Dichloroethene	75-35-4	5	µg/L	<5	<5	0.0	No Limit
		EP074: Iodomethane	74-88-4	5	µg/L	<5	<5	0.0	No Limit
		EP074: trans-1.2-Dichloroethene	156-60-5	5	µg/L	<5	<5	0.0	No Limit
		EP074: 1.1-Dichloroethane	75-34-3	5	µg/L	<5	<5	0.0	No Limit
		EP074: cis-1.2-Dichloroethene	156-59-2	5	µg/L	<5	<5	0.0	No Limit
		EP074: 1.1.1-Trichloroethane	71-55-6	5	µg/L	<5	<5	0.0	No Limit
		EP074: 1.1-Dichloropropylene	563-58-6	5	µg/L	<5	<5	0.0	No Limit
		EP074: Carbon Tetrachloride	56-23-5	5	µg/L	<5	<5	0.0	No Limit
		EP074: 1.2-Dichloroethane	107-06-2	5	µg/L	<5	<5	0.0	No Limit
		EP074: Trichloroethene	79-01-6	5	µg/L	<5	<5	0.0	No Limit
		EP074: Dibromomethane	74-95-3	5	µg/L	<5	<5	0.0	No Limit
		EP074: 1.1.2-Trichloroethane	79-00-5	5	µg/L	<5	<5	0.0	No Limit
		EP074: 1.3-Dichloropropane	142-28-9	5	µg/L	<5	<5	0.0	No Limit
		EP074: Tetrachloroethene	127-18-4	5	µg/L	<5	<5	0.0	No Limit
		EP074: 1.1.1.2-Tetrachloroethane	630-20-6	5	µg/L	<5	<5	0.0	No Limit
		EP074: trans-1.4-Dichloro-2-butene	110-57-6	5	µg/L	<5	<5	0.0	No Limit
		EP074: cis-1.4-Dichloro-2-butene	1476-11-5	5	µg/L	<5	<5	0.0	No Limit
		EP074: 1.1.2.2-Tetrachloroethane	79-34-5	5	µg/L	<5	<5	0.0	No Limit
		EP074: 1.2.3-Trichloropropane	96-18-4	5	µg/L	<5	<5	0.0	No Limit
		EP074: Pentachloroethane	76-01-7	5	µg/L	<5	<5	0.0	No Limit
		EP074: 1.2-Dibromo-3-chloropropane	96-12-8	5	µg/L	<5	<5	0.0	No Limit
		EP074: Dichlorodifluoromethane	75-71-8	50	µg/L	<50	<50	0.0	No Limit
		EP074: Chloromethane	74-87-3	50	µg/L	<50	<50	0.0	No Limit
		EP074: Vinyl chloride	75-01-4	50	µg/L	<50	<50	0.0	No Limit
		EP074: Bromomethane	74-83-9	50	µg/L	<50	<50	0.0	No Limit

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
EP074E: Halogenated Aliphatic Compounds (QC Lot: 2450015) - continued									
EM1209245-001	"Tindilpie Pad Clean" frac make up water from pond	EP074: Chloroethane	75-00-3	50	µg/L	<50	<50	0.0	No Limit
		EP074: Trichlorofluoromethane	75-69-4	50	µg/L	<50	<50	0.0	No Limit
EP074F: Halogenated Aromatic Compounds (QC Lot: 2450015)									
EM1209245-001	"Tindilpie Pad Clean" frac make up water from pond	EP074: Chlorobenzene	108-90-7	5	µg/L	<5	<5	0.0	No Limit
		EP074: Bromobenzene	108-86-1	5	µg/L	<5	<5	0.0	No Limit
		EP074: 2-Chlorotoluene	95-49-8	5	µg/L	<5	<5	0.0	No Limit
		EP074: 4-Chlorotoluene	106-43-4	5	µg/L	<5	<5	0.0	No Limit
		EP074: 1.2.3-Trichlorobenzene	87-61-6	5	µg/L	<5	<5	0.0	No Limit
EP074G: Trihalomethanes (QC Lot: 2450015)									
EM1209245-001	"Tindilpie Pad Clean" frac make up water from pond	EP074: Chloroform	67-66-3	5	µg/L	<5	<5	0.0	No Limit
		EP074: Bromodichloromethane	75-27-4	5	µg/L	<5	<5	0.0	No Limit
		EP074: Dibromochloromethane	124-48-1	5	µg/L	<5	<5	0.0	No Limit
		EP074: Bromoform	75-25-2	5	µg/L	<5	<5	0.0	No Limit
EP075A: Phenolic Compounds (QC Lot: 2449947)									
EM1209245-001	"Tindilpie Pad Clean" frac make up water from pond	EP075: Phenol	108-95-2	2	µg/L	<2	<2	0.0	No Limit
		EP075: 2-Chlorophenol	95-57-8	2	µg/L	<2	<2	0.0	No Limit
		EP075: 2-Methylphenol	95-48-7	2	µg/L	<2	<2	0.0	No Limit
		EP075: 2-Nitrophenol	88-75-5	2	µg/L	<2	<2	0.0	No Limit
		EP075: 2.4-Dimethylphenol	105-67-9	2	µg/L	6	7	0.0	No Limit
		EP075: 2.4-Dichlorophenol	120-83-2	2	µg/L	<2	<2	0.0	No Limit
		EP075: 2.6-Dichlorophenol	87-65-0	2	µg/L	<2	<2	0.0	No Limit
		EP075: 4-Chloro-3-Methylphenol	59-50-7	2	µg/L	<2	<2	0.0	No Limit
		EP075: 2.4.6-Trichlorophenol	88-06-2	2	µg/L	<2	<2	0.0	No Limit
		EP075: 2.4.5-Trichlorophenol	95-95-4	2	µg/L	<2	<2	0.0	No Limit
		EP075: 3- & 4-Methylphenol	1319-77-3	4	µg/L	<4	<4	0.0	No Limit
		EP075: Pentachlorophenol	87-86-5	4	µg/L	<4	<4	0.0	No Limit
EP075B: Polynuclear Aromatic Hydrocarbons (QC Lot: 2449947)									
EM1209245-001	"Tindilpie Pad Clean" frac make up water from pond	EP075: Naphthalene	91-20-3	2	µg/L	<2	<2	0.0	No Limit
		EP075: 2-Methylnaphthalene	91-57-6	2	µg/L	<2	<2	0.0	No Limit
		EP075: 2-Chloronaphthalene	91-58-7	2	µg/L	<2	<2	0.0	No Limit
		EP075: Acenaphthylene	208-96-8	2	µg/L	<2	<2	0.0	No Limit
		EP075: Acenaphthene	83-32-9	2	µg/L	<2	<2	0.0	No Limit
		EP075: Fluorene	86-73-7	2	µg/L	<2	<2	0.0	No Limit
		EP075: Phenanthrene	85-01-8	2	µg/L	<2	<2	0.0	No Limit

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
EP075B: Polynuclear Aromatic Hydrocarbons (QC Lot: 2449947) - continued									
EM1209245-001	"Tindilpie Pad Clean" frac make up water from pond	EP075: Anthracene	120-12-7	2	µg/L	<2	<2	0.0	No Limit
		EP075: Fluoranthene	206-44-0	2	µg/L	<2	<2	0.0	No Limit
		EP075: Pyrene	129-00-0	2	µg/L	<2	<2	0.0	No Limit
		EP075: N-2-Fluorenyl Acetamide	53-96-3	2	µg/L	<2	<2	0.0	No Limit
		EP075: Benz(a)anthracene	56-55-3	2	µg/L	<2	<2	0.0	No Limit
		EP075: Chrysene	218-01-9	2	µg/L	<2	<2	0.0	No Limit
		EP075: 7.12-Dimethylbenz(a)anthracene	57-97-6	2	µg/L	<2	<2	0.0	No Limit
		EP075: Benzo(a)pyrene	50-32-8	2	µg/L	<2	<2	0.0	No Limit
		EP075: 3-Methylcholanthrene	56-49-5	2	µg/L	<2	<2	0.0	No Limit
		EP075: Indeno(1.2.3.cd)pyrene	193-39-5	2	µg/L	<2	<2	0.0	No Limit
		EP075: Dibenz(a.h)anthracene	53-70-3	2	µg/L	<2	<2	0.0	No Limit
		EP075: Benzo(g.h.i)perylene	191-24-2	2	µg/L	<2	<2	0.0	No Limit
		EP075: Sum of PAHs	----	2	µg/L	<2	<2	0.0	No Limit
		EP075: Benzo(b) & Benzo(k)fluoranthene	205-99-2 207-08-9	4	µg/L	<4	<4	0.0	No Limit
EP075C: Phthalate Esters (QC Lot: 2449947)									
EM1209245-001	"Tindilpie Pad Clean" frac make up water from pond	EP075: Dimethyl phthalate	131-11-3	2	µg/L	<2	<2	0.0	No Limit
		EP075: Diethyl phthalate	84-66-2	2	µg/L	<2	<2	0.0	No Limit
		EP075: Di-n-butyl phthalate	84-74-2	2	µg/L	<2	<2	0.0	No Limit
		EP075: Butyl benzyl phthalate	85-68-7	2	µg/L	<2	<2	0.0	No Limit
		EP075: Di-n-octylphthalate	117-84-0	2	µg/L	<2	<2	0.0	No Limit
		EP075: bis(2-ethylhexyl) phthalate	117-81-7	5	µg/L	<10	<10	0.0	No Limit
EP075D: Nitrosamines (QC Lot: 2449947)									
EM1209245-001	"Tindilpie Pad Clean" frac make up water from pond	EP075: N-Nitrosomethylethylamine	10595-95-6	2	µg/L	<2	<2	0.0	No Limit
		EP075: N-Nitrosodiethylamine	55-18-5	2	µg/L	<2	<2	0.0	No Limit
		EP075: N-Nitrosomorpholine	59-89-2	2	µg/L	<2	<2	0.0	No Limit
		EP075: N-Nitrosodi-n-propylamine	621-64-7	2	µg/L	<2	<2	0.0	No Limit
		EP075: N-Nitrosopiperidine	100-75-4	2	µg/L	<2	<2	0.0	No Limit
		EP075: N-Nitrosodibutylamine	924-16-3	2	µg/L	<2	<2	0.0	No Limit
		EP075: Methapyrilene	91-80-5	2	µg/L	<2	<2	0.0	No Limit
		EP075: N-Nitrosopyrrolidine	930-55-2	4	µg/L	<4	<4	0.0	No Limit
		EP075: N-Nitrosodiphenyl & Diphenylamine	86-30-6 122-39-4	4	µg/L	<4	<4	0.0	No Limit
EP075E: Nitroaromatics and Ketones (QC Lot: 2449947)									
EM1209245-001	"Tindilpie Pad Clean" frac make up water from pond	EP075: 2-Picoline	109-06-8	2	µg/L	<2	<2	0.0	No Limit
		EP075: Acetophenone	98-86-2	2	µg/L	<2	<2	0.0	No Limit

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
EP075E: Nitroaromatics and Ketones (QC Lot: 2449947) - continued									
EM1209245-001	"Tindilpie Pad Clean" frac make up water from pond	EP075: Nitrobenzene	98-95-3	2	µg/L	<2	<2	0.0	No Limit
		EP075: Isophorone	78-59-1	2	µg/L	<2	<2	0.0	No Limit
		EP075: 1-Naphthylamine	134-32-7	2	µg/L	<2	<2	0.0	No Limit
		EP075: 4-Nitroquinoline-N-oxide	56-57-5	2	µg/L	<2	<2	0.0	No Limit
		EP075: 5-Nitro-o-toluidine	99-55-8	2	µg/L	<2	<2	0.0	No Limit
		EP075: Azobenzene	103-33-3	2	µg/L	<2	<2	0.0	No Limit
		EP075: 1.3.5-Trinitrobenzene	99-35-4	2	µg/L	<2	<2	0.0	No Limit
		EP075: Phenacetin	62-44-2	2	µg/L	<2	<2	0.0	No Limit
		EP075: 4-Aminobiphenyl	92-67-1	2	µg/L	<2	<2	0.0	No Limit
		EP075: Pentachloronitrobenzene	82-68-8	2	µg/L	<2	<2	0.0	No Limit
		EP075: Pronamide	23950-58-5	2	µg/L	<2	<2	0.0	No Limit
		EP075: Dimethylaminoazobenzene	60-11-7	2	µg/L	<2	<2	0.0	No Limit
		EP075: Chlorobenzilate	510-15-6	2	µg/L	<2	<2	0.0	No Limit
		EP075: 2.6-Dinitrotoluene	606-20-2	4	µg/L	<4	<4	0.0	No Limit
		EP075: 2.4-Dinitrotoluene	121-14-2	4	µg/L	<4	<4	0.0	No Limit
EP075F: Haloethers (QC Lot: 2449947)									
EM1209245-001	"Tindilpie Pad Clean" frac make up water from pond	EP075: Bis(2-chloroethyl) ether	111-44-4	2	µg/L	<2	<2	0.0	No Limit
		EP075: Bis(2-chloroethoxy) methane	111-91-1	2	µg/L	<2	<2	0.0	No Limit
		EP075: 4-Chlorophenyl phenyl ether	7005-72-3	2	µg/L	<2	<2	0.0	No Limit
		EP075: 4-Bromophenyl phenyl ether	101-55-3	2	µg/L	<2	<2	0.0	No Limit
EP075G: Chlorinated Hydrocarbons (QC Lot: 2449947)									
EM1209245-001	"Tindilpie Pad Clean" frac make up water from pond	EP075: Hexachlorocyclopentadiene	77-47-4	10	µg/L	<10	<10	0.0	No Limit
		EP075: 1.4-Dichlorobenzene	106-46-7	2	µg/L	<4	<4	0.0	No Limit
		EP075: 1.3-Dichlorobenzene	541-73-1	2	µg/L	<2	<2	0.0	No Limit
		EP075: 1.2-Dichlorobenzene	95-50-1	2	µg/L	<2	<2	0.0	No Limit
		EP075: Hexachloroethane	67-72-1	2	µg/L	<2	<2	0.0	No Limit
		EP075: 1.2.4-Trichlorobenzene	120-82-1	2	µg/L	<2	<2	0.0	No Limit
		EP075: Hexachloropropylene	1888-71-7	2	µg/L	<2	<2	0.0	No Limit
		EP075: Hexachlorobutadiene	87-68-3	2	µg/L	<2	<2	0.0	No Limit
		EP075: Pentachlorobenzene	608-93-5	2	µg/L	<2	<2	0.0	No Limit
		EP075: Hexachlorobenzene (HCB)	118-74-1	4	µg/L	<4	<4	0.0	No Limit
EP075H: Anilines and Benzidines (QC Lot: 2449947)									
EM1209245-001	"Tindilpie Pad Clean" frac make up water from pond	EP075: Aniline	62-53-3	2	µg/L	<2	<2	0.0	No Limit
		EP075: 4-Chloroaniline	106-47-8	2	µg/L	<2	<2	0.0	No Limit
		EP075: Dibenzofuran	132-64-9	2	µg/L	<2	<2	0.0	No Limit

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
EP075H: Anilines and Benzidines (QC Lot: 2449947) - continued									
EM1209245-001	"Tindilpie Pad Clean" frac make up water from pond	EP075: 4-Nitroaniline	100-01-6	2	µg/L	<2	<2	0.0	No Limit
		EP075: Carbazole	86-74-8	2	µg/L	<2	<2	0.0	No Limit
		EP075: 3.3`-Dichlorobenzidine	91-94-1	2	µg/L	<2	<2	0.0	No Limit
		EP075: 2-Nitroaniline	88-74-4	4	µg/L	<4	<4	0.0	No Limit
		EP075: 3-Nitroaniline	99-09-2	4	µg/L	<4	<4	0.0	No Limit
EP075I: Organochlorine Pesticides (QC Lot: 2449947)									
EM1209245-001	"Tindilpie Pad Clean" frac make up water from pond	EP075: alpha-BHC	319-84-6	2	µg/L	<2	<2	0.0	No Limit
		EP075: beta-BHC	319-85-7	2	µg/L	<2	<2	0.0	No Limit
		EP075: gamma-BHC	58-89-9	2	µg/L	<2	<2	0.0	No Limit
		EP075: delta-BHC	319-86-8	2	µg/L	<2	<2	0.0	No Limit
		EP075: Heptachlor	76-44-8	2	µg/L	<2	<2	0.0	No Limit
		EP075: Aldrin	309-00-2	2	µg/L	<2	<2	0.0	No Limit
		EP075: Heptachlor epoxide	1024-57-3	2	µg/L	<2	<2	0.0	No Limit
		EP075: alpha-Endosulfan	959-98-8	2	µg/L	<2	<2	0.0	No Limit
		EP075: 4.4`-DDE	72-55-9	2	µg/L	<2	<2	0.0	No Limit
		EP075: Dieldrin	60-57-1	2	µg/L	<2	<2	0.0	No Limit
		EP075: Endrin	72-20-8	2	µg/L	<2	<2	0.0	No Limit
		EP075: beta-Endosulfan	33213-65-9	2	µg/L	<2	<2	0.0	No Limit
		EP075: 4.4`-DDD	72-54-8	2	µg/L	<2	<2	0.0	No Limit
		EP075: Endosulfan sulfate	1031-07-8	2	µg/L	<2	<2	0.0	No Limit
		EP075: 4.4`-DDT	50-29-3	4	µg/L	<4	<4	0.0	No Limit
EP075J: Organophosphorus Pesticides (QC Lot: 2449947)									
EM1209245-001	"Tindilpie Pad Clean" frac make up water from pond	EP075: Dichlorvos	62-73-7	2	µg/L	<2	<2	0.0	No Limit
		EP075: Dimethoate	60-51-5	2	µg/L	<2	<2	0.0	No Limit
		EP075: Diazinon	333-41-5	2	µg/L	<2	<2	0.0	No Limit
		EP075: Chlorpyrifos-methyl	5598-13-0	2	µg/L	<2	<2	0.0	No Limit
		EP075: Malathion	121-75-5	2	µg/L	<2	<2	0.0	No Limit
		EP075: Fenthion	55-38-9	2	µg/L	<2	<2	0.0	No Limit
		EP075: Chlorpyrifos	2921-88-2	2	µg/L	<2	<2	0.0	No Limit
		EP075: Pirimphos-ethyl	23505-41-1	2	µg/L	<2	<2	0.0	No Limit
		EP075: Chlorfenvinphos	470-90-6	2	µg/L	<2	<2	0.0	No Limit
		EP075: Prothiofos	34643-46-4	2	µg/L	<2	<2	0.0	No Limit
		EP075: Ethion	563-12-2	2	µg/L	<2	<2	0.0	No Limit
EP079/070: TPH CWG Aliphatic Hydrocarbon Fractions (QC Lot: 2449949)									
EM1209245-001	"Tindilpie Pad Clean" frac make up water from pond	EP070-CWG: Aliphatic >C10-C12	TPHCWG-ALE1	50	µg/L	<50	<50	0.0	No Limit

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
EP079/070: TPH CWG Aliphatic Hydrocarbon Fractions (QC Lot: 2449949) - continued									
EM1209245-001	"Tindilpie Pad Clean" frac make up water from pond	EP070-CWG: Aliphatic >C12-C16	TPHCWG-ALE2	50	µg/L	<50	<50	0.0	No Limit
		EP070-CWG: Aliphatic >C16-C21	----	50	µg/L	132	60	74.6	No Limit
		EP070-CWG: Aliphatic >C21-C35	----	50	µg/L	264	150	54.6	No Limit
EP079/070: TPH CWG Aliphatic Hydrocarbon Fractions (QC Lot: 2450016)									
EM1209245-001	"Tindilpie Pad Clean" frac make up water from pond	EP079-CWG: Aliphatic >C5-C6	----	20	µg/L	<20	<20	0.0	No Limit
		EP079-CWG: Aliphatic >C6-C8	TPHCWG-ALV2	20	µg/L	20	<20	0.0	No Limit
		EP079-CWG: Aliphatic >C8-C10	TPHCWG-ALV3	20	µg/L	<20	<20	0.0	No Limit
EP079/070: TPH CWG Aromatic Hydrocarbon Fractions (QC Lot: 2449949)									
EM1209245-001	"Tindilpie Pad Clean" frac make up water from pond	EP070-CWG: Aromatic >C10-C12	TPHCWG-ARE1	50	µg/L	<50	<50	0.0	No Limit
		EP070-CWG: Aromatic >C12-C16	TPHCWG-ARE2	50	µg/L	<50	<50	0.0	No Limit
		EP070-CWG: Aromatic >C16-C21	TPHCWG-ARE3	50	µg/L	<50	<50	0.0	No Limit
		EP070-CWG: Aromatic >C21-C35	TPHCWG-ARE4	50	µg/L	99	60	48.6	No Limit
EP079/070: TPH CWG Aromatic Hydrocarbon Fractions (QC Lot: 2450016)									
EM1209245-001	"Tindilpie Pad Clean" frac make up water from pond	EP079-CWG: Aromatic >C5-C7	----	5	µg/L	<5	<5	0.0	No Limit
		EP079-CWG: Aromatic >C7-C8	TPHCWG-ARV2	5	µg/L	<5	<5	0.0	No Limit
		EP079-CWG: Aromatic >C8-C10	TPHCWG-ARV3	5	µg/L	<5	<5	0.0	No Limit
EP117: Alcohols (QC Lot: 2459340)									
EB1221352-001	Anonymous	EP117: Ethanol	64-17-5	50	µg/L	<50	<50	0.0	No Limit
		EP117: Isopropanol	67-63-0	50	µg/L	<50	<50	0.0	No Limit
		EP117: n-Propanol	71-23-8	50	µg/L	<50	<50	0.0	No Limit
		EP117: Isobutanol	78-83-1	50	µg/L	<50	<50	0.0	No Limit
		EP117: n-Butanol	71-36-3	50	µg/L	<50	<50	0.0	No Limit
EM1209271-004	Anonymous	EP117: Ethanol	64-17-5	50	µg/L	<50	<50	0.0	No Limit
		EP117: Isopropanol	67-63-0	50	µg/L	<50	<50	0.0	No Limit
		EP117: n-Propanol	71-23-8	50	µg/L	<50	<50	0.0	No Limit
		EP117: Isobutanol	78-83-1	50	µg/L	<50	<50	0.0	No Limit
		EP117: n-Butanol	71-36-3	50	µg/L	<50	<50	0.0	No Limit

Method Blank (MB) and Laboratory Control Spike (LCS) Report

The quality control term Method / Laboratory Blank refers to an analyte free matrix to which all reagents are added in the same volumes or proportions as used in standard sample preparation. The purpose of this QC parameter is to monitor potential laboratory contamination. The quality control term Laboratory Control Sample (LCS) refers to a certified reference material, or a known interference free matrix spiked with target analytes. The purpose of this QC parameter is to monitor method precision and accuracy independent of sample matrix. Dynamic Recovery Limits are based on statistical evaluation of processed LCS.

Sub-Matrix: **WATER**

				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Recovery Limits (%)	
Method: Compound	CAS Number	LOR	Unit	Result	Concentration	LCS	Low	High
EA015: Total Dissolved Solids (QCLot: 2451186)								
EA015H: Total Dissolved Solids @180°C	GIS-210-010	10	mg/L	<10	2000 mg/L	100	98	104
ED009: Anions (QCLot: 2451265)								
ED009-X: Bromide	24959-67-9	0.01	mg/L	<0.010	2 mg/L	99.4	88	112
ED009-X: Iodide	20461-54-5	0.01	mg/L	<0.010	0.5 mg/L	91.4	75	127
ED037P: Alkalinity by PC Titrator (QCLot: 2450243)								
ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	----	200 mg/L	96.5	77	127
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA (QCLot: 2450176)								
ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	<1	12.5 mg/L	102	81	125
ED045G: Chloride Discrete analyser (QCLot: 2450175)								
ED045G: Chloride	16887-00-6	1	mg/L	<1	1000 mg/L	97.4	89	117
ED093F: Dissolved Major Cations (QCLot: 2450171)								
ED093F: Calcium	7440-70-2	1	mg/L	<1	5 mg/L	98.3	83	129
ED093F: Magnesium	7439-95-4	1	mg/L	<1	5 mg/L	96.9	80	124
ED093F: Sodium	7440-23-5	1	mg/L	<1	50 mg/L	91.1	77	125
ED093F: Potassium	7440-09-7	1	mg/L	<1	50 mg/L	91.0	77	123
ED093F: Dissolved Major Cations (QCLot: 2450177)								
ED093F: Calcium	7440-70-2	1	mg/L	<1	5 mg/L	103	83	129
ED093F: Magnesium	7439-95-4	1	mg/L	<1	5 mg/L	103	80	124
ED093F: Sodium	7440-23-5	1	mg/L	<1	50 mg/L	102	77	125
ED093F: Potassium	7440-09-7	1	mg/L	<1	50 mg/L	100	77	123
EG020F: Dissolved Metals by ICP-MS (QCLot: 2451813)								
EG020A-F: Aluminium	7429-90-5	0.01	mg/L	<0.01	0.5 mg/L	91.6	80	120
EG020A-F: Arsenic	7440-38-2	0.001	mg/L	<0.001	0.1 mg/L	88.4	87	109
EG020A-F: Beryllium	7440-41-7	0.001	mg/L	<0.001	0.1 mg/L	91.9	70	124
EG020A-F: Barium	7440-39-3	0.001	mg/L	<0.001	0.1 mg/L	96.0	88	110
EG020A-F: Cadmium	7440-43-9	0.0001	mg/L	<0.0001	0.1 mg/L	97.2	88	110
EG020A-F: Chromium	7440-47-3	0.001	mg/L	<0.001	0.1 mg/L	88.1	86	112
EG020A-F: Cobalt	7440-48-4	0.001	mg/L	<0.001	0.1 mg/L	98.1	87	111
EG020A-F: Copper	7440-50-8	0.001	mg/L	<0.001	0.1 mg/L	88.8	86	108
EG020A-F: Lead	7439-92-1	0.001	mg/L	<0.001	0.1 mg/L	91.0	90	110
EG020A-F: Lithium	7439-93-2	0.001	mg/L	<0.001	0.1 mg/L	87.8	60	130
EG020A-F: Manganese	7439-96-5	0.001	mg/L	<0.001	0.1 mg/L	89.3	87	111
EG020A-F: Molybdenum	7439-98-7	0.001	mg/L	<0.001	0.1 mg/L	93.6	84	108

Sub-Matrix: **WATER**

Method: Compound	CAS Number	LOR	Unit	Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Recovery Limits (%)	
				Result	Concentration	LCS	Low	High
EG020F: Dissolved Metals by ICP-MS (QCLot: 2451813) - continued								
EG020A-F: Nickel	7440-02-0	0.001	mg/L	<0.001	0.1 mg/L	87.5	86	112
EG020A-F: Selenium	7782-49-2	0.01	mg/L	<0.01	0.1 mg/L	89.8	83	111
EG020A-F: Tin	7440-31-5	0.001	mg/L	<0.001	0.1 mg/L	98.3	83	111
EG020A-F: Vanadium	7440-62-2	0.01	mg/L	<0.01	0.1 mg/L	89.8	85	113
EG020A-F: Zinc	7440-66-6	0.005	mg/L	<0.005	0.1 mg/L	88.7	86	120
EG020A-F: Boron	7440-42-8	0.05	mg/L	<0.05	0.1 mg/L	112	61	133
EG020A-F: Iron	7439-89-6	0.05	mg/L	<0.05	0.5 mg/L	85.1	79	119
EG020F: Dissolved Metals by ICP-MS (QCLot: 2451814)								
EG020B-F: Strontium	7440-24-6	0.001	mg/L	<0.001	0.1 mg/L	89.7	88	108
EG020B-F: Uranium	7440-61-1	0.001	mg/L	<0.001	----	----	----	----
EG035F: Dissolved Mercury by FIMS (QCLot: 2451815)								
EG035F: Mercury	7439-97-6	0.0001	mg/L	<0.0001	0.0100 mg/L	103	71	125
EK025G: Free cyanide by Discrete Analyser (QCLot: 2451312)								
EK025G: Free Cyanide	----	0.004	mg/L	<0.004	0.2 mg/L	101	73	111
EK026G: Total Cyanide By Discrete Analyser (QCLot: 2450067)								
EK026G: Total Cyanide	57-12-5	0.004	mg/L	<0.004	0.2 mg/L	97.9	85	125
EK040P: Fluoride by PC Titrator (QCLot: 2450242)								
EK040P: Fluoride	16984-48-8	0.1	mg/L	<0.1	5 mg/L	102	78	120
EK055G: Ammonia as N by Discrete Analyser (QCLot: 2450475)								
EK055G: Ammonia as N	7664-41-7	0.01	mg/L	<0.01	0.5 mg/L	98.3	76	122
EK057G: Nitrite as N by Discrete Analyser (QCLot: 2450172)								
EK057G: Nitrite as N	----	0.01	mg/L	<0.01	0.5 mg/L	96.3	84	112
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser (QCLot: 2450473)								
EK059G: Nitrite + Nitrate as N	----	0.01	mg/L	<0.01	0.5 mg/L	90.8	73	127
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser (QCLot: 2450356)								
EK061G: Total Kjeldahl Nitrogen as N	----	0.1	mg/L	<0.1	10 mg/L	108	63	117
EK067G: Total Phosphorus as P by Discrete Analyser (QCLot: 2450357)								
EK067G: Total Phosphorus as P	----	0.01	mg/L	<0.01	4.42 mg/L	98.0	73	117
EK071G: Reactive Phosphorus as P by discrete analyser (QCLot: 2450173)								
EK071G: Reactive Phosphorus as P	----	0.01	mg/L	<0.01	0.5 mg/L	97.2	84	108
EP005: Total Organic Carbon (TOC) (QCLot: 2450355)								
EP005: Total Organic Carbon	----	1	mg/L	<1	10 mg/L	101	81	111
EP010: Formaldehyde (QCLot: 2450192)								
EP010: Formaldehyde	50-00-0	0.1	mg/L	<0.1	5.0 mg/L	101	91	117
EP041A: Nonionic Surfactants (QCLot: 2457642)								
EP041A: Nonionic Surfactants as CTAS	----	5	mg/L	<5	10 mg/L	100	81.1	110

Sub-Matrix: **WATER**

Method: Compound	CAS Number	LOR	Unit	Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Recovery Limits (%)	
				Result	Concentration	LCS	Low	High
EP050: Anionic Surfactants as MBAS (QCLot: 2455526)								
EP050: Anionic Surfactants as MBAS		0.1	mg/L	<0.1	1 mg/L	90.0	83.2	115
EP074A: Monocyclic Aromatic Hydrocarbons (QCLot: 2450015)								
EP074: Benzene	71-43-2	1	µg/L	<1	20 µg/L	108	79	121
EP074: Toluene	108-88-3	2	µg/L	<2	20 µg/L	108	80	124
EP074: Ethylbenzene	100-41-4	2	µg/L	<2	20 µg/L	105	79	121
EP074: meta- & para-Xylene	108-38-3 106-42-3	2	µg/L	<2	40 µg/L	110	80	122
EP074: Styrene	100-42-5	5	µg/L	<5	20 µg/L	104	74	122
EP074: ortho-Xylene	95-47-6	2	µg/L	<2	20 µg/L	107	81	123
EP074: Isopropylbenzene	98-82-8	5	µg/L	<5	20 µg/L	114	80	120
EP074: n-Propylbenzene	103-65-1	5	µg/L	<5	20 µg/L	96.6	70	120
EP074: 1.3.5-Trimethylbenzene	108-67-8	5	µg/L	<5	20 µg/L	91.4	71	119
EP074: sec-Butylbenzene	135-98-8	5	µg/L	<5	20 µg/L	100	72	120
EP074: 1.2.4-Trimethylbenzene	95-63-6	5	µg/L	<5	20 µg/L	88.5	73	119
EP074: tert-Butylbenzene	98-06-6	5	µg/L	<5	20 µg/L	99.4	73	119
EP074: p-Isopropyltoluene	99-87-6	5	µg/L	<5	20 µg/L	96.8	71	121
EP074: n-Butylbenzene	104-51-8	5	µg/L	<5	20 µg/L	93.1	65	121
EP074B: Oxygenated Compounds (QCLot: 2450015)								
EP074: Vinyl Acetate	108-05-4	50	µg/L	<50	200 µg/L	118	57	131
EP074: 2-Butanone (MEK)	78-93-3	50	µg/L	<50	200 µg/L	92.0	69	135
EP074: 4-Methyl-2-pentanone (MIBK)	108-10-1	50	µg/L	<50	200 µg/L	95.9	68	136
EP074: 2-Hexanone (MBK)	591-78-6	50	µg/L	<50	200 µg/L	77.4	68	138
EP074C: Sulfonated Compounds (QCLot: 2450015)								
EP074: Carbon disulfide	75-15-0	5	µg/L	<5	20 µg/L	114	67	127
EP074D: Fumigants (QCLot: 2450015)								
EP074: 2.2-Dichloropropane	594-20-7	5	µg/L	<5	20 µg/L	102	59	128
EP074: 1.2-Dichloropropane	78-87-5	5	µg/L	<5	20 µg/L	96.7	77	121
EP074: cis-1.3-Dichloropropylene	10061-01-5	5	µg/L	<5	20 µg/L	# 68.4	70	118
EP074: trans-1.3-Dichloropropylene	10061-02-6	5	µg/L	<5	20 µg/L	# 60.9	66	120
EP074: 1.2-Dibromoethane (EDB)	106-93-4	5	µg/L	<5	20 µg/L	102	78	124
EP074E: Halogenated Aliphatic Compounds (QCLot: 2450015)								
EP074: Dichlorodifluoromethane	75-71-8	50	µg/L	<50	200 µg/L	105	58	148
EP074: Chloromethane	74-87-3	50	µg/L	<50	200 µg/L	104	62	142
EP074: Vinyl chloride	75-01-4	50	µg/L	<50	200 µg/L	99.0	61	141
EP074: Bromomethane	74-83-9	50	µg/L	<50	200 µg/L	102	57	131
EP074: Chloroethane	75-00-3	50	µg/L	<50	200 µg/L	127	64	138
EP074: Trichlorofluoromethane	75-69-4	50	µg/L	<50	200 µg/L	122	67	131
EP074: 1.1-Dichloroethene	75-35-4	5	µg/L	<5	20 µg/L	# 127	71	125

Sub-Matrix: **WATER**

Method: Compound	CAS Number	LOR	Unit	Method Blank (MB) Report	Laboratory Control Spike (LCS) Report		
					Spike	Spike Recovery (%)	Recovery Limits (%)
				Result	Concentration	LCS	Low	High
EP074E: Halogenated Aliphatic Compounds (QCLot: 2450015) - continued								
EP074: Iodomethane	74-88-4	5	µg/L	<5	20 µg/L	82.1	61	135
EP074: trans-1.2-Dichloroethene	156-60-5	5	µg/L	<5	20 µg/L	119	75	121
EP074: 1.1-Dichloroethane	75-34-3	5	µg/L	<5	20 µg/L	# 122	77	121
EP074: cis-1.2-Dichloroethene	156-59-2	5	µg/L	<5	20 µg/L	119	78	122
EP074: 1.1.1-Trichloroethane	71-55-6	5	µg/L	<5	20 µg/L	104	70	120
EP074: 1.1-Dichloropropylene	563-58-6	5	µg/L	<5	20 µg/L	121	74	122
EP074: Carbon Tetrachloride	56-23-5	5	µg/L	<5	20 µg/L	92.4	57	123
EP074: 1.2-Dichloroethane	107-06-2	5	µg/L	<5	20 µg/L	111	75	125
EP074: Trichloroethene	79-01-6	5	µg/L	<5	20 µg/L	99.6	77	121
EP074: Dibromomethane	74-95-3	5	µg/L	<5	20 µg/L	91.7	76	122
EP074: 1.1.2-Trichloroethane	79-00-5	5	µg/L	<5	20 µg/L	111	78	126
EP074: 1.3-Dichloropropane	142-28-9	5	µg/L	<5	20 µg/L	105	79	125
EP074: Tetrachloroethene	127-18-4	5	µg/L	<5	20 µg/L	113	76	122
EP074: 1.1.1.2-Tetrachloroethane	630-20-6	5	µg/L	<5	20 µg/L	72.6	65	119
EP074: trans-1.4-Dichloro-2-butene	110-57-6	5	µg/L	<5	20 µg/L	85.7	46	126
EP074: cis-1.4-Dichloro-2-butene	1476-11-5	5	µg/L	<5	20 µg/L	81.4	54	132
EP074: 1.1.2.2-Tetrachloroethane	79-34-5	5	µg/L	<5	20 µg/L	97.7	75	131
EP074: 1.2.3-Trichloropropane	96-18-4	5	µg/L	<5	20 µg/L	100	75	133
EP074: Pentachloroethane	76-01-7	5	µg/L	<5	20 µg/L	56.7	46	118
EP074: 1.2-Dibromo-3-chloropropane	96-12-8	5	µg/L	<5	20 µg/L	64.8	54	124
EP074F: Halogenated Aromatic Compounds (QCLot: 2450015)								
EP074: Chlorobenzene	108-90-7	5	µg/L	<5	20 µg/L	106	81	121
EP074: Bromobenzene	108-86-1	5	µg/L	<5	20 µg/L	84.3	75	119
EP074: 2-Chlorotoluene	95-49-8	5	µg/L	<5	20 µg/L	93.2	73	121
EP074: 4-Chlorotoluene	106-43-4	5	µg/L	<5	20 µg/L	92.0	72	120
EP074: 1.2.3-Trichlorobenzene	87-61-6	5	µg/L	<5	20 µg/L	83.5	69	123
EP074G: Trihalomethanes (QCLot: 2450015)								
EP074: Chloroform	67-66-3	5	µg/L	<5	20 µg/L	113	77	121
EP074: Bromodichloromethane	75-27-4	5	µg/L	<5	20 µg/L	71.9	69	117
EP074: Dibromochloromethane	124-48-1	5	µg/L	<5	20 µg/L	72.7	59	119
EP074: Bromoform	75-25-2	5	µg/L	<5	20 µg/L	67.6	49	121
EP075A: Phenolic Compounds (QCLot: 2449947)								
EP075: Phenol	108-95-2	2	µg/L	<2	10 µg/L	33.0	10	65
EP075: 2-Chlorophenol	95-57-8	2	µg/L	<2	10 µg/L	79.8	29.8	108
EP075: 2-Methylphenol	95-48-7	2	µg/L	<2	10 µg/L	80.5	21.9	110
EP075: 3- & 4-Methylphenol	1319-77-3	2	µg/L	----	20 µg/L	69.1	10	108
		4	µg/L	<4	----	----	----	----
EP075: 2-Nitrophenol	88-75-5	2	µg/L	<2	10 µg/L	88.5	31.2	123
EP075: 2.4-Dimethylphenol	105-67-9	2	µg/L	<2	10 µg/L	101	36	124

Sub-Matrix: **WATER**

Method: Compound	CAS Number	LOR	Unit	Method Blank (MB) Report	Laboratory Control Spike (LCS) Report		
					Spike	Spike Recovery (%)	Recovery Limits (%)
				Result	Concentration	LCS	Low	High
EP075A: Phenolic Compounds (QCLot: 2449947) - continued								
EP075: 2.4-Dichlorophenol	120-83-2	2	µg/L	<2	10 µg/L	85.2	31.2	125
EP075: 2.6-Dichlorophenol	87-65-0	2	µg/L	<2	10 µg/L	83.2	33	123
EP075: 4-Chloro-3-Methylphenol	59-50-7	2	µg/L	<2	10 µg/L	86.6	39	125
EP075: 2.4.6-Trichlorophenol	88-06-2	2	µg/L	<2	10 µg/L	81.7	23.9	134
EP075: 2.4.5-Trichlorophenol	95-95-4	2	µg/L	<2	10 µg/L	81.3	31.6	136
EP075: Pentachlorophenol	87-86-5	2	µg/L	----	10 µg/L	66.9	47	153
		4	µg/L	<4	----	----	----	----
EP075B: Polynuclear Aromatic Hydrocarbons (QCLot: 2449947)								
EP075: Naphthalene	91-20-3	2	µg/L	<2	10 µg/L	95.7	33	117
EP075: 2-Methylnaphthalene	91-57-6	2	µg/L	<2	10 µg/L	85.2	33	123
EP075: 2-Chloronaphthalene	91-58-7	2	µg/L	<2	10 µg/L	85.3	22.6	133
EP075: Acenaphthylene	208-96-8	2	µg/L	<2	10 µg/L	85.9	35	131
EP075: Acenaphthene	83-32-9	2	µg/L	<2	10 µg/L	91.8	37	127
EP075: Fluorene	86-73-7	2	µg/L	<2	10 µg/L	92.1	39	133
EP075: Phenanthrene	85-01-8	2	µg/L	<2	10 µg/L	94.5	42	134
EP075: Anthracene	120-12-7	2	µg/L	<2	10 µg/L	94.9	41	135
EP075: Fluoranthene	206-44-0	2	µg/L	<2	10 µg/L	93.0	40	146
EP075: Pyrene	129-00-0	2	µg/L	<2	10 µg/L	93.8	42	142
EP075: N-2-Fluorenyl Acetamide	53-96-3	2	µg/L	<2	10 µg/L	101	40	146
EP075: Benz(a)anthracene	56-55-3	2	µg/L	<2	10 µg/L	91.5	41	143
EP075: Chrysene	218-01-9	2	µg/L	<2	10 µg/L	92.4	40	146
EP075: Benzo(b) & Benzo(k)fluoranthene	205-99-2 207-08-9	4	µg/L	<4	20 µg/L	105	21	151
EP075: 7.12-Dimethylbenz(a)anthracene	57-97-6	2	µg/L	<2	10 µg/L	98.4	39	151
EP075: Benzo(a)pyrene	50-32-8	2	µg/L	<2	10 µg/L	107	39	141
EP075: 3-Methylcholanthrene	56-49-5	2	µg/L	<2	10 µg/L	101	33	139
EP075: Indeno(1.2.3.cd)pyrene	193-39-5	2	µg/L	<2	10 µg/L	103	31.5	139
EP075: Dibenz(a.h)anthracene	53-70-3	2	µg/L	<2	10 µg/L	102	30.1	140
EP075: Benzo(g.h.i)perylene	191-24-2	2	µg/L	<2	10 µg/L	107	29.5	138
EP075C: Phthalate Esters (QCLot: 2449947)								
EP075: Dimethyl phthalate	131-11-3	2	µg/L	<2	10 µg/L	89.7	41	141
EP075: Diethyl phthalate	84-66-2	2	µg/L	<2	10 µg/L	101	45	139
EP075: Di-n-butyl phthalate	84-74-2	2	µg/L	<2	10 µg/L	104	42	150
EP075: Butyl benzyl phthalate	85-68-7	2	µg/L	<2	10 µg/L	104	36	152
EP075: bis(2-ethylhexyl) phthalate	117-81-7	10	µg/L	<10	----	----	----	----
		20	µg/L	----	10 µg/L	139	42	158
EP075: Di-n-octylphthalate	117-84-0	2	µg/L	<2	10 µg/L	116	43	141
EP075D: Nitrosamines (QCLot: 2449947)								
EP075: N-Nitrosomethylethylamine	10595-95-6	2	µg/L	<2	10 µg/L	62.5	10	109

Sub-Matrix: **WATER**

Method: Compound	CAS Number	LOR	Unit	Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Recovery Limits (%)	
				Result	Concentration	LCS	Low	High
EP075D: Nitrosamines (QCLot: 2449947) - continued								
EP075: N-Nitrosodiethylamine	55-18-5	2	µg/L	<2	10 µg/L	83.2	23.5	124
EP075: N-Nitrosopyrrolidine	930-55-2	4	µg/L	<4	10 µg/L	62.5	18.8	97
EP075: N-Nitrosomorpholine	59-89-2	2	µg/L	<2	10 µg/L	69.3	18.3	94
EP075: N-Nitrosodi-n-propylamine	621-64-7	2	µg/L	<2	10 µg/L	101	30.6	129
EP075: N-Nitrosopiperidine	100-75-4	2	µg/L	<2	10 µg/L	88.6	32	126
EP075: N-Nitrosodibutylamine	924-16-3	2	µg/L	<2	10 µg/L	95.7	29.1	135
EP075: N-Nitrosodiphenyl & Diphenylamine	86-30-6 122-39-4	4	µg/L	<4	10 µg/L	90.6	39	139
EP075: Methapyrilene	91-80-5	2	µg/L	<2	10 µg/L	# 22.0	28.1	70
EP075E: Nitroaromatics and Ketones (QCLot: 2449947)								
EP075: 2-Picoline	109-06-8	2	µg/L	<2	10 µg/L	# 12.4	28.4	57
EP075: Acetophenone	98-86-2	2	µg/L	<2	10 µg/L	93.3	34	126
EP075: Nitrobenzene	98-95-3	2	µg/L	<2	10 µg/L	98.1	36	120
EP075: Isophorone	78-59-1	2	µg/L	<2	10 µg/L	99.3	38	124
EP075: 2.6-Dinitrotoluene	606-20-2	4	µg/L	<4	10 µg/L	87.5	38	142
EP075: 2.4-Dinitrotoluene	121-14-2	4	µg/L	<4	10 µg/L	89.2	44	138
EP075: 1-Naphthylamine	134-32-7	2	µg/L	<2	10 µg/L	59.2	29.8	152
EP075: 4-Nitroquinoline-N-oxide	56-57-5	2	µg/L	<2	10 µg/L	91.9	25.9	168
EP075: 5-Nitro-o-toluidine	99-55-8	2	µg/L	<2	10 µg/L	95.7	26.2	138
EP075: Azobenzene	103-33-3	2	µg/L	<2	10 µg/L	106	43	135
EP075: 1.3.5-Trinitrobenzene	99-35-4	2	µg/L	<2	10 µg/L	79.4	10	158
EP075: Phenacetin	62-44-2	2	µg/L	<2	10 µg/L	88.2	37	131
EP075: 4-Aminobiphenyl	92-67-1	2	µg/L	<2	10 µg/L	59.6	10	150
EP075: Pentachloronitrobenzene	82-68-8	2	µg/L	<2	10 µg/L	92.0	38	146
EP075: Pronamide	23950-58-5	2	µg/L	<2	10 µg/L	102	45	139
EP075: Dimethylaminoazobenzene	60-11-7	2	µg/L	<2	10 µg/L	86.6	37	147
EP075: Chlorobenzilate	510-15-6	2	µg/L	<2	10 µg/L	89.1	42	148
EP075F: Haloethers (QCLot: 2449947)								
EP075: Bis(2-chloroethyl) ether	111-44-4	2	µg/L	<2	10 µg/L	106	10	142
EP075: Bis(2-chloroethoxy) methane	111-91-1	2	µg/L	<2	10 µg/L	96.1	34	126
EP075: 4-Chlorophenyl phenyl ether	7005-72-3	2	µg/L	<2	10 µg/L	87.2	39	133
EP075: 4-Bromophenyl phenyl ether	101-55-3	2	µg/L	<2	10 µg/L	84.5	39	137
EP075G: Chlorinated Hydrocarbons (QCLot: 2449947)								
EP075: 1.4-Dichlorobenzene	106-46-7	2	µg/L	<4	10 µg/L	# 114	23	109
EP075: 1.3-Dichlorobenzene	541-73-1	2	µg/L	<2	10 µg/L	84.5	19.8	112
EP075: 1.2-Dichlorobenzene	95-50-1	2	µg/L	<2	10 µg/L	84.1	25.2	109
EP075: Hexachloroethane	67-72-1	2	µg/L	<2	10 µg/L	79.8	17.4	115
EP075: 1.2.4-Trichlorobenzene	120-82-1	2	µg/L	<2	10 µg/L	83.4	25.7	112
EP075: Hexachloropropylene	1888-71-7	2	µg/L	<2	10 µg/L	79.2	19.1	115

Sub-Matrix: **WATER**

Method: Compound	CAS Number	LOR	Unit	Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Recovery Limits (%)	
				Result	Concentration	LCS	Low	High
EP075G: Chlorinated Hydrocarbons (QCLot: 2449947) - continued								
EP075: Hexachlorobutadiene	87-68-3	2	µg/L	<2	10 µg/L	80.6	21.1	117
EP075: Hexachlorocyclopentadiene	77-47-4	10	µg/L	<10	10 µg/L	71.8	10	120
EP075: Pentachlorobenzene	608-93-5	2	µg/L	<2	10 µg/L	82.0	36	130
EP075: Hexachlorobenzene (HCB)	118-74-1	4	µg/L	<4	20 µg/L	82.4	11.1	135
EP075H: Anilines and Benzidines (QCLot: 2449947)								
EP075: Aniline	62-53-3	2	µg/L	<2	10 µg/L	62.0	19.8	96
EP075: 4-Chloroaniline	106-47-8	2	µg/L	<2	10 µg/L	37.3	16.4	130
EP075: 2-Nitroaniline	88-74-4	4	µg/L	<4	10 µg/L	86.1	38	138
EP075: 3-Nitroaniline	99-09-2	4	µg/L	<4	10 µg/L	60.7	10	135
EP075: Dibenzofuran	132-64-9	2	µg/L	<2	10 µg/L	90.5	39	129
EP075: 4-Nitroaniline	100-01-6	2	µg/L	<2	10 µg/L	80.5	22.8	133
EP075: Carbazole	86-74-8	2	µg/L	<2	10 µg/L	95.4	44	138
EP075: 3.3`-Dichlorobenzidine	91-94-1	2	µg/L	<2	10 µg/L	105	14.6	107
EP075I: Organochlorine Pesticides (QCLot: 2449947)								
EP075: alpha-BHC	319-84-6	2	µg/L	<2	10 µg/L	98.7	41	143
EP075: beta-BHC	319-85-7	2	µg/L	<2	10 µg/L	103	39	145
EP075: gamma-BHC	58-89-9	2	µg/L	<2	10 µg/L	101	39	143
EP075: delta-BHC	319-86-8	2	µg/L	<2	10 µg/L	103	42	142
EP075: Heptachlor	76-44-8	2	µg/L	<2	10 µg/L	85.5	39	139
EP075: Aldrin	309-00-2	2	µg/L	<2	10 µg/L	92.8	40	142
EP075: Heptachlor epoxide	1024-57-3	2	µg/L	<2	10 µg/L	79.4	37	147
EP075: alpha-Endosulfan	959-98-8	2	µg/L	<2	10 µg/L	104	42	146
EP075: 4.4`-DDE	72-55-9	2	µg/L	<2	10 µg/L	91.7	41	141
EP075: Dieldrin	60-57-1	2	µg/L	<2	10 µg/L	96.9	42	144
EP075: Endrin	72-20-8	2	µg/L	<2	10 µg/L	90.9	41	145
EP075: beta-Endosulfan	33213-65-9	2	µg/L	<2	10 µg/L	101	42	146
EP075: 4.4`-DDD	72-54-8	2	µg/L	<2	10 µg/L	96.4	40	148
EP075: Endosulfan sulfate	1031-07-8	2	µg/L	<2	10 µg/L	104	38	152
EP075: 4.4`-DDT	50-29-3	4	µg/L	<4	10 µg/L	92.5	33	145
EP075J: Organophosphorus Pesticides (QCLot: 2449947)								
EP075: Dichlorvos	62-73-7	2	µg/L	<2	10 µg/L	95.2	38	132
EP075: Dimethoate	60-51-5	2	µg/L	<2	10 µg/L	91.6	36	138
EP075: Diazinon	333-41-5	2	µg/L	<2	10 µg/L	106	43	141
EP075: Chlorpyrifos-methyl	5598-13-0	2	µg/L	<2	10 µg/L	83.9	43	141
EP075: Malathion	121-75-5	2	µg/L	<2	10 µg/L	98.5	44	148
EP075: Fenthion	55-38-9	2	µg/L	<2	10 µg/L	85.8	42	144
EP075: Chlorpyrifos	2921-88-2	2	µg/L	<2	10 µg/L	97.3	42	142
EP075: Pirimphos-ethyl	23505-41-1	2	µg/L	<2	10 µg/L	101	44	142
EP075: Chlorfenvinphos	470-90-6	2	µg/L	<2	10 µg/L	93.2	44	146

Sub-Matrix: **WATER**

Method: Compound	CAS Number	LOR	Unit	Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Recovery Limits (%)	
				Result	Concentration	LCS	Low	High
EP075J: Organophosphorus Pesticides (QCLot: 2449947) - continued								
EP075: Prothiofos	34643-46-4	2	µg/L	<2	10 µg/L	98.5	40	142
EP075: Ethion	563-12-2	2	µg/L	<2	10 µg/L	82.5	42	146
EP079/070: TPH CWG Aliphatic Hydrocarbon Fractions (QCLot: 2449949)								
EP070-CWG: Aliphatic >C10-C12	TPHCWG-AL E1	50	µg/L	<50	2505 µg/L	75.0	70	130
EP070-CWG: Aliphatic >C12-C16	TPHCWG-AL E2	50	µg/L	<50	10590 µg/L	83.2	70	130
EP070-CWG: Aliphatic >C16-C21	----	50	µg/L	<50	9345 µg/L	97.2	70	130
EP070-CWG: Aliphatic >C21-C35	----	50	µg/L	<50	2253 µg/L	93.6	70	130
EP079/070: TPH CWG Aliphatic Hydrocarbon Fractions (QCLot: 2450016)								
EP079-CWG: Aliphatic >C5-C6	----	20	µg/L	<20	50 µg/L	73.5	70	130
EP079-CWG: Aliphatic >C6-C8	TPHCWG-AL V2	20	µg/L	<20	100 µg/L	102	70	130
EP079-CWG: Aliphatic >C8-C10	TPHCWG-AL V3	20	µg/L	<20	120 µg/L	78.3	70	130
EP079/070: TPH CWG Aromatic Hydrocarbon Fractions (QCLot: 2449949)								
EP070-CWG: Aromatic >C10-C12	TPHCWG-AR E1	50	µg/L	<50	750 µg/L	83.4	70	130
EP070-CWG: Aromatic >C12-C16	TPHCWG-AR E2	50	µg/L	<50	3174 µg/L	95.2	70	130
EP070-CWG: Aromatic >C16-C21	TPHCWG-AR E3	50	µg/L	<50	2607 µg/L	86.8	70	130
EP070-CWG: Aromatic >C21-C35	TPHCWG-AR E4	50	µg/L	<50	606 µg/L	86.9	70	130
EP079/070: TPH CWG Aromatic Hydrocarbon Fractions (QCLot: 2450016)								
EP079-CWG: Aromatic >C5-C7	----	1	µg/L	<1	20 µg/L	84.1	70	130
EP079-CWG: Aromatic >C7-C8	TPHCWG-AR V2	2	µg/L	<2	20 µg/L	101	70	130
EP079-CWG: Aromatic >C8-C10	TPHCWG-AR V3	2	µg/L	<2	180 µg/L	89.6	70	130
EP117: Alcohols (QCLot: 2459340)								
EP117: Ethanol	64-17-5	50	µg/L	<50	100 µg/L	105	73	121
EP117: Isopropanol	67-63-0	50	µg/L	<50	100 µg/L	103	73	113
EP117: n-Propanol	71-23-8	50	µg/L	<50	100 µg/L	107	68	116
EP117: Isobutanol	78-83-1	50	µg/L	<50	100 µg/L	107	67	117
EP117: n-Butanol	71-36-3	50	µg/L	<50	100 µg/L	110	65	119

Matrix Spike (MS) Report

The quality control term Matrix Spike (MS) refers to an intralaboratory split sample spiked with a representative set of target analytes. The purpose of this QC parameter is to monitor potential matrix effects on analyte recoveries. Static Recovery Limits as per laboratory Data Quality Objectives (DQOs). Ideal recovery ranges stated may be waived in the event of sample matrix interference.

Sub-Matrix: **WATER**

				Matrix Spike (MS) Report			
				Spike	Spike Recovery (%)	Recovery Limits (%)	
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Concentration	MS	Low	High
ED009: Anions (QCLot: 2451265)							
EM1209245-001	"Tindilpie Pad Clean" frac make up water from pond	ED009-X: Bromide	24959-67-9	0.2 mg/L	# Not Determined	70	130
		ED009-X: Iodide	20461-54-5	1 mg/L	92.8	70	130
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA (QCLot: 2450176)							
EM1209245-002	"Tindilpie Pad Pit Circ" Pit water prior to flowback	ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	10 mg/L	106	70	130
ED045G: Chloride Discrete analyser (QCLot: 2450175)							
EM1209245-002	"Tindilpie Pad Pit Circ" Pit water prior to flowback	ED045G: Chloride	16887-00-6	400 mg/L	# Not Determined	70	130
EG020F: Dissolved Metals by ICP-MS (QCLot: 2451813)							
EM1209234-001	Anonymous	EG020A-F: Arsenic	7440-38-2	0.2 mg/L	106	89	139
		EG020A-F: Beryllium	7440-41-7	0.2 mg/L	71.3	64	138
		EG020A-F: Barium	7440-39-3	0.2 mg/L	108	80	122
		EG020A-F: Cadmium	7440-43-9	0.05 mg/L	# Not Determined	75	131
		EG020A-F: Chromium	7440-47-3	0.2 mg/L	77.9	70	130
		EG020A-F: Cobalt	7440-48-4	0.2 mg/L	# Not Determined	77	129
		EG020A-F: Copper	7440-50-8	0.2 mg/L	# Not Determined	71	127
		EG020A-F: Lead	7439-92-1	0.2 mg/L	94.0	71	123
		EG020A-F: Manganese	7439-96-5	0.2 mg/L	68.6	66	132
		EG020A-F: Nickel	7440-02-0	0.2 mg/L	# Not Determined	73	129
		EG020A-F: Vanadium	7440-62-2	0.2 mg/L	# Not Determined	70	130
		EG020A-F: Zinc	7440-66-6	0.2 mg/L	# Not Determined	68	136
EG035F: Dissolved Mercury by FIMS (QCLot: 2451815)							
EM1209245-002	"Tindilpie Pad Pit Circ" Pit water prior to flowback	EG035F: Mercury	7439-97-6	0.0100 mg/L	106	70	130
EK025G: Free cyanide by Discrete Analyser (QCLot: 2451312)							
EM1209245-002	"Tindilpie Pad Pit Circ" Pit water prior to flowback	EK025G: Free Cyanide	----	0.2 mg/L	78.9	70	130
EK026G: Total Cyanide By Discrete Analyser (QCLot: 2450067)							
EB1220875-001	Anonymous	EK026G: Total Cyanide	57-12-5	0.2 mg/L	75.1	70	130
EK040P: Fluoride by PC Titrator (QCLot: 2450242)							
EM1209228-002	Anonymous	EK040P: Fluoride	16984-48-8	50 mg/L	106	70	130
EK055G: Ammonia as N by Discrete Analyser (QCLot: 2450475)							
EM1209290-003	Anonymous	EK055G: Ammonia as N	7664-41-7	0.5 mg/L	96.8	70	130

Sub-Matrix: **WATER**

Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Matrix Spike (MS) Report: Spike Concentration	Spike Recovery (%): MS	Recovery Limits (%): Low	Recovery Limits (%): High
EK057G: Nitrite as N by Discrete Analyser (QCLot: 2450172)							
EM1209229-002	Anonymous	EK057G: Nitrite as N	----	0.5 mg/L	112	70	130
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser (QCLot: 2450473)							
EM1209168-002	Anonymous	EK059G: Nitrite + Nitrate as N	----	0.5 mg/L	102	70	130
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser (QCLot: 2450356)							
EM1209230-002	Anonymous	EK061G: Total Kjeldahl Nitrogen as N	----	5 mg/L	94.1	70	130
EK067G: Total Phosphorus as P by Discrete Analyser (QCLot: 2450357)							
EM1209230-002	Anonymous	EK067G: Total Phosphorus as P	----	1 mg/L	109	70	130
EK071G: Reactive Phosphorus as P by discrete analyser (QCLot: 2450173)							
EM1209229-002	Anonymous	EK071G: Reactive Phosphorus as P	----	0.5 mg/L	114	70	130
EP005: Total Organic Carbon (TOC) (QCLot: 2450355)							
EM1209171-003	Anonymous	EP005: Total Organic Carbon	----	100 mg/L	90.3	70	130
EP010: Formaldehyde (QCLot: 2450192)							
EM1209245-001	"Tindilpie Pad Clean" frac make up water from pond	EP010: Formaldehyde	50-00-0	2.5 mg/L	95.6	70	130
EP041A: Nonionic Surfactants (QCLot: 2457642)							
EM1209245-001	"Tindilpie Pad Clean" frac make up water from pond	EP041A: Nonionic Surfactants as CTAS	----	5 mg/L	# Not Determined	70	130
EP050: Anionic Surfactants as MBAS (QCLot: 2455526)							
EM1209245-001	"Tindilpie Pad Clean" frac make up water from pond	EP050: Anionic Surfactants as MBAS		1.0 mg/L	110	70	130
EP074A: Monocyclic Aromatic Hydrocarbons (QCLot: 2450015)							
EM1209245-001	"Tindilpie Pad Clean" frac make up water from pond	EP074: Benzene	71-43-2	20 µg/L	83.9	64	121
		EP074: Toluene	108-88-3	20 µg/L	103	63	125
EP074E: Halogenated Aliphatic Compounds (QCLot: 2450015)							
EM1209245-001	"Tindilpie Pad Clean" frac make up water from pond	EP074: 1.1-Dichloroethene	75-35-4	20 µg/L	63.8	52	104
		EP074: Trichloroethene	79-01-6	20 µg/L	83.4	59	120
EP074F: Halogenated Aromatic Compounds (QCLot: 2450015)							
EM1209245-001	"Tindilpie Pad Clean" frac make up water from pond	EP074: Chlorobenzene	108-90-7	20 µg/L	103	63	132
EP075A: Phenolic Compounds (QCLot: 2449947)							
EM1209245-002	"Tindilpie Pad Pit Circ" Pit water prior to flowback	EP075: Phenol	108-95-2	10 µg/L	# Not Determined	10	51
		EP075: 2-Chlorophenol	95-57-8	10 µg/L	# Not Determined	26.1	104
		EP075: 2-Nitrophenol	88-75-5	10 µg/L	# Not Determined	34	118
		EP075: 4-Chloro-3-Methylphenol	59-50-7	10 µg/L	# Not Determined	24.9	135
		EP075: Pentachlorophenol	87-86-5	10 µg/L	# Not Determined	29.9	194
EP075B: Polynuclear Aromatic Hydrocarbons (QCLot: 2449947)							

Sub-Matrix: **WATER**

Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Matrix Spike (MS) Report: Spike Concentration	Spike Recovery (%): MS	Recovery Limits (%): Low	Recovery Limits (%): High
EP075B: Polynuclear Aromatic Hydrocarbons (QCLot: 2449947) - continued							
EM1209245-002	"Tindilpie Pad Pit Circ" Pit water prior to flowback	EP075: Acenaphthene	83-32-9	10 µg/L	# Not Determined	27	133
		EP075: Pyrene	129-00-0	10 µg/L	# Not Determined	28.1	146
EP075D: Nitrosamines (QCLot: 2449947)							
EM1209245-002	"Tindilpie Pad Pit Circ" Pit water prior to flowback	EP075: N-Nitrosodi-n-propylamine	621-64-7	10 µg/L	# Not Determined	22.8	125
EP075E: Nitroaromatics and Ketones (QCLot: 2449947)							
EM1209245-002	"Tindilpie Pad Pit Circ" Pit water prior to flowback	EP075: 2.4-Dinitrotoluene	121-14-2	10 µg/L	# Not Determined	27.9	138
EP075G: Chlorinated Hydrocarbons (QCLot: 2449947)							
EM1209245-002	"Tindilpie Pad Pit Circ" Pit water prior to flowback	EP075: 1.4-Dichlorobenzene	106-46-7	10 µg/L	# Not Determined	22.1	112
		EP075: 1.2.4-Trichlorobenzene	120-82-1	10 µg/L	# Not Determined	15.3	117
EP079/070: TPH CWG Aliphatic Hydrocarbon Fractions (QCLot: 2449949)							
EM1209245-002	"Tindilpie Pad Pit Circ" Pit water prior to flowback	EP070-CWG: Aliphatic >C10-C12	TPHCWG-ALE1	2505 µg/L	# 19.5	70	130
		EP070-CWG: Aliphatic >C12-C16	TPHCWG-ALE2	10590 µg/L	# 25.1	70	130
		EP070-CWG: Aliphatic >C16-C21	----	9345 µg/L	# 31.2	70	130
		EP070-CWG: Aliphatic >C21-C35	----	2253 µg/L	# 25.8	70	130
EP079/070: TPH CWG Aliphatic Hydrocarbon Fractions (QCLot: 2450016)							
EM1209245-001	"Tindilpie Pad Clean" frac make up water from pond	EP079-CWG: Aliphatic >C5-C6	----	70 µg/L	89.4	70	130
		EP079-CWG: Aliphatic >C6-C8	TPHCWG-ALV2	120 µg/L	99.6	70	130
		EP079-CWG: Aliphatic >C8-C10	TPHCWG-ALV3	120 µg/L	# 131	70	130
EP079/070: TPH CWG Aromatic Hydrocarbon Fractions (QCLot: 2449949)							
EM1209245-002	"Tindilpie Pad Pit Circ" Pit water prior to flowback	EP070-CWG: Aromatic >C10-C12	TPHCWG-ARE1	750 µg/L	# 33.0	70	130
		EP070-CWG: Aromatic >C12-C16	TPHCWG-ARE2	3174 µg/L	# 32.9	70	130
		EP070-CWG: Aromatic >C16-C21	TPHCWG-ARE3	2607 µg/L	# 33.2	70	130
		EP070-CWG: Aromatic >C21-C35	TPHCWG-ARE4	606 µg/L	# 25.5	70	130
EP079/070: TPH CWG Aromatic Hydrocarbon Fractions (QCLot: 2450016)							
EM1209245-001	"Tindilpie Pad Clean" frac make up water from pond	EP079-CWG: Aromatic >C5-C7	----	20 µg/L	73.9	70	130
		EP079-CWG: Aromatic >C7-C8	TPHCWG-ARV2	20 µg/L	97.1	70	130

Sub-Matrix: **WATER**

Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Matrix Spike (MS) Report: Spike Concentration	Matrix Spike (MS) Report: Spike Recovery (%) MS	Matrix Spike (MS) Report: Recovery Limits (%) Low	Matrix Spike (MS) Report: Recovery Limits (%) High
EP117: Alcohols (QCLot: 2459340)							
EB1221352-001	Anonymous	EP117: Ethanol	64-17-5	100 µg/L	96.7	70	130
		EP117: Isopropanol	67-63-0	100 µg/L	105	70	130
		EP117: n-Propanol	71-23-8	100 µg/L	114	70	130
		EP117: Isobutanol	78-83-1	100 µg/L	111	70	130
		EP117: n-Butanol	71-36-3	100 µg/L	108	70	130

INTERPRETIVE QUALITY CONTROL REPORT

Work Order	: **EM1209245**	Page	: 1 of 15
Client	: SANTOS LTD	Laboratory	: Environmental Division Melbourne
Contact	: MR BARRY RITCHIE	Contact	: Jodie Hancock
Address	: GROUND FLOOR SANTOS CENTRE 60 FLINDERS STREET ADELAIDE SA, AUSTRALIA 5001	Address	: 4 Westall Rd Springvale VIC Australia 3171
E-mail	: barry.ritchie@santos.com	E-mail	: Jodie.Hancock@alsenviro.com
Telephone	: +61 08 8116 5000	Telephone	: +61 7 3243 7128
Facsimile	: +61 08 8116 5050	Facsimile	: +61 7 3243 7218
Project	: HFRA Fluids Sampling - Extended Analysis	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Site	: ----		
C-O-C number	: ----	Date Samples Received	: 14-AUG-2012
Sampler	: TD / AJ	Issue Date	: 28-AUG-2012
Order number	: 879002/538		
		No. of samples received	: 2
Quote number	: EN/039/11	No. of samples analysed	: 2

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Interpretive Quality Control Report contains the following information:

- Analysis Holding Time Compliance
- Quality Control Parameter Frequency Compliance
- Brief Method Summaries
- Summary of Outliers

Analysis Holding Time Compliance

The following report summarises extraction / preparation and analysis times and compares with recommended holding times. Dates reported represent first date of extraction or analysis and precludes subsequent dilutions and reruns. Information is also provided re the sample container (preservative) from which the analysis aliquot was taken. Elapsed period to analysis represents number of days from sampling where no extraction / digestion is involved or period from extraction / digestion where this is present. For composite samples, sampling date is assumed to be that of the oldest sample contributing to the composite. Sample date for laboratory produced leachates is assumed as the completion date of the leaching process. Outliers for holding time are based on USEPA SW 846, APHA, AS and NEPM (1999). A listing of breaches is provided in the Summary of Outliers.

Holding times for leachate methods (excluding elutriates) vary according to the analytes being determined on the resulting solution. For non-volatile analytes, the holding time compliance assessment compares the leach date with the shortest analyte holding time for the equivalent soil method. These soil holding times are: Organics (14 days); Mercury (28 days) & other metals (180 days). A recorded breach therefore does not guarantee a breach for all non-volatile parameters.

Matrix: **WATER**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method / Container / Client Sample ID(s)	Sample Date	Extraction / Preparation			Analysis		
		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EA005: pH							
Clear Plastic Bottle - Natural							
"Tindilpie Pad Clean" - frac make up water from pond, "Tindilpie Pad Pit Circ" - Pit water prior to flowback	**13-AUG-2012**	**----**	----	----	**15-AUG-2012**	13-AUG-2012	×
EA006: Sodium Adsorption Ratio (SAR)							
Clear Plastic Bottle - Natural							
"Tindilpie Pad Clean" - frac make up water from pond, "Tindilpie Pad Pit Circ" - Pit water prior to flowback	**13-AUG-2012**	**---**	20-AUG-2012	----	**16-AUG-2012**	20-AUG-2012	✓
EA015: Total Dissolved Solids							
Clear Plastic Bottle - Natural							
"Tindilpie Pad Clean" - frac make up water from pond, "Tindilpie Pad Pit Circ" - Pit water prior to flowback	**13-AUG-2012**	**----**	----	----	**16-AUG-2012**	20-AUG-2012	✓
ED009: Anions							
Clear Plastic Bottle - Natural							
"Tindilpie Pad Clean" - frac make up water from pond, "Tindilpie Pad Pit Circ" - Pit water prior to flowback	**13-AUG-2012**	**----**	----	----	**17-AUG-2012**	10-SEP-2012	✓
ED037P: Alkalinity by PC Titrator							
Clear Plastic Bottle - Natural							
"Tindilpie Pad Clean" - frac make up water from pond, "Tindilpie Pad Pit Circ" - Pit water prior to flowback	**13-AUG-2012**	**---**	27-AUG-2012	----	**15-AUG-2012**	27-AUG-2012	✓
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA							
Clear Plastic Bottle - Natural							
"Tindilpie Pad Clean" - frac make up water from pond, "Tindilpie Pad Pit Circ" - Pit water prior to flowback	**13-AUG-2012**	**---**	10-SEP-2012	----	**16-AUG-2012**	10-SEP-2012	✓
ED045G: Chloride Discrete analyser							
Clear Plastic Bottle - Natural							
"Tindilpie Pad Clean" - frac make up water from pond, "Tindilpie Pad Pit Circ" - Pit water prior to flowback	**13-AUG-2012**	**---**	10-SEP-2012	----	**16-AUG-2012**	10-SEP-2012	✓
ED093F: Dissolved Major Cations							
Clear Plastic Bottle - Natural							
"Tindilpie Pad Clean" - frac make up water from pond, "Tindilpie Pad Pit Circ" - Pit water prior to flowback	**13-AUG-2012**	**---**	20-AUG-2012	----	**16-AUG-2012**	20-AUG-2012	✓
EG020F: Dissolved Metals by ICP-MS							
Clear Plastic Bottle - Natural							
"Tindilpie Pad Clean" - frac make up water from pond, "Tindilpie Pad Pit Circ" - Pit water prior to flowback	**13-AUG-2012**	**---**	09-FEB-2013	----	**16-AUG-2012**	09-FEB-2013	✓
EG035F: Dissolved Mercury by FIMS							
Clear Plastic Bottle - Natural							
"Tindilpie Pad Clean" - frac make up water from pond, "Tindilpie Pad Pit Circ" - Pit water prior to flowback	**13-AUG-2012**	**---**	10-SEP-2012	----	**16-AUG-2012**	10-SEP-2012	✓
EK011: Chlorine - Free							
Clear Plastic Bottle - Natural							
"Tindilpie Pad Clean" - frac make up water from pond, "Tindilpie Pad Pit Circ" - Pit water prior to flowback	**13-AUG-2012**	**----**	----	----	**14-AUG-2012**	13-AUG-2012	×

Matrix: **WATER**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method / Container / Client Sample ID(s)	Sample Date	Extraction / Preparation			Analysis		
		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EK025G: Free cyanide by Discrete Analyser							
White Plastic Bottle-NaOH							
"Tindilpie Pad Clean" - frac make up water from pond, "Tindilpie Pad Pit Circ" - Pit water prior to flowback	**13-AUG-2012**	**16-AUG-2012**	27-AUG-2012	✓	**16-AUG-2012**	27-AUG-2012	✓
EK026G: Total Cyanide By Discrete Analyser							
White Plastic Bottle-NaOH							
"Tindilpie Pad Clean" - frac make up water from pond, "Tindilpie Pad Pit Circ" - Pit water prior to flowback	**13-AUG-2012**	**15-AUG-2012**	27-AUG-2012	✓	**15-AUG-2012**	27-AUG-2012	✓
EK040P: Fluoride by PC Titrator							
Clear Plastic Bottle - Natural							
"Tindilpie Pad Clean" - frac make up water from pond, "Tindilpie Pad Pit Circ" - Pit water prior to flowback	**13-AUG-2012**	**---**	10-SEP-2012	----	**15-AUG-2012**	10-SEP-2012	✓
EK055G: Ammonia as N by Discrete Analyser							
Clear Plastic Bottle - Sulfuric Acid							
"Tindilpie Pad Clean" - frac make up water from pond, "Tindilpie Pad Pit Circ" - Pit water prior to flowback	**13-AUG-2012**	**---**	10-SEP-2012	----	**16-AUG-2012**	10-SEP-2012	✓
EK057G: Nitrite as N by Discrete Analyser							
Clear Plastic Bottle - Natural							
"Tindilpie Pad Clean" - frac make up water from pond, "Tindilpie Pad Pit Circ" - Pit water prior to flowback	**13-AUG-2012**	**---**	15-AUG-2012	----	**15-AUG-2012**	15-AUG-2012	✓
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser							
Clear Plastic Bottle - Sulfuric Acid							
"Tindilpie Pad Clean" - frac make up water from pond, "Tindilpie Pad Pit Circ" - Pit water prior to flowback	**13-AUG-2012**	**---**	10-SEP-2012	----	**16-AUG-2012**	10-SEP-2012	✓
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser							
Clear Plastic Bottle - Sulfuric Acid							
"Tindilpie Pad Clean" - frac make up water from pond, "Tindilpie Pad Pit Circ" - Pit water prior to flowback	**13-AUG-2012**	**16-AUG-2012**	10-SEP-2012	✓	**16-AUG-2012**	10-SEP-2012	✓
EK067G: Total Phosphorus as P by Discrete Analyser							
Clear Plastic Bottle - Sulfuric Acid							
"Tindilpie Pad Clean" - frac make up water from pond, "Tindilpie Pad Pit Circ" - Pit water prior to flowback	**13-AUG-2012**	**16-AUG-2012**	10-SEP-2012	✓	**16-AUG-2012**	10-SEP-2012	✓
EK071G: Reactive Phosphorus as P by discrete analyser							
Clear Plastic Bottle - Natural							
"Tindilpie Pad Clean" - frac make up water from pond, "Tindilpie Pad Pit Circ" - Pit water prior to flowback	**13-AUG-2012**	**---**	15-AUG-2012	----	**15-AUG-2012**	15-AUG-2012	✓
EP005: Total Organic Carbon (TOC)							
Amber TOC Vial - Sulfuric Acid							
"Tindilpie Pad Clean" - frac make up water from pond, "Tindilpie Pad Pit Circ" - Pit water prior to flowback	**13-AUG-2012**	**----**	----	----	**15-AUG-2012**	10-SEP-2012	✓
EP010: Formaldehyde							
Clear Plastic Bottle - Natural							
"Tindilpie Pad Clean" - frac make up water from pond, "Tindilpie Pad Pit Circ" - Pit water prior to flowback	**13-AUG-2012**	**----**	----	----	**14-AUG-2012**	15-AUG-2012	✓
EP041A: Nonionic Surfactants							
Pres. with Formaldehyde on receipt							
"Tindilpie Pad Clean" - frac make up water from pond, "Tindilpie Pad Pit Circ" - Pit water prior to flowback	**13-AUG-2012**	**----**	----	----	**20-AUG-2012**	10-SEP-2012	✓
EP050: Anionic Surfactants as MBAS							
Pres. with Formaldehyde on receipt							
"Tindilpie Pad Clean" - frac make up water from pond, "Tindilpie Pad Pit Circ" - Pit water prior to flowback	**13-AUG-2012**	**----**	----	----	**17-AUG-2012**	17-AUG-2012	✓
EP074A: Monocyclic Aromatic Hydrocarbons							
Amber VOC Vial - Sulfuric Acid							
"Tindilpie Pad Clean" - frac make up water from pond, "Tindilpie Pad Pit Circ" - Pit water prior to flowback	**13-AUG-2012**	**15-AUG-2012**	27-AUG-2012	✓	**15-AUG-2012**	27-AUG-2012	✓

Matrix: **WATER**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method / Container / Client Sample ID(s)	Sample Date	Extraction / Preparation			Analysis		
		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EP074B: Oxygenated Compounds							
Amber VOC Vial - Sulfuric Acid							
"Tindilpie Pad Clean" - frac make up water from pond, "Tindilpie Pad Pit Circ" - Pit water prior to flowback	**13-AUG-2012**	**15-AUG-2012**	27-AUG-2012	✓	**15-AUG-2012**	27-AUG-2012	✓
EP074C: Sulfonated Compounds							
Amber VOC Vial - Sulfuric Acid							
"Tindilpie Pad Clean" - frac make up water from pond, "Tindilpie Pad Pit Circ" - Pit water prior to flowback	**13-AUG-2012**	**15-AUG-2012**	27-AUG-2012	✓	**15-AUG-2012**	27-AUG-2012	✓
EP074D: Fumigants							
Amber VOC Vial - Sulfuric Acid							
"Tindilpie Pad Clean" - frac make up water from pond, "Tindilpie Pad Pit Circ" - Pit water prior to flowback	**13-AUG-2012**	**15-AUG-2012**	27-AUG-2012	✓	**15-AUG-2012**	27-AUG-2012	✓
EP074E: Halogenated Aliphatic Compounds							
Amber VOC Vial - Sulfuric Acid							
"Tindilpie Pad Clean" - frac make up water from pond, "Tindilpie Pad Pit Circ" - Pit water prior to flowback	**13-AUG-2012**	**15-AUG-2012**	27-AUG-2012	✓	**15-AUG-2012**	27-AUG-2012	✓
EP074F: Halogenated Aromatic Compounds							
Amber VOC Vial - Sulfuric Acid							
"Tindilpie Pad Clean" - frac make up water from pond, "Tindilpie Pad Pit Circ" - Pit water prior to flowback	**13-AUG-2012**	**15-AUG-2012**	27-AUG-2012	✓	**15-AUG-2012**	27-AUG-2012	✓
EP074G: Trihalomethanes							
Amber VOC Vial - Sulfuric Acid							
"Tindilpie Pad Clean" - frac make up water from pond, "Tindilpie Pad Pit Circ" - Pit water prior to flowback	**13-AUG-2012**	**15-AUG-2012**	27-AUG-2012	✓	**15-AUG-2012**	27-AUG-2012	✓
EP075A: Phenolic Compounds							
Amber Glass Bottle - Unpreserved							
"Tindilpie Pad Clean" - frac make up water from pond, "Tindilpie Pad Pit Circ" - Pit water prior to flowback	**13-AUG-2012**	**15-AUG-2012**	20-AUG-2012	✓	**20-AUG-2012**	24-SEP-2012	✓
EP075B: Polynuclear Aromatic Hydrocarbons							
Amber Glass Bottle - Unpreserved							
"Tindilpie Pad Clean" - frac make up water from pond, "Tindilpie Pad Pit Circ" - Pit water prior to flowback	**13-AUG-2012**	**15-AUG-2012**	20-AUG-2012	✓	**20-AUG-2012**	24-SEP-2012	✓
EP075C: Phthalate Esters							
Amber Glass Bottle - Unpreserved							
"Tindilpie Pad Clean" - frac make up water from pond, "Tindilpie Pad Pit Circ" - Pit water prior to flowback	**13-AUG-2012**	**15-AUG-2012**	20-AUG-2012	✓	**20-AUG-2012**	24-SEP-2012	✓
EP075D: Nitrosamines							
Amber Glass Bottle - Unpreserved							
"Tindilpie Pad Clean" - frac make up water from pond, "Tindilpie Pad Pit Circ" - Pit water prior to flowback	**13-AUG-2012**	**15-AUG-2012**	20-AUG-2012	✓	**20-AUG-2012**	24-SEP-2012	✓
EP075E: Nitroaromatics and Ketones							
Amber Glass Bottle - Unpreserved							
"Tindilpie Pad Clean" - frac make up water from pond, "Tindilpie Pad Pit Circ" - Pit water prior to flowback	**13-AUG-2012**	**15-AUG-2012**	20-AUG-2012	✓	**20-AUG-2012**	24-SEP-2012	✓
EP075F: Haloethers							
Amber Glass Bottle - Unpreserved							
"Tindilpie Pad Clean" - frac make up water from pond, "Tindilpie Pad Pit Circ" - Pit water prior to flowback	**13-AUG-2012**	**15-AUG-2012**	20-AUG-2012	✓	**20-AUG-2012**	24-SEP-2012	✓
EP075G: Chlorinated Hydrocarbons							
Amber Glass Bottle - Unpreserved							
"Tindilpie Pad Clean" - frac make up water from pond, "Tindilpie Pad Pit Circ" - Pit water prior to flowback	**13-AUG-2012**	**15-AUG-2012**	20-AUG-2012	✓	**20-AUG-2012**	24-SEP-2012	✓
EP075H: Anilines and Benzidines							
Amber Glass Bottle - Unpreserved							
"Tindilpie Pad Clean" - frac make up water from pond, "Tindilpie Pad Pit Circ" - Pit water prior to flowback	**13-AUG-2012**	**15-AUG-2012**	20-AUG-2012	✓	**20-AUG-2012**	24-SEP-2012	✓

Matrix: **WATER**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method / Container / Client Sample ID(s)	Sample Date	Extraction / Preparation			Analysis		
		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EP075I: Organochlorine Pesticides							
Amber Glass Bottle - Unpreserved							
"Tindilpie Pad Clean" - frac make up water from pond, "Tindilpie Pad Pit Circ" - Pit water prior to flowback	**13-AUG-2012**	**15-AUG-2012**	20-AUG-2012	✓	**20-AUG-2012**	24-SEP-2012	✓
EP075J: Organophosphorus Pesticides							
Amber Glass Bottle - Unpreserved							
"Tindilpie Pad Clean" - frac make up water from pond, "Tindilpie Pad Pit Circ" - Pit water prior to flowback	**13-AUG-2012**	**15-AUG-2012**	20-AUG-2012	✓	**20-AUG-2012**	24-SEP-2012	✓
EP117: Alcohols							
Amber VOC Vial - Sulfuric Acid							
"Tindilpie Pad Clean" - frac make up water from pond, "Tindilpie Pad Pit Circ" - Pit water prior to flowback	**13-AUG-2012**	**----**	----	----	**21-AUG-2012**	27-AUG-2012	✓
RIVM Aliphatic Hydrocarbon Fractions							
Amber Glass Bottle - Unpreserved							
"Tindilpie Pad Clean" - frac make up water from pond, "Tindilpie Pad Pit Circ" - Pit water prior to flowback	**13-AUG-2012**	**17-AUG-2012**	20-AUG-2012	✓	**21-AUG-2012**	24-SEP-2012	✓
Amber VOC Vial - Sulfuric Acid							
"Tindilpie Pad Clean" - frac make up water from pond, "Tindilpie Pad Pit Circ" - Pit water prior to flowback	**13-AUG-2012**	**15-AUG-2012**	27-AUG-2012	✓	**15-AUG-2012**	27-AUG-2012	✓
RIVM Aromatic Hydrocarbon Fractions							
Amber Glass Bottle - Unpreserved							
"Tindilpie Pad Clean" - frac make up water from pond, "Tindilpie Pad Pit Circ" - Pit water prior to flowback	**13-AUG-2012**	**17-AUG-2012**	20-AUG-2012	✓	**21-AUG-2012**	24-SEP-2012	✓
Amber VOC Vial - Sulfuric Acid							
"Tindilpie Pad Clean" - frac make up water from pond, "Tindilpie Pad Pit Circ" - Pit water prior to flowback	**13-AUG-2012**	**15-AUG-2012**	27-AUG-2012	✓	**15-AUG-2012**	27-AUG-2012	✓

Quality Control Parameter Frequency Compliance

The following report summarises the frequency of laboratory QC samples analysed within the analytical lot(s) in which the submitted sample(s) was(where) processed. Actual rate should be greater than or equal to the expected rate. A listing of breaches is provided in the Summary of Outliers.

Matrix: **WATER**

Evaluation: × = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	*Method*	*QC*	*Regular*	***Actual***	***Expected***	*Evaluation*	
Laboratory Duplicates (DUP)							
Alcohols by HS-GC-MS	EP117	2	11	**18.2**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Alkalinity by PC Titrator	ED037-P	2	10	**20.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Ammonia as N by Discrete analyser	EK055G	2	20	**10.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Anionic Surfactants as MBAS	EP050	2	20	**10.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Chloride by Discrete Analyser	ED045G	1	6	**16.7**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Dissolved Mercury by FIMS	EG035F	2	20	**10.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Dissolved Metals by ICP-MS - Suite A	EG020A-F	2	19	**10.5**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Dissolved Metals by ICP-MS - Suite B	EG020B-F	2	16	**12.5**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Fluoride by PC Titrator	EK040P	1	9	**11.1**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Formaldehyde	EP010	1	2	**50.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Free CN by Discrete Analyser	EK025G	1	2	**50.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Major Cations - Dissolved	ED093F	3	25	**12.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	2	16	**12.5**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Nitrite as N by Discrete Analyser	EK057G	2	20	**10.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Nonionic Surfactants as CTAS	EP041A	1	2	**50.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
pH	EA005	2	20	**10.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Reactive Phosphorus as P-By Discrete Analyser	EK071G	1	6	**16.7**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Semivolatile Organic Compounds	EP075	1	2	**50.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Standard Anions -by IC (Extended Method)	ED009-X	2	13	**15.4**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	1	6	**16.7**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Cyanide By Discrete Analyser	EK026G	2	12	**16.7**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Dissolved Solids (High Level)	EA015H	2	20	**10.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Kjeldahl Nitrogen as N By Discrete Analyser	EK061G	2	18	**11.1**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Organic Carbon	EP005	2	13	**15.4**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Phosphorus as P By Discrete Analyser	EK067G	2	18	**11.1**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
TPH Speciation (TPH CWG RIVM fractions)	EP070-CWG	1	2	**50.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Volatile Hydrocarbon Speciation (TPH CWG fractions)	EP079-CWG	1	2	**50.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Volatile Organic Compounds	EP074	1	2	**50.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Laboratory Control Samples (LCS)							
Alcohols by HS-GC-MS	EP117	1	11	**9.1**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Alkalinity by PC Titrator	ED037-P	1	10	**10.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Ammonia as N by Discrete analyser	EK055G	1	20	**5.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Anionic Surfactants as MBAS	EP050	1	20	**5.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Chloride by Discrete Analyser	ED045G	2	6	**33.3**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Dissolved Mercury by FIMS	EG035F	1	20	**5.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Dissolved Metals by ICP-MS - Suite A	EG020A-F	1	19	**5.3**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Dissolved Metals by ICP-MS - Suite B	EG020B-F	1	16	**6.3**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Fluoride by PC Titrator	EK040P	1	9	**11.1**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Formaldehyde	EP010	1	2	**50.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement

Matrix: **WATER**

Evaluation: × = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	*Method*	*QC*	*Regular*	***Actual***	***Expected***	*Evaluation*	
Laboratory Control Samples (LCS) - Continued							
Free CN by Discrete Analyser	EK025G	1	2	**50.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Major Cations - Dissolved	ED093F	2	25	**8.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	1	16	**6.3**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Nitrite as N by Discrete Analyser	EK057G	1	20	**5.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Nonionic Surfactants as CTAS	EP041A	1	2	**50.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Reactive Phosphorus as P-By Discrete Analyser	EK071G	1	6	**16.7**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Semivolatile Organic Compounds	EP075	1	2	**50.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Standard Anions -by IC (Extended Method)	ED009-X	1	13	**7.7**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	1	6	**16.7**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Cyanide By Discrete Analyser	EK026G	1	12	**8.3**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Dissolved Solids (High Level)	EA015H	1	20	**5.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Kjeldahl Nitrogen as N By Discrete Analyser	EK061G	1	18	**5.6**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Organic Carbon	EP005	1	13	**7.7**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Phosphorus as P By Discrete Analyser	EK067G	1	18	**5.6**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
TPH Speciation (TPH CWG RIVM fractions)	EP070-CWG	1	2	**50.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Volatile Hydrocarbon Speciation (TPH CWG fractions)	EP079-CWG	1	2	**50.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Volatile Organic Compounds	EP074	1	2	**50.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Method Blanks (MB)							
Alcohols by HS-GC-MS	EP117	1	11	**9.1**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Ammonia as N by Discrete analyser	EK055G	1	20	**5.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Anionic Surfactants as MBAS	EP050	1	20	**5.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Chloride by Discrete Analyser	ED045G	1	6	**16.7**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Dissolved Mercury by FIMS	EG035F	1	20	**5.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Dissolved Metals by ICP-MS - Suite A	EG020A-F	1	19	**5.3**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Dissolved Metals by ICP-MS - Suite B	EG020B-F	1	16	**6.3**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Fluoride by PC Titrator	EK040P	1	9	**11.1**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Formaldehyde	EP010	1	2	**50.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Free CN by Discrete Analyser	EK025G	1	2	**50.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Major Cations - Dissolved	ED093F	2	25	**8.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	1	16	**6.3**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Nitrite as N by Discrete Analyser	EK057G	1	20	**5.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Nonionic Surfactants as CTAS	EP041A	1	2	**50.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Reactive Phosphorus as P-By Discrete Analyser	EK071G	1	6	**16.7**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Semivolatile Organic Compounds	EP075	1	2	**50.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Standard Anions -by IC (Extended Method)	ED009-X	1	13	**7.7**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	1	6	**16.7**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Cyanide By Discrete Analyser	EK026G	1	12	**8.3**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Dissolved Solids (High Level)	EA015H	1	20	**5.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Kjeldahl Nitrogen as N By Discrete Analyser	EK061G	1	18	**5.6**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Organic Carbon	EP005	1	13	**7.7**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Phosphorus as P By Discrete Analyser	EK067G	1	18	**5.6**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
TPH Speciation (TPH CWG RIVM fractions)	EP070-CWG	1	2	**50.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Volatile Hydrocarbon Speciation (TPH CWG fractions)	EP079-CWG	1	2	**50.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement

Matrix: **WATER**

Evaluation: × = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	*Method*	*QC*	*Regular*	***Actual***	***Expected***	*Evaluation*	
Method Blanks (MB) - Continued							
Volatile Organic Compounds	EP074	1	2	**50.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Matrix Spikes (MS)							
Alcohols by HS-GC-MS	EP117	1	11	**9.1**	**5.0**	✓	ALS QCS3 requirement
Ammonia as N by Discrete analyser	EK055G	1	20	**5.0**	**5.0**	✓	ALS QCS3 requirement
Anionic Surfactants as MBAS	EP050	1	20	**5.0**	**5.0**	✓	ALS QCS3 requirement
Chloride by Discrete Analyser	ED045G	1	6	**16.7**	**5.0**	✓	ALS QCS3 requirement
Dissolved Mercury by FIMS	EG035F	1	20	**5.0**	**5.0**	✓	ALS QCS3 requirement
Dissolved Metals by ICP-MS - Suite A	EG020A-F	1	19	**5.3**	**5.0**	✓	ALS QCS3 requirement
Fluoride by PC Titrator	EK040P	1	9	**11.1**	**5.0**	✓	ALS QCS3 requirement
Formaldehyde	EP010	1	2	**50.0**	**5.0**	✓	ALS QCS3 requirement
Free CN by Discrete Analyser	EK025G	1	2	**50.0**	**5.0**	✓	ALS QCS3 requirement
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	1	16	**6.3**	**5.0**	✓	ALS QCS3 requirement
Nitrite as N by Discrete Analyser	EK057G	1	20	**5.0**	**5.0**	✓	ALS QCS3 requirement
Nonionic Surfactants as CTAS	EP041A	1	2	**50.0**	**5.0**	✓	ALS QCS3 requirement
Reactive Phosphorus as P-By Discrete Analyser	EK071G	1	6	**16.7**	**5.0**	✓	ALS QCS3 requirement
Semivolatile Organic Compounds	EP075	1	2	**50.0**	**5.0**	✓	ALS QCS3 requirement
Standard Anions -by IC (Extended Method)	ED009-X	1	13	**7.7**	**5.0**	✓	ALS QCS3 requirement
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	1	6	**16.7**	**5.0**	✓	ALS QCS3 requirement
Total Cyanide By Discrete Analyser	EK026G	1	12	**8.3**	**5.0**	✓	ALS QCS3 requirement
Total Kjeldahl Nitrogen as N By Discrete Analyser	EK061G	1	18	**5.6**	**5.0**	✓	ALS QCS3 requirement
Total Organic Carbon	EP005	1	13	**7.7**	**5.0**	✓	ALS QCS3 requirement
Total Phosphorus as P By Discrete Analyser	EK067G	1	18	**5.6**	**5.0**	✓	ALS QCS3 requirement
TPH Speciation (TPH CWG RIVM fractions)	EP070-CWG	1	2	**50.0**	**5.0**	✓	ALS QCS3 requirement
Volatile Hydrocarbon Speciation (TPH CWG fractions)	EP079-CWG	1	2	**50.0**	**5.0**	✓	ALS QCS3 requirement
Volatile Organic Compounds	EP074	1	2	**50.0**	**5.0**	✓	ALS QCS3 requirement

Brief Method Summaries

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the US EPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request. The following report provides brief descriptions of the analytical procedures employed for results reported in the Certificate of Analysis. Sources from which ALS methods have been developed are provided within the Method Descriptions.

Analytical Methods	Method	Matrix	Method Descriptions
pH	EA005	WATER	APHA 21st ed. 4500 H+ B. pH of water samples is determined by ISE either manually or by automated pH meter. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Total Dissolved Solids (High Level)	EA015H	WATER	In-House, APHA 21st ed., 2540C A gravimetric procedure that determines the amount of `filterable` residue in an aqueous sample. A well-mixed sample is filtered through a glass fibre filter (1.2um). The filtrate is evaporated to dryness and dried to constant weight at 180+/-5C. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Hardness as CaCO3	EA065	WATER	APHA 21st ed., 2340 B. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Standard Anions -by IC (Extended Method)	* ED009-X	WATER	APHA 21st ed., 4110. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Alkalinity by PC Titrator	ED037-P	WATER	APHA 21st ed., 2320 B This procedure determines alkalinity by automated measurement (e.g. PC Titrate) using pH 4.5 for indicating the total alkalinity end-point. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Major Anions - Dissolved	ED040F	WATER	APHA 21st ed., 3120. The 0.45um filtered samples are determined by ICP/AES for Sulfur and/or Silcon content and reported as Sulfate and/or Silica after conversion by gravimetric factor.
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	WATER	APHA 21st ed., 4500-SO4 Sulfate ions are converted to a barium sulfate suspension in an acetic acid medium with barium chloride. Light absorbance of the BaSO4 suspension is measured by a photometer and the SO4-2 concentration is determined by comparison of the reading with a standard curve. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Chloride by Discrete Analyser	ED045G	WATER	APHA 21st ed., 4500 Cl - G.The thiocyanate ion is liberated from mercuric thiocyanate through sequestration of mercury by the chloride ion to form non-ionised mercuric chloride.in the presence of ferric ions the librated thiocynate forms highly-coloured ferric thiocynate which is measured at 480 nm APHA 21st edition seal method 2 017-1-L april 2003
Major Cations - Dissolved	ED093F	WATER	Major Cations is determined based on APHA 21st ed., 3120; USEPA SW 846 - 6010 The ICPAES technique ionises the 0.45um filtered sample atoms emitting a characteristic spectrum. This spectrum is then compared against matrix matched standards for quantification. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2) Sodium Absorption Ratio is calculated from Ca, Mg and Na which determined by ALS in house method QWI-EN/ED093F. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2) Hardness parameters are calculated based on APHA 21st ed., 2340 B. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Dissolved Metals by ICP-MS - Suite A	EG020A-F	WATER	(APHA 21st ed., 3125; USEPA SW846 - 6020, ALS QWI-EN/EG020): Samples are 0.45 um filtered prior to analysis. The ICPMS technique utilizes a highly efficient argon plasma to ionize selected elements. Ions are then passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to their measurement by a discrete dynode ion detector.
Dissolved Metals by ICP-MS - Suite B	EG020B-F	WATER	(APHA 21st ed., 3125; USEPA SW846 - 6020, ALS QWI-EN/EG020): Samples are 0.45 um filtered prior to analysis. The ICPMS technique utilizes a highly efficient argon plasma to ionize selected elements. Ions are then passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to their measurement by a discrete dynode ion detector.

Analytical Methods	Method	Matrix	Method Descriptions
Dissolved Mercury by FIMS	EG035F	WATER	AS 3550, APHA 21st ed. 3112 Hg - B (Flow-injection (SnCl2)(Cold Vapour generation) AAS) Samples are 0.45 um filtered prior to analysis. FIM-AAS is an automated flameless atomic absorption technique. A bromate/bromide reagent is used to oxidise any organic mercury compounds in the filtered sample. The ionic mercury is reduced online to atomic mercury vapour by SnCl2 which is then purged into a heated quartz cell. Quantification is by comparing absorbance against a calibration curve. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Silica (Total Dissolved) by ICPAES	EG052F	WATER	APHA 21st ed., 4500-SiO2. Silica (Total) determined by calculation from Silicon by ICPAES.
Residual Chlorine by DPD Colourimetry	EK010-1 (Field)	WATER	Adapted from APHA 21st edition, 4500-Cl G, using Palintest Chlorometer 1000
Free CN by Discrete Analyser	EK025G	WATER	APHA 21st ed., 4500-CN-C&N Free Cyanide is determined on samples after distillation using a pyridine- barbituric acid colouring reagent followed with an Discrete Analyser finish. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Total Cyanide By Discrete Analyser	EK026G	WATER	APHA 21st ed., 4500-CN-C & N Total Cyanide is determined from aqueous solutions after distillation with sulphuric acid. The resultant distillate is then captured in a caustic absorber solution followed by Discrete Analyser. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Fluoride by PC Titrator	EK040P	WATER	APHA 21st ed., 4500 F--C CDTA is added to the sample to provide a uniform ionic strength background, adjust pH, and break up complexes. Fluoride concentration is determined by either manual or automatic ISE measurement. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Ammonia as N by Discrete analyser	EK055G	WATER	APHA 21st ed., 4500-NH3 G Ammonia is determined by direct colorimetry by Discrete Analyser. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Nitrite as N by Discrete Analyser	EK057G	WATER	APHA 21st ed., 4500-NO2- B. Nitrite is determined by direct colourimetry by Discrete Analyser. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Nitrate as N by Discrete Analyser	EK058G	WATER	APHA 21st ed., 4500-NO3- F. Nitrate is reduced to nitrite by way of a chemical reduction followed by quantification by Discrete Analyser. Nitrite is determined seperately by direct colourimetry and result for Nitrate calculated as the difference between the two results. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	WATER	APHA 21st ed., 4500-NO3- F. Combined oxidised Nitrogen (NO2+NO3) is determined by Chemical Reduction and direct colourimetry by Discrete Analyser. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Total Kjeldahl Nitrogen as N By Discrete Analyser	EK061G	WATER	APHA 21st ed., 4500-Norg D. 25mL water samples are digested using a traditional Kjeldahl digestion followed by determination by Discrete Analyser. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Total Nitrogen as N (TKN + Nox) By Discrete Analyser	EK062G	WATER	APHA 21st ed., 4500-Norg / 4500-NO3-. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Total Phosphorus as P By Discrete Analyser	EK067G	WATER	APHA 21st ed., 4500-P B&F This procedure involves sulphuric acid digestion of a 100mL sample to break phosphorus down to orthophosphate. The orthophosphate reacts with ammonium molybdate and antimony potassium tartrate to form a complex which is then reduced and its concentration measured at 880nm using Discrete Analyser. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Reactive Phosphorus as P-By Discrete Analyser	EK071G	WATER	APHA 21st ed., 4500-P F Ammonium molybdate and potassium antimonyl tartrate reacts in acid medium with othophosphate to form a heteropoly acid -phosphomolybdic acid - which is reduced to intensely coloured molybdenum blue by ascorbic acid. Quantification is by Discrete Analyser. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Ionic Balance by PCT DA and Turbi SO4 DA	EN055 - PG	WATER	APHA 21st Ed. 1030F. The Ionic Balance is calculated based on the major Anions and Cations. The major anions include Alkalinity, Chloride and Sulfate which determined by PCT and DA. The Cations are determined by Turbi SO4 by DA. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Total Organic Carbon	EP005	WATER	APHA 21st ed., 5310 B, The automated TOC analyzer determines Total and Inorganic Carbon by IR cell. TOC is calculated as the difference. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)

Analytical Methods	Method	Matrix	Method Descriptions
Formaldehyde	EP010	WATER	In-house (ASTM D 6303-98) Determined by colourimetry using NASH reagent. The Hantszch reaction method is based on the reaction of acetylacetone with formaldehyde in the presence of excess ammonium acetate to form a coloured compound.
Nonionic Surfactants as CTAS	EP041	WATER	APHA 21st ed., 5540 B & D This method estimates the non-ionic surfactant content of waters. Sublation transfers all surfactants into a solvent matrix. Cationic and Anionic surfactants are removed by an ion exchange resin column. The remaining surfactant is coloured up with Cobalt Thiocyanate solution and quantified by UV-vis against LAS standards. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Nonionic Surfactants as CTAS	EP041A	WATER	APHA 21st ed., 5540 B & D This method estimates the non-ionic surfactant content of waters. Sublation transfers all surfactants into a solvent matrix. Cationic and Anionic surfactants are removed by an ion exchange resin column. The remaining surfactant is coloured up with Cobalt Thiocyanate solution and quantified by UV-vis against LAS standards. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Anionic Surfactants as MBAS	EP050	WATER	APHA 21st ed., 5540 B & C This method comprises three successive extractions from acid aqueous medium containing excess methylene blue, into chloroform, followed by an aqueous backwash and measurement of the colour by spectrophotometry at 652nm. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
TPH Speciation (TPH CWG RIVM fractions)	EP070-CWG	WATER	In-house: Determination of TPH following fractionation by GC-FID. Fractions correspond to those outlined in TPHCWG, 1998,Analysis of Petroleum Hydrocarbons in Environmental Media, TPH Criteria Working Group, Toxicity Technical Action Group, vol I and RIVM report 601501021/2004, Environmental Risk Limits for Mineral Oil (Total Petroleum Hydrocarbons). Aliphatic >C21 - C35 is defined by RIVM only.
Volatile Organic Compounds	EP074	WATER	USEPA SW 846 - 8260B Water samples are directly purged prior to analysis by Capillary GC/MS and quantification is by comparison against an established 5 point calibration curve. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Semivolatile Organic Compounds	EP075	WATER	USEPA SW 846 - 8270D Sample extracts are analysed by Capillary GC/MS and quantification is by comparison against an established 5 point calibration curve. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Volatile Hydrocarbon Speciation (TPH CWG fractions)	EP079-CWG	WATER	In-house. Conventional TPH and MAH data are determined by Purge and Trap GCMS analysis. TIC data (as fractions) and target aromatics (or groups of aromatics) are used to compute aliphatic and aromotic hydrocarbon fractions by addition or difference. Fractions conform to those outlined in TPHCWG, 1998,Analysis of Petroleum Hydrocarbons in Environmental Media, TPH Criteria Working Group, Toxicity Technical Action Group, vol I and RIVM report 601501021/2004, Environmental Risk Limits for Mineral Oil (Total Petroleum Hydrocarbons)
Alcohols by HS-GC-MS	* EP117	WATER	In House. A 10 mL aliquot of sample is mixed with 4 g of sodium chloride, equilibrated at 80 degrees C for 10 minutes and the headspace analysed by GCMS in the selected ion monitoring mode.

Preparation Methods	Method	Matrix	Method Descriptions
Free Cyanide	EK025-PR	WATER	APHA 21st ed., 4500 CN- C&N. The sample is distilled at natural pH. The CN is trapped in a caustic solution, and quanitified by colourimetry on FIA. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Total Cyanide	EK026-PR	WATER	APHA 21st ed., 4500 CN- C&N. The sample is distilled with H2SO4 releasing all bound cyanides as HCN. The CN is trapped in a caustic solution, and quanitified by colourimetry on FIA. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
TKN/TP Digestion	EK061/EK067	WATER	APHA 21st ed., 4500 Norg - D; APHA 21st ed., 4500 P - H. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Separatory Funnel Extraction of Liquids	ORG14	WATER	USEPA SW 846 - 3510B 500 mL to 1L of sample is transferred to a separatory funnel and serially extracted three times using 60mL DCM for each extract. The resultant extracts are combined, dehydrated and concentrated for analysis. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2). ALS default excludes sediment which may be resident in the container.

Preparation Methods	Method	Matrix	Method Descriptions
Separatory Funnel Extraction of Liquids	ORG14-HX	WATER	Variation of USEPA SW 846 - 3510B: 500 mL to 0.5L of sample is transferred to a separatory funnel and serially extracted three times using 30mL DCM for each extract. The resultant extracts are combined, dehydrated, and exchanged into 5 mL of hexane for analysis. ALS default excludes sediment which may be resident in the container.
Volatiles Water Preparation	ORG16-W	WATER	A 5 mL aliquot or 5 mL of a diluted sample is added to a 40 mL VOC vial for sparging.

Summary of Outliers

Outliers : Quality Control Samples

The following report highlights outliers flagged in the Quality Control (QC) Report. Surrogate recovery limits are static and based on USEPA SW846 or ALS-QWI/EN/38 (in the absence of specific USEPA limits). This report displays QC Outliers (breaches) only.

Duplicates, Method Blanks, Laboratory Control Samples and Matrix Spikes

Matrix: **WATER**

Compound Group Name	Laboratory Sample ID	Client Sample ID	Analyte	CAS Number	Data	Limits	Comment
Laboratory Control Spike (LCS) Recoveries							
EP074D: Fumigants	2903282-001	----	**cis-1.3-Dichloropropylene**	10061-01-5	68.4 %	70-118%	**Recovery less than lower control limit**
EP074D: Fumigants	2903282-001	----	**trans-1.3-Dichloropropylene**	10061-02-6	60.9 %	66-120%	**Recovery less than lower control limit**
EP074E: Halogenated Aliphatic Compounds	2903282-001	----	**1.1-Dichloroethene**	75-35-4	127 %	71-125%	**Recovery greater than upper control limit**
EP074E: Halogenated Aliphatic Compounds	2903282-001	----	**1.1-Dichloroethane**	75-34-3	122 %	77-121%	**Recovery greater than upper control limit**
EP075D: Nitrosamines	2903208-001	----	**Methapyrilene**	91-80-5	22.0 %	28.1-70%	**Recovery less than lower control limit**
EP075E: Nitroaromatics and Ketones	2903208-001	----	**2-Picoline**	109-06-8	12.4 %	28.4-57%	**Recovery less than lower control limit**
EP075G: Chlorinated Hydrocarbons	2903208-001	----	**1.4-Dichlorobenzene**	106-46-7	114 %	23-109%	**Recovery greater than upper control limit**
Matrix Spike (MS) Recoveries							
ED009: Anions	EM1209245-001	"Tindilpie Pad Clean" frac mak	**Bromide**	24959-67-9	Not Determined	----	**MS recovery not determined, background level greater than or equal to 4x spike level.**
ED045G: Chloride Discrete analyser	EM1209245-002	"Tindilpie Pad Pit Circ" Pit wate	**Chloride**	16887-00-6	Not Determined	----	**MS recovery not determined, background level greater than or equal to 4x spike level.**
EG020F: Dissolved Metals by ICP-MS	EM1209234-001	Anonymous	**Cadmium**	7440-43-9	Not Determined	----	**MS recovery not determined, background level greater than or equal to 4x spike level.**
EG020F: Dissolved Metals by ICP-MS	EM1209234-001	Anonymous	**Cobalt**	7440-48-4	Not Determined	----	**MS recovery not determined, background level greater than or equal to 4x spike level.**
EG020F: Dissolved Metals by ICP-MS	EM1209234-001	Anonymous	**Copper**	7440-50-8	Not Determined	----	**MS recovery not determined, background level greater than or equal to 4x spike level.**
EG020F: Dissolved Metals by ICP-MS	EM1209234-001	Anonymous	**Nickel**	7440-02-0	Not Determined	----	**MS recovery not determined, background level greater than or equal to 4x spike level.**
EG020F: Dissolved Metals by ICP-MS	EM1209234-001	Anonymous	**Vanadium**	7440-62-2	Not Determined	----	**MS recovery not determined, background level greater than or equal to 4x spike level.**
EG020F: Dissolved Metals by ICP-MS	EM1209234-001	Anonymous	**Zinc**	7440-66-6	Not Determined	----	**MS recovery not determined, background level greater than or equal to 4x spike level.**
EP041A: Nonionic Surfactants	EM1209245-001	"Tindilpie Pad Clean" frac mak	**Nonionic Surfactants as CTAS**	----	Not Determined	----	**Matrix spike recovery not determined due to sample matrix interference.**

Matrix: **WATER**

Compound Group Name	Laboratory Sample ID	Client Sample ID	Analyte	CAS Number	Data	Limits	Comment
Matrix Spike (MS) Recoveries - Continued							
EP075A: Phenolic Compounds	EM1209245-002	"Tindilpie Pad Pit Circ" Pit wate	**Phenol**	108-95-2	Not Determined	----	**MS recovery not determined, background level greater than or equal to 4x spike level.**
EP075A: Phenolic Compounds	EM1209245-002	"Tindilpie Pad Pit Circ" Pit wate	**2-Chlorophenol**	95-57-8	Not Determined	----	**Matrix spike recovery not determined due to sample matrix interference.**
EP075A: Phenolic Compounds	EM1209245-002	"Tindilpie Pad Pit Circ" Pit wate	**2-Nitrophenol**	88-75-5	Not Determined	----	**Matrix spike recovery not determined due to sample matrix interference.**
EP075A: Phenolic Compounds	EM1209245-002	"Tindilpie Pad Pit Circ" Pit wate	**4-Chloro-3-Methylphenol**	59-50-7	Not Determined	----	**Matrix spike recovery not determined due to sample matrix interference.**
EP075A: Phenolic Compounds	EM1209245-002	"Tindilpie Pad Pit Circ" Pit wate	**Pentachlorophenol**	87-86-5	Not Determined	----	**Matrix spike recovery not determined due to sample matrix interference.**
EP075B: Polynuclear Aromatic Hydrocarbons	EM1209245-002	"Tindilpie Pad Pit Circ" Pit wate	**Acenaphthene**	83-32-9	Not Determined	----	**Matrix spike recovery not determined due to sample matrix interference.**
EP075B: Polynuclear Aromatic Hydrocarbons	EM1209245-002	"Tindilpie Pad Pit Circ" Pit wate	**Pyrene**	129-00-0	Not Determined	----	**Matrix spike recovery not determined due to sample matrix interference.**
EP075D: Nitrosamines	EM1209245-002	"Tindilpie Pad Pit Circ" Pit wate	**N-Nitrosodi-n-propylamine**	621-64-7	Not Determined	----	**Matrix spike recovery not determined due to sample matrix interference.**
EP075E: Nitroaromatics and Ketones	EM1209245-002	"Tindilpie Pad Pit Circ" Pit wate	**2.4-Dinitrotoluene**	121-14-2	Not Determined	----	**Matrix spike recovery not determined due to sample matrix interference.**
EP075G: Chlorinated Hydrocarbons	EM1209245-002	"Tindilpie Pad Pit Circ" Pit wate	**1.4-Dichlorobenzene**	106-46-7	Not Determined	----	**Matrix spike recovery not determined due to sample matrix interference.**
EP075G: Chlorinated Hydrocarbons	EM1209245-002	"Tindilpie Pad Pit Circ" Pit wate	**1.2.4-Trichlorobenzene**	120-82-1	Not Determined	----	**Matrix spike recovery not determined due to sample matrix interference.**
EP079/070: TPH CWG Aliphatic Hydrocarbon Fractions	EM1209245-002	"Tindilpie Pad Pit Circ" Pit wate	**Aliphatic >C10-C12**	TPHCWG-ALE1	19.5 %	70-130%	**Recovery less than lower data quality objective**
EP079/070: TPH CWG Aliphatic Hydrocarbon Fractions	EM1209245-002	"Tindilpie Pad Pit Circ" Pit wate	**Aliphatic >C12-C16**	TPHCWG-ALE2	25.1 %	70-130%	**Recovery less than lower data quality objective**
EP079/070: TPH CWG Aliphatic Hydrocarbon Fractions	EM1209245-002	"Tindilpie Pad Pit Circ" Pit wate	**Aliphatic >C16-C21**	----	31.2 %	70-130%	**Recovery less than lower data quality objective**
EP079/070: TPH CWG Aliphatic Hydrocarbon Fractions	EM1209245-002	"Tindilpie Pad Pit Circ" Pit wate	**Aliphatic >C21-C35**	----	25.8 %	70-130%	**Recovery less than lower data quality objective**
EP079/070: TPH CWG Aliphatic Hydrocarbon Fractions	EM1209245-001	"Tindilpie Pad Clean" frac mak	**Aliphatic >C8-C10**	TPHCWG-ALV3	131 %	70-130%	**Recovery greater than upper data quality objective**
EP079/070: TPH CWG Aromatic Hydrocarbon Fraction	EM1209245-002	"Tindilpie Pad Pit Circ" Pit wate	**Aromatic >C10-C12**	TPHCWG-ARE1	33.0 %	70-130%	**Recovery less than lower data quality objective**
EP079/070: TPH CWG Aromatic Hydrocarbon Fraction	EM1209245-002	"Tindilpie Pad Pit Circ" Pit wate	**Aromatic >C12-C16**	TPHCWG-ARE2	32.9 %	70-130%	**Recovery less than lower data quality objective**
EP079/070: TPH CWG Aromatic Hydrocarbon Fraction	EM1209245-002	"Tindilpie Pad Pit Circ" Pit wate	**Aromatic >C16-C21**	TPHCWG-ARE3	33.2 %	70-130%	**Recovery less than lower data quality objective**
EP079/070: TPH CWG Aromatic Hydrocarbon Fraction	EM1209245-002	"Tindilpie Pad Pit Circ" Pit wate	**Aromatic >C21-C35**	TPHCWG-ARE4	25.5 %	70-130%	**Recovery less than lower data quality objective**

- **For all matrices, no Method Blank value outliers occur.**
- **For all matrices, no Duplicate outliers occur.**

Regular Sample Surrogates

Sub-Matrix: **WATER**

Compound Group Name	Laboratory Sample ID	Client Sample ID	Analyte	CAS Number	Data	Limits	Comment
Samples Submitted							
EP075S: Acid Extractable Surrogates	EM1209245-002	"Tindilpie Pad Pit Circ" Pit wate	**2-Fluorophenol**	367-12-4	Not Determined	----	**Surrogate recovery not determined due to (target or non-target) matrix interferences**
EP075S: Acid Extractable Surrogates	EM1209245-002	"Tindilpie Pad Pit Circ" Pit wate	**Phenol-d6**	13127-88-3	Not Determined	----	**Surrogate recovery not determined due to (target or non-target) matrix interferences**
EP075S: Acid Extractable Surrogates	EM1209245-002	"Tindilpie Pad Pit Circ" Pit wate	**2-Chlorophenol-D4**	93951-73-6	Not Determined	----	**Surrogate recovery not determined due to (target or non-target) matrix interferences**
EP075S: Acid Extractable Surrogates	EM1209245-002	"Tindilpie Pad Pit Circ" Pit wate	**2.4.6-Tribromophenol**	118-79-6	Not Determined	----	**Surrogate recovery not determined due to (target or non-target) matrix interferences**
EP075T: Base/Neutral Extractable Surrogates	EM1209245-002	"Tindilpie Pad Pit Circ" Pit wate	**Nitrobenzene-D5**	4165-60-0	Not Determined	----	**Surrogate recovery not determined due to (target or non-target) matrix interferences**
EP075T: Base/Neutral Extractable Surrogates	EM1209245-002	"Tindilpie Pad Pit Circ" Pit wate	**1.2-Dichlorobenzene-D4**	2199-69-1	Not Determined	----	**Surrogate recovery not determined due to (target or non-target) matrix interferences**
EP075T: Base/Neutral Extractable Surrogates	EM1209245-002	"Tindilpie Pad Pit Circ" Pit wate	**2-Fluorobiphenyl**	321-60-8	Not Determined	----	**Surrogate recovery not determined due to (target or non-target) matrix interferences**
EP075T: Base/Neutral Extractable Surrogates	EM1209245-002	"Tindilpie Pad Pit Circ" Pit wate	**Anthracene-d10**	1719-06-8	Not Determined	----	**Surrogate recovery not determined due to (target or non-target) matrix interferences**
EP075T: Base/Neutral Extractable Surrogates	EM1209245-002	"Tindilpie Pad Pit Circ" Pit wate	**4-Terphenyl-d14**	1718-51-0	Not Determined	----	**Surrogate recovery not determined due to (target or non-target) matrix interferences**

Outliers : Analysis Holding Time Compliance

This report displays Holding Time breaches only. Only the respective Extraction / Preparation and/or Analysis component is/are displayed.

Matrix: **WATER**

Method / Container / Client Sample ID(s)		Extraction / Preparation			Analysis		
		Date extracted	Due for extraction	Days overdue	Date analysed	Due for analysis	Days overdue
EA005: pH							
Clear Plastic Bottle - Natural							
"Tindilpie Pad Clean" - frac make up water from pond,	"Tindilpie Pad Pit Circ" - Pit water prior to flowback	----	----	----	15-AUG-2012	13-AUG-2012	**2**
EK011: Chlorine - Free							
Clear Plastic Bottle - Natural							
"Tindilpie Pad Clean" - frac make up water from pond,	"Tindilpie Pad Pit Circ" - Pit water prior to flowback	----	----	----	14-AUG-2012	13-AUG-2012	**1**

Outliers : Frequency of Quality Control Samples

The following report highlights breaches in the Frequency of Quality Control Samples.

- **No Quality Control Sample Frequency Outliers exist.**

CHAIN OF CUSTODY

ALS Laboratory: please tick →

☐ Sydney, 277 Woodpark Rd, Smithfield NSW 2176 Ph: 02 8784 8555 E: samples.sydney@alsenviro.com
☐ Newcastle: 5 Rosegum Rd, Warabrook NSW 2304 Ph 02 4606 0433 E: samples.newcastle@alsenviro.com
☐ Brisbane, 32 Shand St, Stafford QLD 4053 Ph 07 3243 7222 E: samples.brisbane@alsenviro.com
☐ Townsville: 14-15 Desma Ct, Bohle QLD 4818 Ph: 07 4796 0600 E: townsville.environmental@alsenviro.com
☐ Melbourne, 2-4 Westall Rd, Springvale VIC 3171 Ph 03 8549 9600 E: samples.melbourne@alsenviro.com
☐ Adelaide: 2-4 Burma Rd, Pooraka SA 5095 Ph: 08 8359 0890 E: adelaide@alsenviro.com
☐ Perth: 10 Hod Way, Malaga WA 6090 Ph: 08 9209 7655 E: samples.perth@alsenviro.com
☐ Launceston: 27 Wellington St, Launceston TAS 7250 Ph: 03 6331 2158 E: launceston@alsenviro.com

CLIENT:	SANTOS	TURNAROUND REQUIREMENTS : (Standard TAT may be longer for some tests e.g., Ultra Trace Organics)	■ Standard TAT (List due date):	FOR LABORATORY USE ONLY (Circle)	
OFFICE:	Eastern Australia D&C, 60 Flinders Street, Adelaide SA		☐ Non Standard or urgent TAT (List due date):	Custody Seal Intact?	Yes / No / N/A
PROJECT:	HFRA Fluids Sampling - Extended Analysis	ALS QUOTE NO.:	EN/039/11	Free ice / frozen ice bricks present upon receipt?	Yes / No / N/A
ORDER NUMBER:	879002/538			Random Sample Temperature on Receipt:	°C
PROJECT MANAGER:	Barry Ritchie	CONTACT PH: 8116		Other comment:	13.0-13.5
SAMPLER:	Tom Delaney / Andrew Johnston	SAMPLER MOBILE: 0421312739			
COC emailed to ALS? (YES / NO)		EDD FORMAT (or default):			

COC SEQUENCE NUMBER (Circle): COC: ■ 2 3 4 5 6 7 OF: ■ 2 3 4 5 6 7

RELINQUISHED BY:	RECEIVED BY:	RELINQUISHED BY:	RECEIVED BY:
Tom Delaney			Rosmond
DATE/TIME: 13/8/12 8:30	DATE/TIME:	DATE/TIME:	DATE/TIME: 13/8/12 08:57

Email Reports to (will default to PM if no other addresses are listed): andrew.johnston@santos.com; frac.rig.rep.completions@santos.com; barry.ritchie@santos.com; thomas.delaney@santos.com

Email Invoice to (will default to PM if no other addresses are listed): barry.ritchie@santos.com

COMMENTS/SPECIAL HANDLING/STORAGE OR DISPOSAL: Dissolved Metals Required are W-3 + Fe, Se, B, Sr, Al, Mo, Sn, U, Li

Samples received 14/8/12 08:50

ALS USE ONLY	SAMPLE DETAILS MATRIX: Solid(S) Water(W)			CONTAINER INFORMATION		ANALYSIS REQUIRED including SUITES (NB. Suite Codes must be listed to attract suite price) Where Metals are required, specify Total (unfiltered bottle required) or Dissolved (field filtered bottle required).								Additional Information
LAB ID	SAMPLE ID	DATE / TIME	MATRIX	TYPE & PRESERVATIVE (refer to codes below)	TOTAL BOTTLES	EA005, EA015H, EK011	NT-1B, NT-2A, NT-8A	EG052, EN055-DA, ED009X	EA065, EK025, EK026, EP005	W-3 and EG020F (See Additional Info)	EP117, TRH-CWG	EP074A-H, EP075	EP010, EP050, EP041	Comments on likely contaminant levels, dilutions, or samples requiring specific QC analysis etc.
1	"Tindilpie Pad Clean" - frac make up water from pond	13/8/12 0800	W	1L plastic / green; 60ml plastic green; 125ml plastic purple; 60ml plastic blue; 40ml vial purple; 60ml plastic red; 2 x 40ml vial purple; 3x 100ml glass orange; 2 x 40ml amber glass maroon; 3 x 100ml glass orange; 2 x 500ml amber brown;	18	X	X	X	X	X	X	X	X	Sample taken from Frac Fluid at Tindilpie Pad Wellisterneclean fluid pond prior to treatment. Dissolved Metals Required are W-3 + Fe, Se, B, Sr, Al, Mo, Sn, U, Li
2	"Tindilpie Pad Pit Circ" - Pit water prior to flowback	13/8/12 0730	W	1L plastic / green; 60ml plastic green; 125ml plastic purple; 60ml plastic blue; 40ml vial purple; 60ml plastic red; 2 x 40ml vial purple; 3x 100ml glass orange; 2 x 40ml amber glass maroon; 3 x 100ml glass orange; 2 x 500ml amber brown;	18	X	X	X	X	X	X	X	X	Sample taken from Frac Fluid at Tindilpie Pad Welliste pit after coil tubing clean outs haveioccured prior to flowback. Dissolved Metals Required are W-3 + Fe, Se, B, Sr, Al, Mo, Sn, U, Li
				TOTAL	36									

Samples sent to lab for
Micro Nitrate BOD pH
Colour Turbidity RP
Other Nitrite
Date 14-8-12 4:30pm

Environmental Division
Melbourne
Work Order
EM1209245

Telephone : +61-3-8549 9600

Water Container Codes: P = Unpreserved Plastic; N = Nitric Preserved Plastic; ORC = Nitric Preserved ORC; SH = Sodium Hydroxide/Cd Preserved; S = Sodium Hydroxide Preserved Plastic; AG = Amber Glass Unpreserved; AP - Airfreight Unpreserved Plastic
V = VOA Vial HCl Preserved; VB = VOA Vial Sodium Bisulphate Preserved; VS = VOA Vial Sulfuric Preserved; AV = Airfreight Unpreserved Vial SG = Sulfuric Preserved Amber Glass; H = HCl preserved Plastic; HS = HCl preserved Speciation bottle; SP = Sulfuric Preserved Plastic; F = Formaldehyde Preserved Glass;
Z = Zinc Acetate Preserved Bottle; E = EDTA Preserved Bottles; ST = Sterile Bottle; ASS = Plastic Bag for Acid Sulphate Soils; B = Unpreserved Bag.

CHAIN OF CUSTODY

ALS Laboratory: ***please tick à***

CLIENT:	**SANTOS**	**TURNAROUND REQUIREMENTS :** (Standard TAT may be longer for some tests e.g.. Ultra Trace Organics)	Standard TAT **(List due date):** ..
OFFICE:	**Eastern Australia D&C, 60 Flinders Street, Adelaide SA**		Non Standard or urgent TAT **(Li**

PROJECT:	**HFRA Fluids Sampling - Extended Analysis**	**ALS QUOTE NO.:**	**EN/039/11**
ORDER NUMBER:	**879002/538**		
PROJECT MANAGER:	**Barry Ritchie**	**CONTACT PH: 8116**	
SAMPLER:	**Tom Delaney / Andrew Johnston**	**SAMPLER MOBILE: 0421312739**	**RELINQUISHED BY:**
COC emailed to ALS? (YES / NO)		**EDD FORMAT (or default):**	***Tom Delaney***
Email Reports to (will default to PM if no other addresses are listed): andrew.johnston@santos.com; frac.rig.rep.completions@santos.com; barry.ritchie@santos.com; thomas.delaney@santos.com			DATE/TIME:
Email Invoice to (will default to PM if no other addresses are listed): barry.ritchie@santos.com			***13/8/12 8:30***

COMMENTS/SPECIAL HANDLING/STORAGE OR DISPOSAL: Dissolved Metals Required are W-3 + Fe, Se, B, Sr, Al, Mo, Sn, U, Li

ALS USE ONLY	SAMPLE DETAILS MATRIX: Solid(S) Water(W)			CONTAINER INFORMATION		Al
LAB ID	**SAMPLE ID**	**DATE / TIME**	**MATRIX**	**TYPE & PRESERVATIVE** *(refer to codes below)*	**TOTAL BOTTLES**	**EA005, EA015H, EK011**

	"Tindilpie Pad Clean" - frac make up water from pond	**13/8/12 0800**	**W**	1L plastic / green; 60ml plastic green; 125ml plastic purple; 60ml plastic blue; 40ml vial purple; 60ml plastic red; 2 x 40ml vial purple; 3x 100ml glass orange; 2 x 40ml amber glass maroon; 3 x 100ml glass orange; 2 x 500ml amber brown;	18	X
	"Tindilpie Pad Pit Circ" - Pit water prior to flowback	**13/8/12 0730**	**W**	1L plastic / green; 60ml plastic green; 125ml plastic purple; 60ml plastic blue; 40ml vial purple; 60ml plastic red; 2 x 40ml vial purple; 3x 100ml glass orange; 2 x 40ml amber glass maroon; 3 x 100ml glass orange; 2 x 500ml amber brown;	18	X

					TOTAL	36

Water Container Codes: P = Unpreserved Plastic; N = Nitric Preserved Plastic; ORC = Nitric Preserved ORC; SH = Sodium Hydroxide/Cd Preserved; S = Sodium Hydroxide Preserved Plastic; A
V = VOA Vial HCl Preserved; VB = VOA Vial Sodium Bisulphate Preserved; VS = VOA Vial Sulfuric Preserved; AV = Airfreight Unpreserved Vial SG = Sulfuric Preserved Amber Glass; H = HCl pre
Z = Zinc Acetate Preserved Bottle; E = EDTA Preserved Bottles; ST = Sterile Bottle; ASS = Plastic Bag for Acid Sulphate Soils; B = Unpreserved Bag.

Ranil Weerakkody

From: Delaney, Thomas [Thomas.Delaney@santos.com]
Sent: Monday, 13 August 2012 8:57 AM
To: Samples Melbourne; Kieren Burns
Cc: Johnston, Andrew
Subject: Fwd: Environmental Visitation - Frac Spread, Tindilpie
Attachments: Santos_-_Tindilpie_PAD_-_Frac_Fluid_Sample_-_HFRA_Analysis_Aug_2012(1).xlsx; ATT00001.htm

Als,
There will be 2 sets of 18 samples in a blue esky arriving at you Melbourne lab sometime soon - these were taken this morning and should be flying over there this afternoon. See attached for the COC which is included in the package.

Any queries call my mobile.

Thanks

Tom Delaney
0421312739

Begin forwarded message:

From: Thomas Delaney <thomas.j.delaney@gmail.com<mailto:thomas.j.delaney@gmail.com>>
Date: 12 August 2012 4:30:35 PM ACST
To: "Delaney, Thomas" <thomas.delaney@santos.com<mailto:thomas.delaney@santos.com>>
Subject: Re: FW: Environmental Visitation - Frac Spread, Tindilpie

samples.melbourne@alsenviro.com<mailto:samples.melbourne@alsenviro.com>;
Kieren.burns@alsglobal.com<mailto:Kieren.burns@alsglobal.com>;

On Sat, Aug 11, 2012 at 5:19 PM, Delaney, Thomas
<Thomas.Delaney@santos.com<mailto:Thomas.Delaney@santos.com>> wrote:

From: Delaney, Thomas
Sent: Saturday, 11 August 2012 17:19
To: Completions, Frac Rig Rep
Subject: FW: Environmental Visitation - Frac Spread, Tindilpie
Importance: High

Hey Jeff - any chance you can print these out for me? Just the email and attached chain of custody forms when you get a chance. Thivanka wants me to sort this out with Mr PIC to get it into Moomba by Monday morning - so want to have a read and get our head around it.

Cheers mate
TD

Kind regards,

Tom Delaney | Subsurface Lead
Cooper Basin SIMOPS - EA Drilling & Completions | Santos Limited Ph +61 8 8116 5358<tel:%2B61%208%208116%C2%A05358> | Fax +61 8 8116 7755<tel:%2B61%208%208116%207755> | Mob: +61 421 312 739<tel:%2B61%C2%A0421%20312%20739> | thomas.delaney@santos.com<mailto:thomas.delaney@santos.com>

Level 8, Santos Centre, 60 Flinders Street, Adelaide SA 5000 | GPO Box 2455, Adelaide SA 5001 Santos

From: Dedigama, Thivanka
Sent: Wednesday, 8 August 2012 12:11
To: Japp, Kenneth; Delaney, Thomas
Cc: Best, William
Subject: FW: Environmental Visitation - Frac Spread, Tindilpie
Importance: High

Hi Ken and Tom,

Here's one that's going to be interesting. Please review the email below. Only wanted to give you a heads-up on what coming. Don't collect samples yet.

This has previously been communicated to Mark and Paul but I'd like you to take the lead on this for Tindilpie.

For now could you please:

1. Review this and see if you have and EHS or operational concerns about this sampling

2. Locate the cool box, ice packs and 3 x 18 bottles that already supposed to be out there

If you can't find these we have another set coming

3. Locate the 'swing sampler' referred to below. No idea what this looks like. Mark may know.

4. Review the attached CoC form. Some changes will need to be made to update names etc.

I am in the process of getting approval for these samples to fly. Also need to work out with our logistics guys how best that can be rushed to Melbourne for testing. Should have answers in a couple of days.

The sampling that Bill Best did yesterday should get us out of trouble for this pad. This is more a longer term thing.

Thivanka Dedigama
Deputy Field Superintendent - Drilling and Petroleum Engineering
Tel: 08 8678 4191<tel:08%208678%204191>
Mob: 0431 375 187<tel:0431%20375%20187>

From: Johnston, Andrew
Sent: Wednesday, 8 August 2012 09:06
To: Dedigama, Thivanka; Ritchie, Barry
Cc: Johnston, Andrew; Swann, Louise; Best, William; Smith, Chris
Subject: FW: Environmental Visitation - Frac Spread, Tindilpie
Importance: High

Thivanka,

A proposed schedule for the HFRA sampling is below, I have received no feedback as yet so I suggest we run with it, unless some FR or Frac fluid samples overlap? If this is the case please advise in which case maybe 4 samples in total.

A water sample representing influent stream in considered essential. We picked up some unexpected contaminants in the SWQ samples (Coonaberry 3) that may have been present in the bore water being used. This data can be used to give us an indication of quality prior to addition of frac chemicals, or reservoir constituents from flowback. The procedure for collection of this could be applying the same methodology as per below, but taking from the Turkey's Nest or similar storage of influent water.

Sample Collection procedure / COC is as follows:

Pre sampling

- Place cooler blocks in freezer the day before sample collection – these are located in esky from ALS

- Use of ALS supplied bottles (as per attached COC) is essential. Once obtained, label each bottle (18 make a full "sample) with Sample ID, sampler name, date time etc, and ensure this is consistent with updated COC (example attached – note this needs amending to suit this and other events)

- Aim to collect sample early in the day, and despatch via Airfreight that day for minimum lab turnaround time

On the day

- Make sure disposable gloves are worn, and other PPE also

- Take care when standing near pit, and choose a steady location

- The "swing" sampler is located at the frac spread, and there are specific sample containers that fit this apparatus. Ensure a clean sampling container (500ml) is fitted for each sampling event (an "event" requiring 18 sub samples – you don't need 18 separate sampling containers!)

- Using sampler, extract sample from approximately 10cm below surface of the fluid. Repeat and purge 3x

- From then, fill all 18 sample containers to the top with fluids collected in a similar manner to above. Aim to lay off air bubbles so as to minimise voids when lids are placed on. Places these containers into bubble wrap and straight into esky with cooler blocks present.

- Record any field observations, such as HC sheen present, presence of condensate, and approximate volume in pit at the time of sample collection directly onto the COC in the final column. Stage of frac operations would be valuable information also.

- Update COC electronically, as this needs to be both emailed to ALS and also printed off and placed inside the esky prior to despatch. Ensure info on sample containers is entirely consistent with info on COC, otherwise ALS will note this and contact us for clarification

- Seal up esky with completed COC and all containers using labels supplied by ALS

- Either clean thoroughly or discard used 500ml sample container as this must not be used for subsequent collection events (to prevent cross contamination)

- Dispose of gloves appropriately also

CERTIFICATE OF ANALYSIS

Work Order	: **EM1209924**	Page	: 1 of 14
Amendment	: **1**		
Client	: **SANTOS LTD**	Laboratory	: Environmental Division Melbourne
Contact	: MR BARRY RITCHIE	Contact	: Jodie Hancock
Address	: GROUND FLOOR SANTOS CENTRE 60 FLINDERS STREET ADELAIDE SA, AUSTRALIA 5001	Address	: 4 Westall Rd Springvale VIC Australia 3171
E-mail	: barry.ritchie@santos.com	E-mail	: Jodie.Hancock@alsenviro.com
Telephone	: +61 08 8116 5000	Telephone	: +61 7 3243 7128
Facsimile	: +61 08 8116 5050	Facsimile	: +61 7 3243 7218
Project	: HFRA Fluids Sampling - Extended Analysis	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Order number	: 879002/538		
C-O-C number	: ----	Date Samples Received	: 28-AUG-2012
Sampler	: BC/AJ	Issue Date	: 12-SEP-2012
Site	: ----		
		No. of samples received	: 1
Quote number	: EN/039/11	No. of samples analysed	: 1

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results
- Surrogate Control Limits

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting

- **(11/09/2012) This report has been amended following changes to anonymous quality control samples attached to this analytical data reported. All analysis results are as per the previous report.**
- **Alcohols, Bromide, Iodide, MBAS & CTAS analysis conducted by ALS Sydney, NATA accreditation no. 825, site no 10911.**
- **EG035F positive mecury result has been confirmed for EM1209924#1 by repreparation and reanalysis.**
- **EK025G: Free cyanide was analysed by Segmented Flow analyser Method (EK025SF).**
- **EK026G: Total cyanide was analysed by Segmented Flow analyser Method (EK026SF).**
- **EK059G : EM1209937-001 matrix spike failed for Nitrite and Nitrate as N due to possible sample matrix interference. This has been confirmed by re-digestion and re-analysis.**
- **EK059G:Nitrite and Nitrate as N was analysed by NOX Vanadium Chloride Method (EK059GV).**
- **EP050: The MBAS reported is calculated as LAS, mol wt 342**
- **EP074/079-CWG: Particular sample (EM-1209924-001) required dilution due to the presence of high level contaminants. LOR values have been adjusted accordingly.**
- **EP075: EM1209924-001 Particular sample required dilution prior to analysis due to matrix interferences. LOR values have been adjusted accordingly.**
- **EP075: LOR raised for Di-n-butylphthalate due to laboratory background.**
- **EP075: Matrix spike not determined due to matrix interferences.**
- **EP075: 'Sum of PAH' is the sum of the USEPA 16 priority PAHs**
- **EP117: Matrix spike recovery bias low due to sample matrix interferences.**
- **EP117: Particular samples required dilution due to the presence of high level contaminants. LOR values have been adjusted accordingly.**
- **Ionic Balance out of acceptable limits due to analytes not quantified in this report.**
- **Ionic balances were calculated using: major anions - chloride, alkalinity and sulfate; and major cations - calcium, magnesium, potassium and sodium.**
- **It is recognised that Nitrite + Nitrate as N is less than Nitrite as N for EM1209924 #1. However, the difference is within experimental variation of the methods.**

NATA Accredited Laboratory 825

Accredited for compliance with ISO/IEC 17025.

Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	Position	Accreditation Category
Dilani Fernando	Senior Inorganic Chemist	Melbourne Inorganics
Eric Chau	Metals Team Leader	Melbourne Inorganics
Hoa Nguyen	Inorganic Chemist	Sydney Inorganics
Pabi Subba	Senior Organic Chemist	Sydney Organics
Sarah Millington	Senior Inorganic Chemist	Sydney Inorganics
Varsha Ho Wing	Non-Metals Team Leader	Melbourne Inorganics
Xingbin Lin	Senior Organic Chemist	Melbourne Organics

Analytical Results

Sub-Matrix: **WATER**

Compound	CAS Number	LOR	Unit	Client sample ID				
				Tindilpie Pad Pit Flowback frac pit water post flowback	----	----	----	----
			Client sampling date / time	27-AUG-2012 06:15	----	----	----	----
				EM1209924-001	**----**	**----**	**----**	**----**
EA005: pH								
pH Value	----	0.01	pH Unit	**7.46**	----	----	----	----
EA006: Sodium Adsorption Ratio (SAR)								
Sodium Absorption Ratio	----	0.01	-	**105**	----	----	----	----
EA015: Total Dissolved Solids								
Total Dissolved Solids @180°C	GIS-210-010	10	mg/L	**10100**	----	----	----	----
EA065: Total Hardness as CaCO3								
Total Hardness as CaCO3	----	1	mg/L	**135**	----	----	----	----
ED009: Anions								
Bromide	24959-67-9	0.010	mg/L	**16.7**	----	----	----	----
Iodide	20461-54-5	0.010	mg/L	**1.29**	----	----	----	----
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	----	----	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	----	----	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	**2150**	----	----	----	----
Total Alkalinity as CaCO3	----	1	mg/L	**2150**	----	----	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	**22**	----	----	----	----
ED045G: Chloride Discrete analyser								
Chloride	16887-00-6	1	mg/L	**3710**	----	----	----	----
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	**41**	----	----	----	----
Magnesium	7439-95-4	1	mg/L	**8**	----	----	----	----
Sodium	7440-23-5	1	mg/L	**2810**	----	----	----	----
Potassium	7440-09-7	1	mg/L	**83**	----	----	----	----
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	**0.09**	----	----	----	----
Arsenic	7440-38-2	0.001	mg/L	**0.182**	----	----	----	----
Barium	7440-39-3	0.001	mg/L	**31.6**	----	----	----	----
Beryllium	7440-41-7	0.001	mg/L	<0.001	----	----	----	----
Cadmium	7440-43-9	0.0001	mg/L	**0.0001**	----	----	----	----
Cobalt	7440-48-4	0.001	mg/L	**0.006**	----	----	----	----
Chromium	7440-47-3	0.001	mg/L	<0.001	----	----	----	----
Copper	7440-50-8	0.001	mg/L	**0.061**	----	----	----	----

Analytical Results

Sub-Matrix: **WATER**

Compound	CAS Number	LOR	Unit	Client sample ID: Tindilpie Pad Pit Flowback frac pit water post flowback	----	----	----	----
				Client sampling date / time: 27-AUG-2012 06:15	----	----	----	----
				EM1209924-001	----	----	----	----
EG020F: Dissolved Metals by ICP-MS - Continued								
Manganese	7439-96-5	0.001	mg/L	**2.68**	----	----	----	----
Nickel	7440-02-0	0.001	mg/L	**0.028**	----	----	----	----
Lead	7439-92-1	0.001	mg/L	**0.088**	----	----	----	----
Vanadium	7440-62-2	0.01	mg/L	**0.02**	----	----	----	----
Zinc	7440-66-6	0.005	mg/L	**0.052**	----	----	----	----
Lithium	7439-93-2	0.001	mg/L	**2.58**	----	----	----	----
Molybdenum	7439-98-7	0.001	mg/L	**0.020**	----	----	----	----
Selenium	7782-49-2	0.01	mg/L	<0.01	----	----	----	----
Strontium	7440-24-6	0.001	mg/L	**1.70**	----	----	----	----
Tin	7440-31-5	0.001	mg/L	<0.001	----	----	----	----
Uranium	7440-61-1	0.001	mg/L	<0.001	----	----	----	----
Boron	7440-42-8	0.05	mg/L	**57.9**	----	----	----	----
Iron	7439-89-6	0.05	mg/L	**15.6**	----	----	----	----
EG035F: Dissolved Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	**0.0005**	----	----	----	----
EG052F: Dissolved Silica by ICPAES								
Silica	7631-86-9	0.1	mg/L	**12.6**	----	----	----	----
EK011: Chlorine - Free								
Free Chlorine	----	0.02	mg/L	**0.30**	----	----	----	----
EK025G: Free cyanide by Discrete Analyser								
Free Cyanide	----	0.004	mg/L	<0.004	----	----	----	----
EK026G: Total Cyanide By Discrete Analyser								
Total Cyanide	57-12-5	0.004	mg/L	<0.004	----	----	----	----
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	**1.8**	----	----	----	----
EK055G: Ammonia as N by Discrete Analyser								
Ammonia as N	7664-41-7	0.01	mg/L	**55.4**	----	----	----	----
EK057G: Nitrite as N by Discrete Analyser								
Nitrite as N	----	0.01	mg/L	**0.05**	----	----	----	----
EK058G: Nitrate as N by Discrete Analyser								
Nitrate as N	14797-55-8	0.01	mg/L	<0.01	----	----	----	----
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								

Analytical Results

Sub-Matrix: **WATER**

Compound	CAS Number	LOR	Unit	Client sample ID: Tindilpie Pad Pit Flowback frac pit water post flowback	----	----	----	----
				Client sampling date / time: 27-AUG-2012 06:15	----	----	----	----
				EM1209924-001	----	----	----	----
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser - Continued								
Nitrite + Nitrate as N	----	0.01	mg/L	<0.01	----	----	----	----
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser								
Total Kjeldahl Nitrogen as N	----	0.1	mg/L	**166**	----	----	----	----
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser								
^ Total Nitrogen as N	----	0.1	mg/L	**166**	----	----	----	----
EK067G: Total Phosphorus as P by Discrete Analyser								
Total Phosphorus as P	----	0.01	mg/L	**2.22**	----	----	----	----
EK071G: Reactive Phosphorus as P by discrete analyser								
Reactive Phosphorus as P	----	0.01	mg/L	**0.09**	----	----	----	----
EN055: Ionic Balance								
Total Anions	----	0.01	meq/L	**148**	----	----	----	----
Total Cations	----	0.01	meq/L	**127**	----	----	----	----
Ionic Balance	----	0.01	%	**7.67**	----	----	----	----
EP005: Total Organic Carbon (TOC)								
Total Organic Carbon	----	1	mg/L	**1320**	----	----	----	----
EP010: Formaldehyde								
Formaldehyde	50-00-0	0.1	mg/L	**2.9**	----	----	----	----
EP041A: Nonionic Surfactants								
Nonionic Surfactants as CTAS	----	5	mg/L	<5	----	----	----	----
EP050: Anionic Surfactants as MBAS								
Anionic Surfactants as MBAS	----	0.1	mg/L	**0.1**	----	----	----	----
EP074A: Monocyclic Aromatic Hydrocarbons								
Benzene	71-43-2	1	µg/L	**848**	----	----	----	----
Toluene	108-88-3	2	µg/L	**5320**	----	----	----	----
Ethylbenzene	100-41-4	2	µg/L	**533**	----	----	----	----
meta- & para-Xylene	108-38-3 106-42-3	2	µg/L	**7210**	----	----	----	----
Styrene	100-42-5	5	µg/L	<100	----	----	----	----
ortho-Xylene	95-47-6	2	µg/L	**1350**	----	----	----	----
Isopropylbenzene	98-82-8	5	µg/L	**118**	----	----	----	----
n-Propylbenzene	103-65-1	5	µg/L	**628**	----	----	----	----
1.3.5-Trimethylbenzene	108-67-8	5	µg/L	**1760**	----	----	----	----
sec-Butylbenzene	135-98-8	5	µg/L	<100	----	----	----	----

Analytical Results

Sub-Matrix: **WATER**

Compound	CAS Number	LOR	Unit	Client sample ID: Tindilpie Pad Pit Flowback frac pit water post flowback	----	----	----	----
			Client sampling date / time	27-AUG-2012 06:15	----	----	----	----
				EM1209924-001	**----**	**----**	**----**	**----**
EP074A: Monocyclic Aromatic Hydrocarbons - Continued								
1.2.4-Trimethylbenzene	95-63-6	5	µg/L	**2550**	----	----	----	----
tert-Butylbenzene	98-06-6	5	µg/L	<100	----	----	----	----
p-Isopropyltoluene	99-87-6	5	µg/L	**2680**	----	----	----	----
n-Butylbenzene	104-51-8	5	µg/L	**199**	----	----	----	----
EP074B: Oxygenated Compounds								
Vinyl Acetate	108-05-4	50	µg/L	<1000	----	----	----	----
2-Butanone (MEK)	78-93-3	50	µg/L	<1000	----	----	----	----
4-Methyl-2-pentanone (MIBK)	108-10-1	50	µg/L	<1000	----	----	----	----
2-Hexanone (MBK)	591-78-6	50	µg/L	<1000	----	----	----	----
EP074C: Sulfonated Compounds								
Carbon disulfide	75-15-0	5	µg/L	<100	----	----	----	----
EP074D: Fumigants								
2.2-Dichloropropane	594-20-7	5	µg/L	<100	----	----	----	----
1.2-Dichloropropane	78-87-5	5	µg/L	<100	----	----	----	----
cis-1.3-Dichloropropylene	10061-01-5	5	µg/L	<100	----	----	----	----
trans-1.3-Dichloropropylene	10061-02-6	5	µg/L	<100	----	----	----	----
1.2-Dibromoethane (EDB)	106-93-4	5	µg/L	<100	----	----	----	----
EP074E: Halogenated Aliphatic Compounds								
Dichlorodifluoromethane	75-71-8	50	µg/L	<1000	----	----	----	----
Chloromethane	74-87-3	50	µg/L	<1000	----	----	----	----
Vinyl chloride	75-01-4	50	µg/L	<1000	----	----	----	----
Bromomethane	74-83-9	50	µg/L	<1000	----	----	----	----
Chloroethane	75-00-3	50	µg/L	<1000	----	----	----	----
Trichlorofluoromethane	75-69-4	50	µg/L	<1000	----	----	----	----
1.1-Dichloroethene	75-35-4	5	µg/L	<100	----	----	----	----
Iodomethane	74-88-4	5	µg/L	<100	----	----	----	----
trans-1.2-Dichloroethene	156-60-5	5	µg/L	<100	----	----	----	----
1.1-Dichloroethane	75-34-3	5	µg/L	<100	----	----	----	----
cis-1.2-Dichloroethene	156-59-2	5	µg/L	<100	----	----	----	----
1.1.1-Trichloroethane	71-55-6	5	µg/L	<100	----	----	----	----
1.1-Dichloropropylene	563-58-6	5	µg/L	<100	----	----	----	----
Carbon Tetrachloride	56-23-5	5	µg/L	<100	----	----	----	----
1.2-Dichloroethane	107-06-2	5	µg/L	<100	----	----	----	----

Analytical Results

Sub-Matrix: **WATER**

Compound	CAS Number	LOR	Unit	Client sample ID: Tindilpie Pad Pit Flowback frac pit water post flowback	----	----	----	----
				Client sampling date / time: 27-AUG-2012 06:15	----	----	----	----
				EM1209924-001	**----**	**----**	**----**	**----**
EP074E: Halogenated Aliphatic Compounds - Continued								
Trichloroethene	79-01-6	5	µg/L	<100	----	----	----	----
Dibromomethane	74-95-3	5	µg/L	<100	----	----	----	----
1.1.2-Trichloroethane	79-00-5	5	µg/L	<100	----	----	----	----
1.3-Dichloropropane	142-28-9	5	µg/L	<100	----	----	----	----
Tetrachloroethene	127-18-4	5	µg/L	<100	----	----	----	----
1.1.1.2-Tetrachloroethane	630-20-6	5	µg/L	<100	----	----	----	----
trans-1.4-Dichloro-2-butene	110-57-6	5	µg/L	<100	----	----	----	----
cis-1.4-Dichloro-2-butene	1476-11-5	5	µg/L	<100	----	----	----	----
1.1.2.2-Tetrachloroethane	79-34-5	5	µg/L	<100	----	----	----	----
1.2.3-Trichloropropane	96-18-4	5	µg/L	<100	----	----	----	----
Pentachloroethane	76-01-7	5	µg/L	<100	----	----	----	----
1.2-Dibromo-3-chloropropane	96-12-8	5	µg/L	<100	----	----	----	----
EP074F: Halogenated Aromatic Compounds								
Chlorobenzene	108-90-7	5	µg/L	<100	----	----	----	----
Bromobenzene	108-86-1	5	µg/L	<100	----	----	----	----
2-Chlorotoluene	95-49-8	5	µg/L	<100	----	----	----	----
4-Chlorotoluene	106-43-4	5	µg/L	<100	----	----	----	----
1.2.3-Trichlorobenzene	87-61-6	5	µg/L	<100	----	----	----	----
EP074G: Trihalomethanes								
Chloroform	67-66-3	5	µg/L	<100	----	----	----	----
Bromodichloromethane	75-27-4	5	µg/L	<100	----	----	----	----
Dibromochloromethane	124-48-1	5	µg/L	<100	----	----	----	----
Bromoform	75-25-2	5	µg/L	<100	----	----	----	----
EP075A: Phenolic Compounds								
Phenol	108-95-2	2	µg/L	**418**	----	----	----	----
2-Chlorophenol	95-57-8	2	µg/L	<10	----	----	----	----
2-Methylphenol	95-48-7	2	µg/L	**503**	----	----	----	----
3- & 4-Methylphenol	1319-77-3	4	µg/L	**354**	----	----	----	----
2-Nitrophenol	88-75-5	2	µg/L	<10	----	----	----	----
2.4-Dimethylphenol	105-67-9	2	µg/L	**337**	----	----	----	----
2.4-Dichlorophenol	120-83-2	2	µg/L	<10	----	----	----	----
2.6-Dichlorophenol	87-65-0	2	µg/L	<10	----	----	----	----
4-Chloro-3-Methylphenol	59-50-7	2	µg/L	<10	----	----	----	----

Analytical Results

Sub-Matrix: **WATER**

Compound	CAS Number	LOR	Unit	Client sample ID: Tindilpie Pad Pit Flowback frac pit water post flowback	----	----	----	----
				Client sampling date / time: 27-AUG-2012 06:15	----	----	----	----
				EM1209924-001	----	----	----	----
EP075A: Phenolic Compounds - Continued								
2.4.6-Trichlorophenol	88-06-2	2	µg/L	<10	----	----	----	----
2.4.5-Trichlorophenol	95-95-4	2	µg/L	<10	----	----	----	----
Pentachlorophenol	87-86-5	4	µg/L	<20	----	----	----	----
EP075B: Polynuclear Aromatic Hydrocarbons								
Naphthalene	91-20-3	2	µg/L	**156**	----	----	----	----
2-Methylnaphthalene	91-57-6	2	µg/L	**330**	----	----	----	----
2-Chloronaphthalene	91-58-7	2	µg/L	<10	----	----	----	----
Acenaphthylene	208-96-8	2	µg/L	<10	----	----	----	----
Acenaphthene	83-32-9	2	µg/L	<10	----	----	----	----
Fluorene	86-73-7	2	µg/L	**14**	----	----	----	----
Phenanthrene	85-01-8	2	µg/L	**32**	----	----	----	----
Anthracene	120-12-7	2	µg/L	<10	----	----	----	----
Fluoranthene	206-44-0	2	µg/L	<10	----	----	----	----
Pyrene	129-00-0	2	µg/L	<10	----	----	----	----
N-2-Fluorenyl Acetamide	53-96-3	2	µg/L	<10	----	----	----	----
Benz(a)anthracene	56-55-3	2	µg/L	<10	----	----	----	----
Chrysene	218-01-9	2	µg/L	<10	----	----	----	----
Benzo(b) & Benzo(k)fluoranthene	205-99-2 207-08-9	4	µg/L	<20	----	----	----	----
7.12-Dimethylbenz(a)anthracene	57-97-6	2	µg/L	<10	----	----	----	----
Benzo(a)pyrene	50-32-8	2	µg/L	<10	----	----	----	----
3-Methylcholanthrene	56-49-5	2	µg/L	<10	----	----	----	----
Indeno(1.2.3.cd)pyrene	193-39-5	2	µg/L	<10	----	----	----	----
Dibenz(a.h)anthracene	53-70-3	2	µg/L	<10	----	----	----	----
Benzo(g.h.i)perylene	191-24-2	2	µg/L	<10	----	----	----	----
^ **Sum of PAHs**	----	2	µg/L	**202**	----	----	----	----
^ **Benzo(a)pyrene TEQ (WHO)**	----	2	µg/L	<10	----	----	----	----
EP075C: Phthalate Esters								
Dimethyl phthalate	131-11-3	2	µg/L	<10	----	----	----	----
Diethyl phthalate	84-66-2	2	µg/L	<10	----	----	----	----
Di-n-butyl phthalate	84-74-2	2	µg/L	<10	----	----	----	----
Butyl benzyl phthalate	85-68-7	2	µg/L	<10	----	----	----	----
bis(2-ethylhexyl) phthalate	117-81-7	10	µg/L	<50	----	----	----	----
Di-n-octylphthalate	117-84-0	2	µg/L	<10	----	----	----	----

Analytical Results

Sub-Matrix: **WATER**

Compound	CAS Number	LOR	Unit	Client sample ID: Tindilpie Pad Pit Flowback frac pit water post flowback	----	----	----	----
				Client sampling date / time: 27-AUG-2012 06:15	----	----	----	----
				EM1209924-001	----	----	----	----
EP075C: Phthalate Esters - Continued								
EP075D: Nitrosamines								
N-Nitrosomethylethylamine	10595-95-6	2	µg/L	<10	----	----	----	----
N-Nitrosodiethylamine	55-18-5	2	µg/L	<10	----	----	----	----
N-Nitrosopyrrolidine	930-55-2	4	µg/L	<20	----	----	----	----
N-Nitrosomorpholine	59-89-2	2	µg/L	<10	----	----	----	----
N-Nitrosodi-n-propylamine	621-64-7	2	µg/L	<10	----	----	----	----
N-Nitrosopiperidine	100-75-4	2	µg/L	<10	----	----	----	----
N-Nitrosodibutylamine	924-16-3	2	µg/L	<10	----	----	----	----
N-Nitrosodiphenyl & Diphenylamine	86-30-6 122-39-4	4	µg/L	<20	----	----	----	----
Methapyrilene	91-80-5	2	µg/L	<10	----	----	----	----
EP075E: Nitroaromatics and Ketones								
2-Picoline	109-06-8	2	µg/L	<10	----	----	----	----
Acetophenone	98-86-2	2	µg/L	<10	----	----	----	----
Nitrobenzene	98-95-3	2	µg/L	<10	----	----	----	----
Isophorone	78-59-1	2	µg/L	<10	----	----	----	----
2.6-Dinitrotoluene	606-20-2	4	µg/L	<20	----	----	----	----
2.4-Dinitrotoluene	121-14-2	4	µg/L	<20	----	----	----	----
1-Naphthylamine	134-32-7	2	µg/L	<10	----	----	----	----
4-Nitroquinoline-N-oxide	56-57-5	2	µg/L	<10	----	----	----	----
5-Nitro-o-toluidine	99-55-8	2	µg/L	<10	----	----	----	----
Azobenzene	103-33-3	2	µg/L	<10	----	----	----	----
1.3.5-Trinitrobenzene	99-35-4	2	µg/L	<10	----	----	----	----
Phenacetin	62-44-2	2	µg/L	<10	----	----	----	----
4-Aminobiphenyl	92-67-1	2	µg/L	<10	----	----	----	----
Pentachloronitrobenzene	82-68-8	2	µg/L	<10	----	----	----	----
Pronamide	23950-58-5	2	µg/L	<10	----	----	----	----
Dimethylaminoazobenzene	60-11-7	2	µg/L	<10	----	----	----	----
Chlorobenzilate	510-15-6	2	µg/L	<10	----	----	----	----
EP075F: Haloethers								
Bis(2-chloroethyl) ether	111-44-4	2	µg/L	<10	----	----	----	----
Bis(2-chloroethoxy) methane	111-91-1	2	µg/L	<10	----	----	----	----
4-Chlorophenyl phenyl ether	7005-72-3	2	µg/L	<10	----	----	----	----

Analytical Results

Sub-Matrix: **WATER**

Compound	CAS Number	LOR	Unit	Client sample ID: Tindilpie Pad Pit Flowback frac pit water post flowback	----	----	----	----
				Client sampling date / time: 27-AUG-2012 06:15	----	----	----	----
				EM1209924-001	----	----	----	----
EP075F: Haloethers - Continued								
4-Bromophenyl phenyl ether	101-55-3	2	µg/L	<10	----	----	----	----
EP075G: Chlorinated Hydrocarbons								
1.3-Dichlorobenzene	541-73-1	2	µg/L	<10	----	----	----	----
1.4-Dichlorobenzene	106-46-7	2	µg/L	<10	----	----	----	----
1.2-Dichlorobenzene	95-50-1	2	µg/L	<10	----	----	----	----
Hexachloroethane	67-72-1	2	µg/L	<10	----	----	----	----
1.2.4-Trichlorobenzene	120-82-1	2	µg/L	<10	----	----	----	----
Hexachloropropylene	1888-71-7	2	µg/L	<10	----	----	----	----
Hexachlorobutadiene	87-68-3	2	µg/L	<10	----	----	----	----
Hexachlorocyclopentadiene	77-47-4	10	µg/L	<50	----	----	----	----
Pentachlorobenzene	608-93-5	2	µg/L	<10	----	----	----	----
Hexachlorobenzene (HCB)	118-74-1	4	µg/L	<20	----	----	----	----
EP075H: Anilines and Benzidines								
Aniline	62-53-3	2	µg/L	<10	----	----	----	----
4-Chloroaniline	106-47-8	2	µg/L	<10	----	----	----	----
2-Nitroaniline	88-74-4	4	µg/L	<20	----	----	----	----
3-Nitroaniline	99-09-2	4	µg/L	<20	----	----	----	----
Dibenzofuran	132-64-9	2	µg/L	<10	----	----	----	----
4-Nitroaniline	100-01-6	2	µg/L	<10	----	----	----	----
Carbazole	86-74-8	2	µg/L	<10	----	----	----	----
3.3`-Dichlorobenzidine	91-94-1	2	µg/L	<10	----	----	----	----
EP075I: Organochlorine Pesticides								
alpha-BHC	319-84-6	2	µg/L	<10	----	----	----	----
beta-BHC	319-85-7	2	µg/L	<10	----	----	----	----
gamma-BHC	58-89-9	2	µg/L	<10	----	----	----	----
delta-BHC	319-86-8	2	µg/L	<10	----	----	----	----
Heptachlor	76-44-8	2	µg/L	<10	----	----	----	----
Aldrin	309-00-2	2	µg/L	<10	----	----	----	----
Heptachlor epoxide	1024-57-3	2	µg/L	<10	----	----	----	----
alpha-Endosulfan	959-98-8	2	µg/L	<10	----	----	----	----
4.4`-DDE	72-55-9	2	µg/L	<10	----	----	----	----
Dieldrin	60-57-1	2	µg/L	<10	----	----	----	----
Endrin	72-20-8	2	µg/L	<10	----	----	----	----

Analytical Results

Sub-Matrix: **WATER**

Compound	CAS Number	LOR	Unit	Client sample ID: Tindilpie Pad Pit Flowback frac pit water post flowback	----	----	----	----
				Client sampling date / time: 27-AUG-2012 06:15	----	----	----	----
				EM1209924-001	----	----	----	----
EP075I: Organochlorine Pesticides - Continued								
beta-Endosulfan	33213-65-9	2	µg/L	<10	----	----	----	----
4.4`-DDD	72-54-8	2	µg/L	<10	----	----	----	----
Endosulfan sulfate	1031-07-8	2	µg/L	<10	----	----	----	----
4.4`-DDT	50-29-3	4	µg/L	<20	----	----	----	----
^ **Sum of Aldrin + Dieldrin**	309-00-2/60-57-1	4	µg/L	<20	----	----	----	----
^ **Sum of DDD + DDE + DDT**	----	4	µg/L	<20	----	----	----	----
EP075J: Organophosphorus Pesticides								
Dichlorvos	62-73-7	2	µg/L	<10	----	----	----	----
Dimethoate	60-51-5	2	µg/L	<10	----	----	----	----
Diazinon	333-41-5	2	µg/L	<10	----	----	----	----
Chlorpyrifos-methyl	5598-13-0	2	µg/L	<10	----	----	----	----
Malathion	121-75-5	2	µg/L	<10	----	----	----	----
Fenthion	55-38-9	2	µg/L	<10	----	----	----	----
Chlorpyrifos	2921-88-2	2	µg/L	<10	----	----	----	----
Pirimphos-ethyl	23505-41-1	2	µg/L	<10	----	----	----	----
Chlorfenvinphos	470-90-6	2	µg/L	<10	----	----	----	----
Prothiofos	34643-46-4	2	µg/L	<10	----	----	----	----
Ethion	563-12-2	2	µg/L	<10	----	----	----	----
EP117: Alcohols								
Ethanol	64-17-5	50	µg/L	**1360**	----	----	----	----
Isopropanol	67-63-0	50	µg/L	**2840**	----	----	----	----
n-Propanol	71-23-8	50	µg/L	**22800**	----	----	----	----
Isobutanol	78-83-1	50	µg/L	<250	----	----	----	----
n-Butanol	71-36-3	50	µg/L	<250	----	----	----	----
RIVM Aliphatic Hydrocarbon Fractions								
Aliphatic >C5-C6	----	20	µg/L	**3440**	----	----	----	----
Aliphatic >C6-C8	TPHCWG-ALV2	20	µg/L	**24100**	----	----	----	----
Aliphatic >C8-C10	TPHCWG-ALV3	20	µg/L	**47400**	----	----	----	----
Aliphatic >C10-C12	TPHCWG-ALE1	50	µg/L	**5180**	----	----	----	----
Aliphatic >C12-C16	TPHCWG-ALE2	50	µg/L	**12500**	----	----	----	----
Aliphatic >C16-C21	----	50	µg/L	**11600**	----	----	----	----
Aliphatic >C21-C35	----	50	µg/L	**4750**	----	----	----	----
RIVM Aromatic Hydrocarbon Fractions								

Analytical Results

Sub-Matrix: WATER				Client sample ID	Tindilpie Pad Pit Flowback frac pit water post flowback	----	----	----	----
				Client sampling date / time	27-AUG-2012 06:15	----	----	----	----
Compound	CAS Number	LOR	Unit		EM1209924-001	----	----	----	----
RIVM Aromatic Hydrocarbon Fractions - Continued									
Aromatic >C5-C7	----	5	µg/L		**837**	----	----	----	----
Aromatic >C7-C8	TPHCWG-ARV2	5	µg/L		**4420**	----	----	----	----
Aromatic >C8-C10	TPHCWG-ARV3	5	µg/L		**10100**	----	----	----	----
Aromatic >C10-C12	TPHCWG-ARE1	50	µg/L		**4100**	----	----	----	----
Aromatic >C12-C16	TPHCWG-ARE2	50	µg/L		**3660**	----	----	----	----
Aromatic >C16-C21	TPHCWG-ARE3	50	µg/L		**2780**	----	----	----	----
Aromatic >C21-C35	TPHCWG-ARE4	50	µg/L		**640**	----	----	----	----
EP074S: VOC Surrogates									
1.2-Dichloroethane-D4	17060-07-0	0.1	%		**92.0**	----	----	----	----
Toluene-D8	2037-26-5	0.1	%		**108**	----	----	----	----
4-Bromofluorobenzene	460-00-4	0.1	%		**104**	----	----	----	----
EP075S: Acid Extractable Surrogates									
2-Fluorophenol	367-12-4	0.1	%		**Not Determined**	----	----	----	----
Phenol-d6	13127-88-3	0.1	%		**Not Determined**	----	----	----	----
2-Chlorophenol-D4	93951-73-6	0.1	%		**Not Determined**	----	----	----	----
2.4.6-Tribromophenol	118-79-6	0.1	%		**Not Determined**	----	----	----	----
EP075T: Base/Neutral Extractable Surrogates									
Nitrobenzene-D5	4165-60-0	0.1	%		**Not Determined**	----	----	----	----
1.2-Dichlorobenzene-D4	2199-69-1	0.1	%		**Not Determined**	----	----	----	----
2-Fluorobiphenyl	321-60-8	0.1	%		**Not Determined**	----	----	----	----
Anthracene-d10	1719-06-8	0.1	%		**Not Determined**	----	----	----	----
4-Terphenyl-d14	1718-51-0	0.1	%		**Not Determined**	----	----	----	----
EP079/EP070S:TPH Surrogates - semivolatile speciation									
2-Fluorobiphenyl	321-60-8	0.1	%		**104**	----	----	----	----
2-Bromonaphthalene	580-13-2	0.1	%		**111**	----	----	----	----

Surrogate Control Limits

Sub-Matrix: **WATER**		Recovery Limits (%)	
Compound	*CAS Number*	*Low*	*High*
EP074S: VOC Surrogates			
1.2-Dichloroethane-D4	17060-07-0	72	132
Toluene-D8	2037-26-5	74	128
4-Bromofluorobenzene	460-00-4	70	132
EP075S: Acid Extractable Surrogates			
2-Fluorophenol	367-12-4	10	83
Phenol-d6	13127-88-3	10	49
2-Chlorophenol-D4	93951-73-6	20.3	101
2.4.6-Tribromophenol	118-79-6	19.5	134
EP075T: Base/Neutral Extractable Surrogates			
Nitrobenzene-D5	4165-60-0	18.2	114
1.2-Dichlorobenzene-D4	2199-69-1	18.8	100
2-Fluorobiphenyl	321-60-8	25.3	122
Anthracene-d10	1719-06-8	35	137
4-Terphenyl-d14	1718-51-0	32	136
EP079/EP070S:TPH Surrogates - semivolatile speciation			
2-Fluorobiphenyl	321-60-8	77	127
2-Bromonaphthalene	580-13-2	67	123

QUALITY CONTROL REPORT

Work Order	: **EM1209924**	Page	: 1 of 24
Amendment	: **1**		
Client	: **SANTOS LTD**	Laboratory	: Environmental Division Melbourne
Contact	: MR BARRY RITCHIE	Contact	: Jodie Hancock
Address	: GROUND FLOOR SANTOS CENTRE 60 FLINDERS STREET ADELAIDE SA, AUSTRALIA 5001	Address	: 4 Westall Rd Springvale VIC Australia 3171
E-mail	: barry.ritchie@santos.com	E-mail	: Jodie.Hancock@alsenviro.com
Telephone	: +61 08 8116 5000	Telephone	: +61 7 3243 7128
Facsimile	: +61 08 8116 5050	Facsimile	: +61 7 3243 7218
Project	: HFRA Fluids Sampling - Extended Analysis	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Site	: ----		
C-O-C number	: ----	Date Samples Received	: 28-AUG-2012
Sampler	: BC/AJ	Issue Date	: 12-SEP-2012
Order number	: 879002/538		
		No. of samples received	: 1
Quote number	: EN/039/11	No. of samples analysed	: 1

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Method Blank (MB) and Laboratory Control Spike (LCS) Report; Recovery and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits

NATA Accredited Laboratory 825

Accredited for compliance with ISO/IEC 17025.

Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Dilani Fernando	Senior Inorganic Chemist	Melbourne Inorganics
Eric Chau	Metals Team Leader	Melbourne Inorganics
Hoa Nguyen	Inorganic Chemist	Sydney Inorganics
Pabi Subba	Senior Organic Chemist	Sydney Organics
Sarah Millington	Senior Inorganic Chemist	Sydney Inorganics
Varsha Ho Wing	Non-Metals Team Leader	Melbourne Inorganics
Xingbin Lin	Senior Organic Chemist	Melbourne Organics

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

Key : Anonymous = Refers to samples which are not specifically part of this work order but formed part of the QC process lot
CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
RPD = Relative Percentage Difference
# = Indicates failed QC

Laboratory Duplicate (DUP) Report

The quality control term Laboratory Duplicate refers to a randomly selected intralaboratory split. Laboratory duplicates provide information regarding method precision and sample heterogeneity. The permitted ranges for the Relative Percent Deviation (RPD) of Laboratory Duplicates are specified in ALS Method QWI-EN/38 and are dependent on the magnitude of results in comparison to the level of reporting: Result < 10 times LOR:- No Limit; Result between 10 and 20 times LOR:- 0% - 50%; Result > 20 times LOR:- 0% - 20%.

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
EA005: pH (QC Lot: 2476913)									
EM1209924-001	Tindilpie Pad Pit Flowback frac pit water post flowback	EA005: pH Value	----	0.01	pH Unit	7.46	7.48	0.3	0% - 20%
EM1209984-003	Anonymous	EA005: pH Value	----	0.01	pH Unit	6.55	6.57	0.3	0% - 20%
EA015: Total Dissolved Solids (QC Lot: 2474076)									
EM1209916-012	Anonymous	EA015H: Total Dissolved Solids @180°C	GIS-210-010	10	mg/L	2350	2380	1.3	0% - 20%
EM1209947-004	Anonymous	EA015H: Total Dissolved Solids @180°C	GIS-210-010	10	mg/L	4790	4850	1.2	0% - 20%
ED009: Anions (QC Lot: 2476447)									
EM1209913-001	Anonymous	ED009-X: Bromide	24959-67-9	0.010	mg/L	16.0	15.6	2.0	0% - 20%
		ED009-X: Iodide	20461-54-5	0.010	mg/L	<0.050	<0.050	0.0	No Limit
ED037P: Alkalinity by PC Titrator (QC Lot: 2475151)									
EM1209916-011	Anonymous	ED037-P: Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	<1	<1	0.0	No Limit
EM1209937-001	Anonymous	ED037-P: Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	103	104	0.0	0% - 20%
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	103	104	0.0	0% - 20%
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA (QC Lot: 2473892)									
EM1209916-010	Anonymous	ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	1	<1	0.0	No Limit
EM1209924-001	Tindilpie Pad Pit Flowback frac pit water post flowback	ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	22	20	9.6	0% - 20%
ED045G: Chloride Discrete analyser (QC Lot: 2473894)									
EM1209916-010	Anonymous	ED045G: Chloride	16887-00-6	1	mg/L	48	48	0.0	0% - 20%
ED093F: Dissolved Major Cations (QC Lot: 2473893)									
EM1209916-010	Anonymous	ED093F: Calcium	7440-70-2	1	mg/L	24	27	11.6	0% - 20%
		ED093F: Magnesium	7439-95-4	1	mg/L	18	19	0.0	0% - 50%
		ED093F: Sodium	7440-23-5	1	mg/L	29	29	0.0	0% - 20%
		ED093F: Potassium	7440-09-7	1	mg/L	2	2	0.0	No Limit
EG020F: Dissolved Metals by ICP-MS (QC Lot: 2476712)									
EM1209762-001	Anonymous	EG020A-F: Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	0.0	No Limit
		EG020A-F: Arsenic	7440-38-2	0.001	mg/L	0.004	0.003	29.9	No Limit
		EG020A-F: Beryllium	7440-41-7	0.001	mg/L	<0.001	<0.001	0.0	No Limit

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
EG020F: Dissolved Metals by ICP-MS (QC Lot: 2476712) - continued									
EM1209762-001	Anonymous	EG020A-F: Barium	7440-39-3	0.001	mg/L	0.109	0.106	2.3	0% - 20%
		EG020A-F: Chromium	7440-47-3	0.001	mg/L	0.035	0.036	3.5	0% - 20%
		EG020A-F: Cobalt	7440-48-4	0.001	mg/L	0.022	0.022	0.0	0% - 20%
		EG020A-F: Copper	7440-50-8	0.001	mg/L	0.006	0.006	0.0	No Limit
		EG020A-F: Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-F: Manganese	7439-96-5	0.001	mg/L	0.745	0.733	1.6	0% - 20%
		EG020A-F: Molybdenum	7439-98-7	0.001	mg/L	0.002	0.002	0.0	No Limit
		EG020A-F: Nickel	7440-02-0	0.001	mg/L	0.183	0.191	4.3	0% - 20%
		EG020A-F: Tin	7440-31-5	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-F: Zinc	7440-66-6	0.005	mg/L	0.029	0.027	7.9	No Limit
		EG020A-F: Aluminium	7429-90-5	0.01	mg/L	0.05	0.03	55.6	No Limit
		EG020A-F: Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	0.0	No Limit
		EG020A-F: Vanadium	7440-62-2	0.01	mg/L	0.04	0.04	0.0	No Limit
		EG020A-F: Boron	7440-42-8	0.05	mg/L	4.66	4.97	6.5	0% - 20%
EM1209762-021	Anonymous	EG020A-F: Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	0.0	No Limit
		EG020A-F: Arsenic	7440-38-2	0.001	mg/L	0.002	0.002	0.0	No Limit
		EG020A-F: Beryllium	7440-41-7	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-F: Barium	7440-39-3	0.001	mg/L	0.098	0.098	0.0	0% - 20%
		EG020A-F: Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-F: Cobalt	7440-48-4	0.001	mg/L	0.032	0.032	0.0	0% - 20%
		EG020A-F: Copper	7440-50-8	0.001	mg/L	0.005	0.005	0.0	No Limit
		EG020A-F: Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-F: Lithium	7439-93-2	0.001	mg/L	0.029	0.030	4.8	0% - 20%
		EG020A-F: Manganese	7439-96-5	0.001	mg/L	1.82	1.87	2.8	0% - 20%
		EG020A-F: Molybdenum	7439-98-7	0.001	mg/L	0.007	0.007	0.0	No Limit
		EG020A-F: Nickel	7440-02-0	0.001	mg/L	0.198	0.202	2.4	0% - 20%
		EG020A-F: Tin	7440-31-5	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-F: Zinc	7440-66-6	0.005	mg/L	0.018	0.019	0.0	No Limit
		EG020A-F: Aluminium	7429-90-5	0.01	mg/L	0.01	0.01	0.0	No Limit
		EG020A-F: Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	0.0	No Limit
		EG020A-F: Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	0.0	No Limit
		EG020A-F: Boron	7440-42-8	0.05	mg/L	5.69	5.46	4.2	0% - 20%
		EG020A-F: Iron	7439-89-6	0.05	mg/L	1.57	1.57	0.0	0% - 20%
EG020F: Dissolved Metals by ICP-MS (QC Lot: 2476713)									
EM1209762-021	Anonymous	EG020B-F: Strontium	7440-24-6	0.001	mg/L	2.96	2.99	1.0	0% - 20%
		EG020B-F: Uranium	7440-61-1	0.001	mg/L	0.008	0.008	0.0	No Limit
EG035F: Dissolved Mercury by FIMS (QC Lot: 2476711)									
EM1209762-001	Anonymous	EG035F: Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	0.0	No Limit
EM1209762-021	Anonymous	EG035F: Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	0.0	No Limit

Sub-Matrix: **WATER**

Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Laboratory Duplicate (DUP) Report					
				LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
EK025G: Free cyanide by Discrete Analyser (QC Lot: 2474592)									
EM1209920-001	Anonymous	EK025SF: Free Cyanide	----	0.004	mg/L	<0.004	<0.004	0.0	No Limit
EK026G: Total Cyanide By Discrete Analyser (QC Lot: 2474599)									
EM1209913-001	Anonymous	EK026SF: Total Cyanide	57-12-5	0.004	mg/L	0.140	0.120	15.8	0% - 20%
EK040P: Fluoride by PC Titrator (QC Lot: 2475152)									
EM1209916-011	Anonymous	EK040P: Fluoride	16984-48-8	0.1	mg/L	<0.1	0.2	0.0	No Limit
EM1209945-003	Anonymous	EK040P: Fluoride	16984-48-8	0.1	mg/L	0.1	0.1	0.0	No Limit
EK055G: Ammonia as N by Discrete Analyser (QC Lot: 2475171)									
EM1209914-001	Anonymous	EK055G: Ammonia as N	7664-41-7	0.01	mg/L	0.04	0.02	68.9	No Limit
EM1209916-006	Anonymous	EK055G: Ammonia as N	7664-41-7	0.01	mg/L	0.03	0.03	0.0	No Limit
EK057G: Nitrite as N by Discrete Analyser (QC Lot: 2473891)									
EM1209916-001	Anonymous	EK057G: Nitrite as N	----	0.01	mg/L	0.01	<0.01	0.0	No Limit
EM1209916-010	Anonymous	EK057G: Nitrite as N	----	0.01	mg/L	<0.01	<0.01	0.0	No Limit
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser (QC Lot: 2475172)									
EM1209924-001	Tindilpie Pad Pit Flowback frac pit water post flowback	EK059G: Nitrite + Nitrate as N	----	0.01	mg/L	<0.01	<0.01	0.0	No Limit
EM1209973-002	Anonymous	EK059G: Nitrite + Nitrate as N	----	0.01	mg/L	5.41	5.21	3.8	0% - 20%
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser (QC Lot: 2475438)									
EM1209916-011	Anonymous	EK061G: Total Kjeldahl Nitrogen as N	----	0.1	mg/L	2.9	2.4	19.8	0% - 20%
EM1210012-001	Anonymous	EK061G: Total Kjeldahl Nitrogen as N	----	0.1	mg/L	3.2	3.6	8.6	0% - 20%
EK067G: Total Phosphorus as P by Discrete Analyser (QC Lot: 2475439)									
EM1209916-011	Anonymous	EK067G: Total Phosphorus as P	----	0.01	mg/L	2.16	1.82	17.1	0% - 20%
EM1210012-001	Anonymous	EK067G: Total Phosphorus as P	----	0.01	mg/L	5.11	6.06	17.0	0% - 20%
EK071G: Reactive Phosphorus as P by discrete analyser (QC Lot: 2473890)									
EM1209913-001	Anonymous	EK071G: Reactive Phosphorus as P	----	0.01	mg/L	<0.01	<0.01	0.0	No Limit
EM1209916-010	Anonymous	EK071G: Reactive Phosphorus as P	----	0.01	mg/L	<0.01	<0.01	0.0	No Limit
EP005: Total Organic Carbon (TOC) (QC Lot: 2488012)									
EM1209762-020	Anonymous	EP005: Total Organic Carbon	----	1	mg/L	122	121	0.0	0% - 20%
EM1210086-001	Anonymous	EP005: Total Organic Carbon	----	1	mg/L	19	19	0.0	0% - 50%
EP010: Formaldehyde (QC Lot: 2473623)									
EM1209924-001	Tindilpie Pad Pit Flowback frac pit water post flowback	EP010: Formaldehyde	50-00-0	0.1	mg/L	2.9	2.9	0.0	0% - 20%
EP041A: Nonionic Surfactants (QC Lot: 2476292)									
EM1209924-001	Tindilpie Pad Pit Flowback frac pit water post flowback	EP041A: Nonionic Surfactants as CTAS	----	5	mg/L	<5	<5	0.0	No Limit
EP050: Anionic Surfactants as MBAS (QC Lot: 2475995)									

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
EP050: Anionic Surfactants as MBAS (QC Lot: 2475995) - continued									
EM1209924-001	Tindilpie Pad Pit Flowback frac pit water post flowback	EP050: Anionic Surfactants as MBAS		0.1	mg/L	0.1	0.1	0.0	No Limit
EP074A: Monocyclic Aromatic Hydrocarbons (QC Lot: 2485081)									
EM1210094-014	Anonymous	EP074: Benzene	71-43-2	1	µg/L	<1	<1	0.0	No Limit
		EP074: Toluene	108-88-3	2	µg/L	<2	<2	0.0	No Limit
		EP074: Ethylbenzene	100-41-4	2	µg/L	<2	<2	0.0	No Limit
		EP074: meta- & para-Xylene	108-38-3 106-42-3	2	µg/L	<2	<2	0.0	No Limit
		EP074: ortho-Xylene	95-47-6	2	µg/L	<2	<2	0.0	No Limit
		EP074: Styrene	100-42-5	5	µg/L	<5	<5	0.0	No Limit
		EP074: Isopropylbenzene	98-82-8	5	µg/L	<5	<5	0.0	No Limit
		EP074: n-Propylbenzene	103-65-1	5	µg/L	<5	<5	0.0	No Limit
		EP074: 1.3.5-Trimethylbenzene	108-67-8	5	µg/L	<5	<5	0.0	No Limit
		EP074: sec-Butylbenzene	135-98-8	5	µg/L	<5	<5	0.0	No Limit
		EP074: 1.2.4-Trimethylbenzene	95-63-6	5	µg/L	<5	<5	0.0	No Limit
		EP074: tert-Butylbenzene	98-06-6	5	µg/L	<5	<5	0.0	No Limit
		EP074: p-Isopropyltoluene	99-87-6	5	µg/L	<5	<5	0.0	No Limit
		EP074: n-Butylbenzene	104-51-8	5	µg/L	<5	<5	0.0	No Limit
EP074B: Oxygenated Compounds (QC Lot: 2485081)									
EM1210094-014	Anonymous	EP074: Vinyl Acetate	108-05-4	50	µg/L	<50	<50	0.0	No Limit
		EP074: 2-Butanone (MEK)	78-93-3	50	µg/L	<50	<50	0.0	No Limit
		EP074: 4-Methyl-2-pentanone (MIBK)	108-10-1	50	µg/L	<50	<50	0.0	No Limit
		EP074: 2-Hexanone (MBK)	591-78-6	50	µg/L	<50	<50	0.0	No Limit
EP074C: Sulfonated Compounds (QC Lot: 2485081)									
EM1210094-014	Anonymous	EP074: Carbon disulfide	75-15-0	5	µg/L	<5	<5	0.0	No Limit
EP074D: Fumigants (QC Lot: 2485081)									
EM1210094-014	Anonymous	EP074: 2.2-Dichloropropane	594-20-7	5	µg/L	<5	<5	0.0	No Limit
		EP074: 1.2-Dichloropropane	78-87-5	5	µg/L	<5	<5	0.0	No Limit
		EP074: cis-1.3-Dichloropropylene	10061-01-5	5	µg/L	<5	<5	0.0	No Limit
		EP074: trans-1.3-Dichloropropylene	10061-02-6	5	µg/L	<5	<5	0.0	No Limit
		EP074: 1.2-Dibromoethane (EDB)	106-93-4	5	µg/L	<5	<5	0.0	No Limit
EP074E: Halogenated Aliphatic Compounds (QC Lot: 2485081)									
EM1210094-014	Anonymous	EP074: 1.1-Dichloroethene	75-35-4	5	µg/L	<5	<5	0.0	No Limit
		EP074: Iodomethane	74-88-4	5	µg/L	<5	<5	0.0	No Limit
		EP074: trans-1.2-Dichloroethene	156-60-5	5	µg/L	<5	<5	0.0	No Limit
		EP074: 1.1-Dichloroethane	75-34-3	5	µg/L	<5	<5	0.0	No Limit
		EP074: cis-1.2-Dichloroethene	156-59-2	5	µg/L	<5	<5	0.0	No Limit
		EP074: 1.1.1-Trichloroethane	71-55-6	5	µg/L	<5	<5	0.0	No Limit

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
EP074E: Halogenated Aliphatic Compounds (QC Lot: 2485081) - continued									
EM1210094-014	Anonymous	EP074: 1.1-Dichloropropylene	563-58-6	5	µg/L	<5	<5	0.0	No Limit
		EP074: Carbon Tetrachloride	56-23-5	5	µg/L	<5	<5	0.0	No Limit
		EP074: 1.2-Dichloroethane	107-06-2	5	µg/L	<5	<5	0.0	No Limit
		EP074: Trichloroethene	79-01-6	5	µg/L	<5	<5	0.0	No Limit
		EP074: Dibromomethane	74-95-3	5	µg/L	<5	<5	0.0	No Limit
		EP074: 1.1.2-Trichloroethane	79-00-5	5	µg/L	<5	<5	0.0	No Limit
		EP074: 1.3-Dichloropropane	142-28-9	5	µg/L	<5	<5	0.0	No Limit
		EP074: Tetrachloroethene	127-18-4	5	µg/L	<5	<5	0.0	No Limit
		EP074: 1.1.1.2-Tetrachloroethane	630-20-6	5	µg/L	<5	<5	0.0	No Limit
		EP074: trans-1.4-Dichloro-2-butene	110-57-6	5	µg/L	<5	<5	0.0	No Limit
		EP074: cis-1.4-Dichloro-2-butene	1476-11-5	5	µg/L	<5	<5	0.0	No Limit
		EP074: 1.1.2.2-Tetrachloroethane	79-34-5	5	µg/L	<5	<5	0.0	No Limit
		EP074: 1.2.3-Trichloropropane	96-18-4	5	µg/L	<5	<5	0.0	No Limit
		EP074: Pentachloroethane	76-01-7	5	µg/L	<5	<5	0.0	No Limit
		EP074: 1.2-Dibromo-3-chloropropane	96-12-8	5	µg/L	<5	<5	0.0	No Limit
		EP074: Dichlorodifluoromethane	75-71-8	50	µg/L	<50	<50	0.0	No Limit
		EP074: Chloromethane	74-87-3	50	µg/L	<50	<50	0.0	No Limit
		EP074: Vinyl chloride	75-01-4	50	µg/L	<50	<50	0.0	No Limit
		EP074: Bromomethane	74-83-9	50	µg/L	<50	<50	0.0	No Limit
		EP074: Chloroethane	75-00-3	50	µg/L	<50	<50	0.0	No Limit
		EP074: Trichlorofluoromethane	75-69-4	50	µg/L	<50	<50	0.0	No Limit
EP074F: Halogenated Aromatic Compounds (QC Lot: 2485081)									
EM1210094-014	Anonymous	EP074: Chlorobenzene	108-90-7	5	µg/L	<5	<5	0.0	No Limit
		EP074: Bromobenzene	108-86-1	5	µg/L	<5	<5	0.0	No Limit
		EP074: 2-Chlorotoluene	95-49-8	5	µg/L	<5	<5	0.0	No Limit
		EP074: 4-Chlorotoluene	106-43-4	5	µg/L	<5	<5	0.0	No Limit
		EP074: 1.2.3-Trichlorobenzene	87-61-6	5	µg/L	<5	<5	0.0	No Limit
EP074G: Trihalomethanes (QC Lot: 2485081)									
EM1210094-014	Anonymous	EP074: Chloroform	67-66-3	5	µg/L	<5	<5	0.0	No Limit
		EP074: Bromodichloromethane	75-27-4	5	µg/L	<5	<5	0.0	No Limit
		EP074: Dibromochloromethane	124-48-1	5	µg/L	<5	<5	0.0	No Limit
		EP074: Bromoform	75-25-2	5	µg/L	<5	<5	0.0	No Limit
EP075A: Phenolic Compounds (QC Lot: 2474975)									
EM1209924-001	Tindilpie Pad Pit Flowback frac pit water post flowback	EP075: Phenol	108-95-2	2	µg/L	418	380	9.3	0% - 20%
		EP075: 2-Chlorophenol	95-57-8	2	µg/L	<10	<10	0.0	No Limit
		EP075: 2-Methylphenol	95-48-7	2	µg/L	503	519	3.2	0% - 20%
		EP075: 2-Nitrophenol	88-75-5	2	µg/L	<10	<10	0.0	No Limit

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
EP075A: Phenolic Compounds (QC Lot: 2474975) - continued									
EM1209924-001	Tindilpie Pad Pit Flowback frac pit water post flowback	EP075: 2.4-Dimethylphenol	105-67-9	2	µg/L	337	311	8.0	0% - 20%
		EP075: 2.4-Dichlorophenol	120-83-2	2	µg/L	<10	<10	0.0	No Limit
		EP075: 2.6-Dichlorophenol	87-65-0	2	µg/L	<10	<10	0.0	No Limit
		EP075: 4-Chloro-3-Methylphenol	59-50-7	2	µg/L	<10	<10	0.0	No Limit
		EP075: 2.4.6-Trichlorophenol	88-06-2	2	µg/L	<10	<10	0.0	No Limit
		EP075: 2.4.5-Trichlorophenol	95-95-4	2	µg/L	<10	<10	0.0	No Limit
		EP075: 3- & 4-Methylphenol	1319-77-3	4	µg/L	354	371	4.8	0% - 20%
		EP075: Pentachlorophenol	87-86-5	4	µg/L	<20	<20	0.0	No Limit
EP075B: Polynuclear Aromatic Hydrocarbons (QC Lot: 2474975)									
EM1209924-001	Tindilpie Pad Pit Flowback frac pit water post flowback	EP075: Naphthalene	91-20-3	2	µg/L	156	136	13.5	0% - 20%
		EP075: 2-Methylnaphthalene	91-57-6	2	µg/L	330	258	# 24.3	0% - 20%
		EP075: 2-Chloronaphthalene	91-58-7	2	µg/L	<10	<10	0.0	No Limit
		EP075: Acenaphthylene	208-96-8	2	µg/L	<10	<10	0.0	No Limit
		EP075: Acenaphthene	83-32-9	2	µg/L	<10	<10	0.0	No Limit
		EP075: Fluorene	86-73-7	2	µg/L	14	14	0.0	No Limit
		EP075: Phenanthrene	85-01-8	2	µg/L	32	27	16.4	0% - 50%
		EP075: Anthracene	120-12-7	2	µg/L	<10	<10	0.0	No Limit
		EP075: Fluoranthene	206-44-0	2	µg/L	<10	<10	0.0	No Limit
		EP075: Pyrene	129-00-0	2	µg/L	<10	<10	0.0	No Limit
		EP075: N-2-Fluorenyl Acetamide	53-96-3	2	µg/L	<10	<10	0.0	No Limit
		EP075: Benz(a)anthracene	56-55-3	2	µg/L	<10	<10	0.0	No Limit
		EP075: Chrysene	218-01-9	2	µg/L	<10	<10	0.0	No Limit
		EP075: 7.12-Dimethylbenz(a)anthracene	57-97-6	2	µg/L	<10	<10	0.0	No Limit
		EP075: Benzo(a)pyrene	50-32-8	2	µg/L	<10	<10	0.0	No Limit
		EP075: 3-Methylcholanthrene	56-49-5	2	µg/L	<10	<10	0.0	No Limit
		EP075: Indeno(1.2.3.cd)pyrene	193-39-5	2	µg/L	<10	<10	0.0	No Limit
		EP075: Dibenz(a.h)anthracene	53-70-3	2	µg/L	<10	<10	0.0	No Limit
		EP075: Benzo(g.h.i)perylene	191-24-2	2	µg/L	<10	<10	0.0	No Limit
		EP075: Sum of PAHs	----	2	µg/L	202	177	13.2	0% - 20%
		EP075: Benzo(b) & Benzo(k)fluoranthene	205-99-2 207-08-9	4	µg/L	<20	<20	0.0	No Limit
EP075C: Phthalate Esters (QC Lot: 2474975)									
EM1209924-001	Tindilpie Pad Pit Flowback frac pit water post flowback	EP075: bis(2-ethylhexyl) phthalate	117-81-7	10	µg/L	<50	<50	0.0	No Limit
		EP075: Dimethyl phthalate	131-11-3	2	µg/L	<10	<10	0.0	No Limit

Sub-Matrix: **WATER**

Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Laboratory Duplicate (DUP) Report LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
EP075C: Phthalate Esters (QC Lot: 2474975) - continued									
EM1209924-001	Tindilpie Pad Pit Flowback frac pit water post flowback	EP075: Diethyl phthalate	84-66-2	2	µg/L	<10	<10	0.0	No Limit
		EP075: Di-n-butyl phthalate	84-74-2	2	µg/L	<10	<10	0.0	No Limit
		EP075: Butyl benzyl phthalate	85-68-7	2	µg/L	<10	<10	0.0	No Limit
		EP075: Di-n-octylphthalate	117-84-0	2	µg/L	<10	<10	0.0	No Limit
EP075D: Nitrosamines (QC Lot: 2474975)									
EM1209924-001	Tindilpie Pad Pit Flowback frac pit water post flowback	EP075: N-Nitrosomethylethylamine	10595-95-6	2	µg/L	<10	<10	0.0	No Limit
		EP075: N-Nitrosodiethylamine	55-18-5	2	µg/L	<10	<10	0.0	No Limit
		EP075: N-Nitrosomorpholine	59-89-2	2	µg/L	<10	<10	0.0	No Limit
		EP075: N-Nitrosodi-n-propylamine	621-64-7	2	µg/L	<10	<10	0.0	No Limit
		EP075: N-Nitrosopiperidine	100-75-4	2	µg/L	<10	<10	0.0	No Limit
		EP075: N-Nitrosodibutylamine	924-16-3	2	µg/L	<10	<10	0.0	No Limit
		EP075: Methapyrilene	91-80-5	2	µg/L	<10	<10	0.0	No Limit
		EP075: N-Nitrosopyrrolidine	930-55-2	4	µg/L	<20	<20	0.0	No Limit
		EP075: N-Nitrosodiphenyl & Diphenylamine	86-30-6 122-39-4	4	µg/L	<20	<20	0.0	No Limit
EP075E: Nitroaromatics and Ketones (QC Lot: 2474975)									
EM1209924-001	Tindilpie Pad Pit Flowback frac pit water post flowback	EP075: 2-Picoline	109-06-8	2	µg/L	<10	<10	0.0	No Limit
		EP075: Acetophenone	98-86-2	2	µg/L	<10	<10	0.0	No Limit
		EP075: Nitrobenzene	98-95-3	2	µg/L	<10	<10	0.0	No Limit
		EP075: Isophorone	78-59-1	2	µg/L	<10	<10	0.0	No Limit
		EP075: 1-Naphthylamine	134-32-7	2	µg/L	<10	<10	0.0	No Limit
		EP075: 4-Nitroquinoline-N-oxide	56-57-5	2	µg/L	<10	<10	0.0	No Limit
		EP075: 5-Nitro-o-toluidine	99-55-8	2	µg/L	<10	<10	0.0	No Limit
		EP075: Azobenzene	103-33-3	2	µg/L	<10	<10	0.0	No Limit
		EP075: 1.3.5-Trinitrobenzene	99-35-4	2	µg/L	<10	<10	0.0	No Limit
		EP075: Phenacetin	62-44-2	2	µg/L	<10	<10	0.0	No Limit
		EP075: 4-Aminobiphenyl	92-67-1	2	µg/L	<10	<10	0.0	No Limit
		EP075: Pentachloronitrobenzene	82-68-8	2	µg/L	<10	<10	0.0	No Limit
		EP075: Pronamide	23950-58-5	2	µg/L	<10	<10	0.0	No Limit
		EP075: Dimethylaminoazobenzene	60-11-7	2	µg/L	<10	<10	0.0	No Limit
		EP075: Chlorobenzilate	510-15-6	2	µg/L	<10	<10	0.0	No Limit
		EP075: 2.6-Dinitrotoluene	606-20-2	4	µg/L	<20	<20	0.0	No Limit
		EP075: 2.4-Dinitrotoluene	121-14-2	4	µg/L	<20	<20	0.0	No Limit
EP075F: Haloethers (QC Lot: 2474975)									

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
EP075F: Haloethers (QC Lot: 2474975) - continued									
EM1209924-001	Tindilpie Pad Pit Flowback frac pit water post flowback	EP075: Bis(2-chloroethyl) ether	111-44-4	2	µg/L	<10	<10	0.0	No Limit
		EP075: Bis(2-chloroethoxy) methane	111-91-1	2	µg/L	<10	<10	0.0	No Limit
		EP075: 4-Chlorophenyl phenyl ether	7005-72-3	2	µg/L	<10	<10	0.0	No Limit
		EP075: 4-Bromophenyl phenyl ether	101-55-3	2	µg/L	<10	<10	0.0	No Limit
EP075G: Chlorinated Hydrocarbons (QC Lot: 2474975)									
EM1209924-001	Tindilpie Pad Pit Flowback frac pit water post flowback	EP075: Hexachlorocyclopentadiene	77-47-4	10	µg/L	<50	<50	0.0	No Limit
		EP075: 1.4-Dichlorobenzene	106-46-7	2	µg/L	<10	<10	0.0	No Limit
		EP075: 1.3-Dichlorobenzene	541-73-1	2	µg/L	<10	<10	0.0	No Limit
		EP075: 1.2-Dichlorobenzene	95-50-1	2	µg/L	<10	<10	0.0	No Limit
		EP075: Hexachloroethane	67-72-1	2	µg/L	<10	<10	0.0	No Limit
		EP075: 1.2.4-Trichlorobenzene	120-82-1	2	µg/L	<10	<10	0.0	No Limit
		EP075: Hexachloropropylene	1888-71-7	2	µg/L	<10	<10	0.0	No Limit
		EP075: Hexachlorobutadiene	87-68-3	2	µg/L	<10	<10	0.0	No Limit
		EP075: Pentachlorobenzene	608-93-5	2	µg/L	<10	<10	0.0	No Limit
		EP075: Hexachlorobenzene (HCB)	118-74-1	4	µg/L	<20	<20	0.0	No Limit
EP075H: Anilines and Benzidines (QC Lot: 2474975)									
EM1209924-001	Tindilpie Pad Pit Flowback frac pit water post flowback	EP075: Aniline	62-53-3	2	µg/L	<10	<10	0.0	No Limit
		EP075: 4-Chloroaniline	106-47-8	2	µg/L	<10	<10	0.0	No Limit
		EP075: Dibenzofuran	132-64-9	2	µg/L	<10	<10	0.0	No Limit
		EP075: 4-Nitroaniline	100-01-6	2	µg/L	<10	<10	0.0	No Limit
		EP075: Carbazole	86-74-8	2	µg/L	<10	<10	0.0	No Limit
		EP075: 3.3`-Dichlorobenzidine	91-94-1	2	µg/L	<10	<10	0.0	No Limit
		EP075: 2-Nitroaniline	88-74-4	4	µg/L	<20	<20	0.0	No Limit
		EP075: 3-Nitroaniline	99-09-2	4	µg/L	<20	<20	0.0	No Limit
EP075I: Organochlorine Pesticides (QC Lot: 2474975)									
EM1209924-001	Tindilpie Pad Pit Flowback frac pit water post flowback	EP075: alpha-BHC	319-84-6	2	µg/L	<10	<10	0.0	No Limit
		EP075: beta-BHC	319-85-7	2	µg/L	<10	<10	0.0	No Limit
		EP075: gamma-BHC	58-89-9	2	µg/L	<10	<10	0.0	No Limit
		EP075: delta-BHC	319-86-8	2	µg/L	<10	<10	0.0	No Limit
		EP075: Heptachlor	76-44-8	2	µg/L	<10	<10	0.0	No Limit
		EP075: Aldrin	309-00-2	2	µg/L	<10	<10	0.0	No Limit
		EP075: Heptachlor epoxide	1024-57-3	2	µg/L	<10	<10	0.0	No Limit

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
EP075I: Organochlorine Pesticides (QC Lot: 2474975) - continued									
EM1209924-001	Tindilpie Pad Pit Flowback frac pit water post flowback	EP075: alpha-Endosulfan	959-98-8	2	µg/L	<10	<10	0.0	No Limit
		EP075: 4.4`-DDE	72-55-9	2	µg/L	<10	<10	0.0	No Limit
		EP075: Dieldrin	60-57-1	2	µg/L	<10	<10	0.0	No Limit
		EP075: Endrin	72-20-8	2	µg/L	<10	<10	0.0	No Limit
		EP075: beta-Endosulfan	33213-65-9	2	µg/L	<10	<10	0.0	No Limit
		EP075: 4.4`-DDD	72-54-8	2	µg/L	<10	<10	0.0	No Limit
		EP075: Endosulfan sulfate	1031-07-8	2	µg/L	<10	<10	0.0	No Limit
		EP075: 4.4`-DDT	50-29-3	4	µg/L	<20	<20	0.0	No Limit
EP075J: Organophosphorus Pesticides (QC Lot: 2474975)									
EM1209924-001	Tindilpie Pad Pit Flowback frac pit water post flowback	EP075: Dichlorvos	62-73-7	2	µg/L	<10	<10	0.0	No Limit
		EP075: Dimethoate	60-51-5	2	µg/L	<10	<10	0.0	No Limit
		EP075: Diazinon	333-41-5	2	µg/L	<10	<10	0.0	No Limit
		EP075: Chlorpyrifos-methyl	5598-13-0	2	µg/L	<10	<10	0.0	No Limit
		EP075: Malathion	121-75-5	2	µg/L	<10	<10	0.0	No Limit
		EP075: Fenthion	55-38-9	2	µg/L	<10	<10	0.0	No Limit
		EP075: Chlorpyrifos	2921-88-2	2	µg/L	<10	<10	0.0	No Limit
		EP075: Pirimphos-ethyl	23505-41-1	2	µg/L	<10	<10	0.0	No Limit
		EP075: Chlorfenvinphos	470-90-6	2	µg/L	<10	<10	0.0	No Limit
		EP075: Prothiofos	34643-46-4	2	µg/L	<10	<10	0.0	No Limit
		EP075: Ethion	563-12-2	2	µg/L	<10	<10	0.0	No Limit
EP079/070: TPH CWG Aliphatic Hydrocarbon Fractions (QC Lot: 2475028)									
EM1209924-001	Tindilpie Pad Pit Flowback frac pit water post flowback	EP070-CWG: Aliphatic >C10-C12	TPHCWG-ALE1	50	µg/L	5180	4870	6.2	0% - 20%
		EP070-CWG: Aliphatic >C12-C16	TPHCWG-ALE2	50	µg/L	12500	11700	6.5	0% - 20%
		EP070-CWG: Aliphatic >C16-C21	----	50	µg/L	11600	10800	7.8	0% - 20%
		EP070-CWG: Aliphatic >C21-C35	----	50	µg/L	4750	4320	9.5	0% - 20%
EP079/070: TPH CWG Aliphatic Hydrocarbon Fractions (QC Lot: 2485082)									
EM1210094-014	Anonymous	EP079-CWG: Aliphatic >C5-C6	----	20	µg/L	<20	<20	0.0	No Limit
		EP079-CWG: Aliphatic >C6-C8	TPHCWG-ALV2	20	µg/L	<20	<20	0.0	No Limit
		EP079-CWG: Aliphatic >C8-C10	TPHCWG-ALV3	20	µg/L	<20	<20	0.0	No Limit
EP079/070: TPH CWG Aromatic Hydrocarbon Fractions (QC Lot: 2475028)									
EM1209924-001	Tindilpie Pad Pit Flowback frac pit water post flowback	EP070-CWG: Aromatic >C10-C12	TPHCWG-ARE1	50	µg/L	4100	4040	1.4	0% - 20%
		EP070-CWG: Aromatic >C12-C16	TPHCWG-ARE2	50	µg/L	3660	3540	3.5	0% - 20%

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
EP079/070: TPH CWG Aromatic Hydrocarbon Fractions (QC Lot: 2475028) - continued									
EM1209924-001	Tindilpie Pad Pit Flowback frac pit water post flowback	EP070-CWG: Aromatic >C16-C21	TPHCWG-ARE3	50	µg/L	2780	2640	5.3	0% - 20%
		EP070-CWG: Aromatic >C21-C35	TPHCWG-ARE4	50	µg/L	640	595	7.3	0% - 50%
EP079/070: TPH CWG Aromatic Hydrocarbon Fractions (QC Lot: 2485082)									
EM1210094-014	Anonymous	EP079-CWG: Aromatic >C5-C7	----	5	µg/L	<5	<5	0.0	No Limit
		EP079-CWG: Aromatic >C7-C8	TPHCWG-ARV 2	5	µg/L	<5	<5	0.0	No Limit
		EP079-CWG: Aromatic >C8-C10	TPHCWG-ARV 3	5	µg/L	<5	<5	0.0	No Limit
EP117: Alcohols (QC Lot: 2477831)									
EM1209924-001	Tindilpie Pad Pit Flowback frac pit water post flowback	EP117: Ethanol	64-17-5	50	µg/L	1360	1350	1.2	0% - 20%
		EP117: Isopropanol	67-63-0	50	µg/L	2840	2920	2.6	0% - 20%
		EP117: n-Propanol	71-23-8	50	µg/L	22800	21300	6.9	0% - 20%
		EP117: Isobutanol	78-83-1	50	µg/L	<250	<250	0.0	No Limit
		EP117: n-Butanol	71-36-3	50	µg/L	<250	<250	0.0	No Limit

Method Blank (MB) and Laboratory Control Spike (LCS) Report

The quality control term Method / Laboratory Blank refers to an analyte free matrix to which all reagents are added in the same volumes or proportions as used in standard sample preparation. The purpose of this QC parameter is to monitor potential laboratory contamination. The quality control term Laboratory Control Sample (LCS) refers to a certified reference material, or a known interference free matrix spiked with target analytes. The purpose of this QC parameter is to monitor method precision and accuracy independent of sample matrix. Dynamic Recovery Limits are based on statistical evaluation of processed LCS.

Sub-Matrix: **WATER**

				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Recovery Limits (%)	
Method: Compound	CAS Number	LOR	Unit	Result	Concentration	LCS	Low	High
EA015: Total Dissolved Solids (QCLot: 2474076)								
EA015H: Total Dissolved Solids @180°C	GIS-210-010	10	mg/L	<10	2000 mg/L	102	98	104
ED009: Anions (QCLot: 2476447)								
ED009-X: Bromide	24959-67-9	0.01	mg/L	<0.010	2 mg/L	96.6	88	112
ED009-X: Iodide	20461-54-5	0.01	mg/L	<0.010	0.5 mg/L	113	75	127
ED037P: Alkalinity by PC Titrator (QCLot: 2475151)								
ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	----	200 mg/L	100	77	127
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA (QCLot: 2473892)								
ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	<1	12.5 mg/L	104	81	125
ED045G: Chloride Discrete analyser (QCLot: 2473894)								
ED045G: Chloride	16887-00-6	1	mg/L	<1	1000 mg/L	99.0	89	117
ED093F: Dissolved Major Cations (QCLot: 2473893)								
ED093F: Calcium	7440-70-2	1	mg/L	<1	5 mg/L	102	83	129
ED093F: Magnesium	7439-95-4	1	mg/L	<1	5 mg/L	101	80	124
ED093F: Sodium	7440-23-5	1	mg/L	<1	50 mg/L	98.4	77	125
ED093F: Potassium	7440-09-7	1	mg/L	<1	50 mg/L	95.8	77	123
EG020F: Dissolved Metals by ICP-MS (QCLot: 2476712)								
EG020A-F: Aluminium	7429-90-5	0.01	mg/L	<0.01	0.5 mg/L	102	80	120
EG020A-F: Arsenic	7440-38-2	0.001	mg/L	<0.001	0.1 mg/L	102	87	109
EG020A-F: Beryllium	7440-41-7	0.001	mg/L	<0.001	0.1 mg/L	100	70	124
EG020A-F: Barium	7440-39-3	0.001	mg/L	<0.001	0.1 mg/L	102	88	110
EG020A-F: Cadmium	7440-43-9	0.0001	mg/L	<0.0001	0.1 mg/L	97.7	88	110
EG020A-F: Chromium	7440-47-3	0.001	mg/L	<0.001	0.1 mg/L	95.0	86	112
EG020A-F: Cobalt	7440-48-4	0.001	mg/L	<0.001	0.1 mg/L	106	87	111
EG020A-F: Copper	7440-50-8	0.001	mg/L	<0.001	0.1 mg/L	97.8	86	108
EG020A-F: Lead	7439-92-1	0.001	mg/L	<0.001	0.1 mg/L	104	90	110
EG020A-F: Lithium	7439-93-2	0.001	mg/L	<0.001	0.1 mg/L	110	60	130
EG020A-F: Manganese	7439-96-5	0.001	mg/L	<0.001	0.1 mg/L	97.0	87	111
EG020A-F: Molybdenum	7439-98-7	0.001	mg/L	<0.001	0.1 mg/L	97.6	84	108
EG020A-F: Nickel	7440-02-0	0.001	mg/L	<0.001	0.1 mg/L	106	86	112
EG020A-F: Selenium	7782-49-2	0.01	mg/L	<0.01	0.1 mg/L	97.5	83	111
EG020A-F: Tin	7440-31-5	0.001	mg/L	<0.001	0.1 mg/L	103	83	111
EG020A-F: Vanadium	7440-62-2	0.01	mg/L	<0.01	0.1 mg/L	93.9	85	113
EG020A-F: Zinc	7440-66-6	0.005	mg/L	<0.005	0.1 mg/L	102	86	120
EG020A-F: Boron	7440-42-8	0.05	mg/L	<0.05	0.1 mg/L	124	61	133

Sub-Matrix: **WATER**

Method: Compound	CAS Number	LOR	Unit	Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Recovery Limits (%)	
				Result	Concentration	LCS	Low	High
EG020F: Dissolved Metals by ICP-MS (QCLot: 2476712) - continued								
EG020A-F: Iron	7439-89-6	0.05	mg/L	<0.05	0.5 mg/L	98.3	79	119
EG020F: Dissolved Metals by ICP-MS (QCLot: 2476713)								
EG020B-F: Strontium	7440-24-6	0.001	mg/L	<0.001	0.1 mg/L	99.4	88	108
EG020B-F: Uranium	7440-61-1	0.001	mg/L	<0.001	----	----	----	----
EG035F: Dissolved Mercury by FIMS (QCLot: 2476711)								
EG035F: Mercury	7439-97-6	0.0001	mg/L	<0.0001	0.0100 mg/L	107	71	125
EK025G: Free cyanide by Discrete Analyser (QCLot: 2474592)								
EK025SF: Free Cyanide	----	0.004	mg/L	<0.004	0.2 mg/L	100	73	111
EK026G: Total Cyanide By Discrete Analyser (QCLot: 2474599)								
EK026SF: Total Cyanide	57-12-5	0.004	mg/L	<0.004	0.2 mg/L	95.8	85	125
EK040P: Fluoride by PC Titrator (QCLot: 2475152)								
EK040P: Fluoride	16984-48-8	0.1	mg/L	<0.1	5 mg/L	101	78	120
EK055G: Ammonia as N by Discrete Analyser (QCLot: 2475171)								
EK055G: Ammonia as N	7664-41-7	0.01	mg/L	<0.01	0.5 mg/L	90.4	76	122
EK057G: Nitrite as N by Discrete Analyser (QCLot: 2473891)								
EK057G: Nitrite as N	----	0.01	mg/L	<0.01	0.5 mg/L	93.1	84	112
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser (QCLot: 2475172)								
EK059G: Nitrite + Nitrate as N	----	0.01	mg/L	<0.01	0.5 mg/L	101	73	127
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser (QCLot: 2475438)								
EK061G: Total Kjeldahl Nitrogen as N	----	0.1	mg/L	<0.1	10 mg/L	85.5	63	117
EK067G: Total Phosphorus as P by Discrete Analyser (QCLot: 2475439)								
EK067G: Total Phosphorus as P	----	0.01	mg/L	<0.01	4.42 mg/L	93.5	73	117
EK071G: Reactive Phosphorus as P by discrete analyser (QCLot: 2473890)								
EK071G: Reactive Phosphorus as P	----	0.01	mg/L	<0.01	0.5 mg/L	99.6	84	108
EP005: Total Organic Carbon (TOC) (QCLot: 2488012)								
EP005: Total Organic Carbon	----	1	mg/L	<1	100 mg/L	98.6	81	111
EP010: Formaldehyde (QCLot: 2473623)								
EP010: Formaldehyde	50-00-0	0.1	mg/L	<0.1	5.0 mg/L	102	91	117
EP041A: Nonionic Surfactants (QCLot: 2476292)								
EP041A: Nonionic Surfactants as CTAS	----	5	mg/L	<5	10 mg/L	97.0	81.1	110
EP050: Anionic Surfactants as MBAS (QCLot: 2475995)								
EP050: Anionic Surfactants as MBAS		0.1	mg/L	<0.1	1 mg/L	90.0	83.2	115
EP074A: Monocyclic Aromatic Hydrocarbons (QCLot: 2485081)								
EP074: Benzene	71-43-2	1	µg/L	<1	20 µg/L	97.5	79	121
EP074: Toluene	108-88-3	2	µg/L	<2	20 µg/L	109	80	124
EP074: Ethylbenzene	100-41-4	2	µg/L	<2	20 µg/L	98.3	79	121

Sub-Matrix: **WATER**

Method: Compound	CAS Number	LOR	Unit	Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Recovery Limits (%)	
				Result	Concentration	LCS	Low	High
EP074A: Monocyclic Aromatic Hydrocarbons (QCLot: 2485081) - continued								
EP074: meta- & para-Xylene	108-38-3 106-42-3	2	µg/L	<2	40 µg/L	96.8	80	122
EP074: Styrene	100-42-5	5	µg/L	<5	20 µg/L	96.1	74	122
EP074: ortho-Xylene	95-47-6	2	µg/L	<2	20 µg/L	99.2	81	123
EP074: Isopropylbenzene	98-82-8	5	µg/L	<5	20 µg/L	91.5	80	120
EP074: n-Propylbenzene	103-65-1	5	µg/L	<5	20 µg/L	94.3	70	120
EP074: 1.3.5-Trimethylbenzene	108-67-8	5	µg/L	<5	20 µg/L	92.8	71	119
EP074: sec-Butylbenzene	135-98-8	5	µg/L	<5	20 µg/L	96.2	72	120
EP074: 1.2.4-Trimethylbenzene	95-63-6	5	µg/L	<5	20 µg/L	91.4	73	119
EP074: tert-Butylbenzene	98-06-6	5	µg/L	<5	20 µg/L	90.1	73	119
EP074: p-Isopropyltoluene	99-87-6	5	µg/L	<5	20 µg/L	92.3	71	121
EP074: n-Butylbenzene	104-51-8	5	µg/L	<5	20 µg/L	92.3	65	121
EP074B: Oxygenated Compounds (QCLot: 2485081)								
EP074: Vinyl Acetate	108-05-4	50	µg/L	<50	200 µg/L	85.1	57	131
EP074: 2-Butanone (MEK)	78-93-3	50	µg/L	<50	200 µg/L	88.5	69	135
EP074: 4-Methyl-2-pentanone (MIBK)	108-10-1	50	µg/L	<50	200 µg/L	95.3	68	136
EP074: 2-Hexanone (MBK)	591-78-6	50	µg/L	<50	200 µg/L	98.1	68	138
EP074C: Sulfonated Compounds (QCLot: 2485081)								
EP074: Carbon disulfide	75-15-0	5	µg/L	<5	20 µg/L	75.0	67	127
EP074D: Fumigants (QCLot: 2485081)								
EP074: 2.2-Dichloropropane	594-20-7	5	µg/L	<5	20 µg/L	91.6	59	128
EP074: 1.2-Dichloropropane	78-87-5	5	µg/L	<5	20 µg/L	93.3	77	121
EP074: cis-1.3-Dichloropropylene	10061-01-5	5	µg/L	<5	20 µg/L	82.0	70	118
EP074: trans-1.3-Dichloropropylene	10061-02-6	5	µg/L	<5	20 µg/L	67.7	66	120
EP074: 1.2-Dibromoethane (EDB)	106-93-4	5	µg/L	<5	20 µg/L	94.4	78	124
EP074E: Halogenated Aliphatic Compounds (QCLot: 2485081)								
EP074: Dichlorodifluoromethane	75-71-8	50	µg/L	<50	200 µg/L	112	58	148
EP074: Chloromethane	74-87-3	50	µg/L	<50	200 µg/L	107	62	142
EP074: Vinyl chloride	75-01-4	50	µg/L	<50	200 µg/L	104	61	141
EP074: Bromomethane	74-83-9	50	µg/L	<50	200 µg/L	81.3	57	131
EP074: Chloroethane	75-00-3	50	µg/L	<50	200 µg/L	107	64	138
EP074: Trichlorofluoromethane	75-69-4	50	µg/L	<50	200 µg/L	99.0	67	131
EP074: 1.1-Dichloroethene	75-35-4	5	µg/L	<5	20 µg/L	88.1	71	125
EP074: Iodomethane	74-88-4	5	µg/L	<5	20 µg/L	66.0	61	135
EP074: trans-1.2-Dichloroethene	156-60-5	5	µg/L	<5	20 µg/L	90.9	75	121
EP074: 1.1-Dichloroethane	75-34-3	5	µg/L	<5	20 µg/L	94.4	77	121
EP074: cis-1.2-Dichloroethene	156-59-2	5	µg/L	<5	20 µg/L	95.1	78	122
EP074: 1.1.1-Trichloroethane	71-55-6	5	µg/L	<5	20 µg/L	86.0	70	120
EP074: 1.1-Dichloropropylene	563-58-6	5	µg/L	<5	20 µg/L	94.5	74	122

Sub-Matrix: **WATER**

Method: Compound	CAS Number	LOR	Unit	Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Recovery Limits (%)	
				Result	Concentration	LCS	Low	High
EP074E: Halogenated Aliphatic Compounds (QCLot: 2485081) - continued								
EP074: Carbon Tetrachloride	56-23-5	5	µg/L	<5	20 µg/L	81.2	57	123
EP074: 1.2-Dichloroethane	107-06-2	5	µg/L	<5	20 µg/L	94.2	75	125
EP074: Trichloroethene	79-01-6	5	µg/L	<5	20 µg/L	93.2	77	121
EP074: Dibromomethane	74-95-3	5	µg/L	<5	20 µg/L	86.6	76	122
EP074: 1.1.2-Trichloroethane	79-00-5	5	µg/L	<5	20 µg/L	118	78	126
EP074: 1.3-Dichloropropane	142-28-9	5	µg/L	<5	20 µg/L	108	79	125
EP074: Tetrachloroethene	127-18-4	5	µg/L	<5	20 µg/L	112	76	122
EP074: 1.1.1.2-Tetrachloroethane	630-20-6	5	µg/L	<5	20 µg/L	89.6	65	119
EP074: trans-1.4-Dichloro-2-butene	110-57-6	5	µg/L	<5	20 µg/L	75.4	46	126
EP074: cis-1.4-Dichloro-2-butene	1476-11-5	5	µg/L	<5	20 µg/L	66.4	54	132
EP074: 1.1.2.2-Tetrachloroethane	79-34-5	5	µg/L	<5	20 µg/L	93.3	75	131
EP074: 1.2.3-Trichloropropane	96-18-4	5	µg/L	<5	20 µg/L	95.2	75	133
EP074: Pentachloroethane	76-01-7	5	µg/L	<5	20 µg/L	64.7	46	118
EP074: 1.2-Dibromo-3-chloropropane	96-12-8	5	µg/L	<5	20 µg/L	71.6	54	124
EP074F: Halogenated Aromatic Compounds (QCLot: 2485081)								
EP074: Chlorobenzene	108-90-7	5	µg/L	<5	20 µg/L	105	81	121
EP074: Bromobenzene	108-86-1	5	µg/L	<5	20 µg/L	98.1	75	119
EP074: 2-Chlorotoluene	95-49-8	5	µg/L	<5	20 µg/L	96.2	73	121
EP074: 4-Chlorotoluene	106-43-4	5	µg/L	<5	20 µg/L	97.1	72	120
EP074: 1.2.3-Trichlorobenzene	87-61-6	5	µg/L	<5	20 µg/L	96.7	69	123
EP074G: Trihalomethanes (QCLot: 2485081)								
EP074: Chloroform	67-66-3	5	µg/L	<5	20 µg/L	94.4	77	121
EP074: Bromodichloromethane	75-27-4	5	µg/L	<5	20 µg/L	76.9	69	117
EP074: Dibromochloromethane	124-48-1	5	µg/L	<5	20 µg/L	78.7	59	119
EP074: Bromoform	75-25-2	5	µg/L	<5	20 µg/L	70.9	49	121
EP075A: Phenolic Compounds (QCLot: 2474975)								
EP075: Phenol	108-95-2	2	µg/L	<2	10 µg/L	34.8	10	65
EP075: 2-Chlorophenol	95-57-8	2	µg/L	<2	10 µg/L	76.7	29.8	108
EP075: 2-Methylphenol	95-48-7	2	µg/L	<2	10 µg/L	72.4	21.9	110
EP075: 3- & 4-Methylphenol	1319-77-3	2	µg/L	----	20 µg/L	73.4	10	108
		4	µg/L	<4	----	----	----	----
EP075: 2-Nitrophenol	88-75-5	2	µg/L	<2	10 µg/L	101	31.2	123
EP075: 2.4-Dimethylphenol	105-67-9	2	µg/L	<2	10 µg/L	60.2	36	124
EP075: 2.4-Dichlorophenol	120-83-2	2	µg/L	<2	10 µg/L	95.2	31.2	125
EP075: 2.6-Dichlorophenol	87-65-0	2	µg/L	<2	10 µg/L	94.5	33	123
EP075: 4-Chloro-3-Methylphenol	59-50-7	2	µg/L	<2	10 µg/L	93.4	39	125
EP075: 2.4.6-Trichlorophenol	88-06-2	2	µg/L	<2	10 µg/L	92.3	23.9	134
EP075: 2.4.5-Trichlorophenol	95-95-4	2	µg/L	<2	10 µg/L	90.7	31.6	136

Sub-Matrix: **WATER**

Method: Compound	CAS Number	LOR	Unit	Method Blank (MB) Report: Result	Laboratory Control Spike (LCS) Report: Spike Concentration	Spike Recovery (%): LCS	Recovery Limits (%): Low	Recovery Limits (%): High
EP075A: Phenolic Compounds (QCLot: 2474975) - continued								
EP075: Pentachlorophenol	87-86-5	2	µg/L	----	10 µg/L	104	47	153
		4	µg/L	<4	----	----	----	----
EP075B: Polynuclear Aromatic Hydrocarbons (QCLot: 2474975)								
EP075: Naphthalene	91-20-3	2	µg/L	<2	10 µg/L	117	33	117
EP075: 2-Methylnaphthalene	91-57-6	2	µg/L	<2	10 µg/L	93.2	33	123
EP075: 2-Chloronaphthalene	91-58-7	2	µg/L	<2	10 µg/L	88.4	22.6	133
EP075: Acenaphthylene	208-96-8	2	µg/L	<2	10 µg/L	93.4	35	131
EP075: Acenaphthene	83-32-9	2	µg/L	<2	10 µg/L	99.6	37	127
EP075: Fluorene	86-73-7	2	µg/L	<2	10 µg/L	102	39	133
EP075: Phenanthrene	85-01-8	2	µg/L	<2	10 µg/L	106	42	134
EP075: Anthracene	120-12-7	2	µg/L	<2	10 µg/L	102	41	135
EP075: Fluoranthene	206-44-0	2	µg/L	<2	10 µg/L	106	40	146
EP075: Pyrene	129-00-0	2	µg/L	<2	10 µg/L	107	42	142
EP075: N-2-Fluorenyl Acetamide	53-96-3	2	µg/L	<2	10 µg/L	104	40	146
EP075: Benz(a)anthracene	56-55-3	2	µg/L	<2	10 µg/L	105	41	143
EP075: Chrysene	218-01-9	2	µg/L	<2	10 µg/L	113	40	146
EP075: Benzo(b) & Benzo(k)fluoranthene	205-99-2 207-08-9	4	µg/L	<4	20 µg/L	114	21	151
EP075: 7.12-Dimethylbenz(a)anthracene	57-97-6	2	µg/L	<2	10 µg/L	123	39	151
EP075: Benzo(a)pyrene	50-32-8	2	µg/L	<2	10 µg/L	101	39	141
EP075: 3-Methylcholanthrene	56-49-5	2	µg/L	<2	10 µg/L	99.8	33	139
EP075: Indeno(1.2.3.cd)pyrene	193-39-5	2	µg/L	<2	10 µg/L	114	31.5	139
EP075: Dibenz(a.h)anthracene	53-70-3	2	µg/L	<2	10 µg/L	112	30.1	140
EP075: Benzo(g.h.i)perylene	191-24-2	2	µg/L	<2	10 µg/L	109	29.5	138
EP075C: Phthalate Esters (QCLot: 2474975)								
EP075: Dimethyl phthalate	131-11-3	2	µg/L	<2	10 µg/L	104	41	141
EP075: Diethyl phthalate	84-66-2	2	µg/L	<2	10 µg/L	112	45	139
EP075: Di-n-butyl phthalate	84-74-2	2	µg/L	<4	10 µg/L	114	42	150
EP075: Butyl benzyl phthalate	85-68-7	2	µg/L	<2	10 µg/L	110	36	152
EP075: bis(2-ethylhexyl) phthalate	117-81-7	10	µg/L	<10	----	----	----	----
		20	µg/L	----	10 µg/L	111	42	158
EP075: Di-n-octylphthalate	117-84-0	2	µg/L	<2	10 µg/L	107	43	141
EP075D: Nitrosamines (QCLot: 2474975)								
EP075: N-Nitrosomethylethylamine	10595-95-6	2	µg/L	<2	10 µg/L	56.8	10	109
EP075: N-Nitrosodiethylamine	55-18-5	2	µg/L	<2	10 µg/L	84.5	23.5	124
EP075: N-Nitrosopyrrolidine	930-55-2	4	µg/L	<4	10 µg/L	68.5	18.8	97
EP075: N-Nitrosomorpholine	59-89-2	2	µg/L	<2	10 µg/L	64.6	18.3	94
EP075: N-Nitrosodi-n-propylamine	621-64-7	2	µg/L	<2	10 µg/L	95.0	30.6	129
EP075: N-Nitrosopiperidine	100-75-4	2	µg/L	<2	10 µg/L	87.4	32	126

Sub-Matrix: **WATER**

Method: Compound	CAS Number	LOR	Unit	Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Recovery Limits (%)	
				Result	Concentration	LCS	Low	High
EP075D: Nitrosamines (QCLot: 2474975) - continued								
EP075: N-Nitrosodibutylamine	924-16-3	2	µg/L	<2	10 µg/L	83.8	29.1	135
EP075: N-Nitrosodiphenyl & Diphenylamine	86-30-6 122-39-4	4	µg/L	<4	10 µg/L	108	39	139
EP075: Methapyrilene	91-80-5	2	µg/L	<2	10 µg/L	# 116	28.1	70
EP075E: Nitroaromatics and Ketones (QCLot: 2474975)								
EP075: 2-Picoline	109-06-8	2	µg/L	<2	10 µg/L	38.1	28.4	57
EP075: Acetophenone	98-86-2	2	µg/L	<2	10 µg/L	98.5	34	126
EP075: Nitrobenzene	98-95-3	2	µg/L	<2	10 µg/L	93.4	36	120
EP075: Isophorone	78-59-1	2	µg/L	<2	10 µg/L	94.2	38	124
EP075: 2.6-Dinitrotoluene	606-20-2	4	µg/L	<4	10 µg/L	105	38	142
EP075: 2.4-Dinitrotoluene	121-14-2	4	µg/L	<4	10 µg/L	112	44	138
EP075: 1-Naphthylamine	134-32-7	2	µg/L	<2	10 µg/L	83.3	29.8	152
EP075: 4-Nitroquinoline-N-oxide	56-57-5	2	µg/L	<2	10 µg/L	153	25.9	168
EP075: 5-Nitro-o-toluidine	99-55-8	2	µg/L	<2	10 µg/L	93.9	26.2	138
EP075: Azobenzene	103-33-3	2	µg/L	<2	10 µg/L	109	43	135
EP075: 1.3.5-Trinitrobenzene	99-35-4	2	µg/L	<2	10 µg/L	110	10	158
EP075: Phenacetin	62-44-2	2	µg/L	<2	10 µg/L	100	37	131
EP075: 4-Aminobiphenyl	92-67-1	2	µg/L	<2	10 µg/L	69.1	10	150
EP075: Pentachloronitrobenzene	82-68-8	2	µg/L	<2	10 µg/L	119	38	146
EP075: Pronamide	23950-58-5	2	µg/L	<2	10 µg/L	95.9	45	139
EP075: Dimethylaminoazobenzene	60-11-7	2	µg/L	<2	10 µg/L	117	37	147
EP075: Chlorobenzilate	510-15-6	2	µg/L	<2	10 µg/L	112	42	148
EP075F: Haloethers (QCLot: 2474975)								
EP075: Bis(2-chloroethyl) ether	111-44-4	2	µg/L	<2	10 µg/L	40.0	10	142
EP075: Bis(2-chloroethoxy) methane	111-91-1	2	µg/L	<2	10 µg/L	103	34	126
EP075: 4-Chlorophenyl phenyl ether	7005-72-3	2	µg/L	<2	10 µg/L	110	39	133
EP075: 4-Bromophenyl phenyl ether	101-55-3	2	µg/L	<2	10 µg/L	114	39	137
EP075G: Chlorinated Hydrocarbons (QCLot: 2474975)								
EP075: 1.4-Dichlorobenzene	106-46-7	2	µg/L	<2	10 µg/L	104	23	109
EP075: 1.3-Dichlorobenzene	541-73-1	2	µg/L	<2	10 µg/L	79.8	19.8	112
EP075: 1.2-Dichlorobenzene	95-50-1	2	µg/L	<2	10 µg/L	87.8	25.2	109
EP075: Hexachloroethane	67-72-1	2	µg/L	<2	10 µg/L	99.5	17.4	115
EP075: 1.2.4-Trichlorobenzene	120-82-1	2	µg/L	<2	10 µg/L	88.6	25.7	112
EP075: Hexachloropropylene	1888-71-7	2	µg/L	<2	10 µg/L	95.6	19.1	115
EP075: Hexachlorobutadiene	87-68-3	2	µg/L	<2	10 µg/L	94.3	21.1	117
EP075: Hexachlorocyclopentadiene	77-47-4	10	µg/L	<10	10 µg/L	94.1	10	120
EP075: Pentachlorobenzene	608-93-5	2	µg/L	<2	10 µg/L	110	36	130
EP075: Hexachlorobenzene (HCB)	118-74-1	4	µg/L	<4	20 µg/L	116	11.1	135
EP075H: Anilines and Benzidines (QCLot: 2474975)								

Sub-Matrix: **WATER**

Method: Compound	CAS Number	LOR	Unit	Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Recovery Limits (%)	
				Result	Concentration	LCS	Low	High
EP075H: Anilines and Benzidines (QCLot: 2474975) - continued								
EP075: Aniline	62-53-3	2	µg/L	<2	10 µg/L	44.5	19.8	96
EP075: 4-Chloroaniline	106-47-8	2	µg/L	<2	10 µg/L	46.0	16.4	130
EP075: 2-Nitroaniline	88-74-4	4	µg/L	<4	10 µg/L	99.3	38	138
EP075: 3-Nitroaniline	99-09-2	4	µg/L	<4	10 µg/L	84.7	10	135
EP075: Dibenzofuran	132-64-9	2	µg/L	<2	10 µg/L	104	39	129
EP075: 4-Nitroaniline	100-01-6	2	µg/L	<2	10 µg/L	98.6	22.8	133
EP075: Carbazole	86-74-8	2	µg/L	<2	10 µg/L	95.0	44	138
EP075: 3.3`-Dichlorobenzidine	91-94-1	2	µg/L	<2	10 µg/L	51.5	14.6	107
EP075I: Organochlorine Pesticides (QCLot: 2474975)								
EP075: alpha-BHC	319-84-6	2	µg/L	<2	10 µg/L	116	41	143
EP075: beta-BHC	319-85-7	2	µg/L	<2	10 µg/L	114	39	145
EP075: gamma-BHC	58-89-9	2	µg/L	<2	10 µg/L	115	39	143
EP075: delta-BHC	319-86-8	2	µg/L	<2	10 µg/L	111	42	142
EP075: Heptachlor	76-44-8	2	µg/L	<2	10 µg/L	110	39	139
EP075: Aldrin	309-00-2	2	µg/L	<2	10 µg/L	113	40	142
EP075: Heptachlor epoxide	1024-57-3	2	µg/L	<2	10 µg/L	113	37	147
EP075: alpha-Endosulfan	959-98-8	2	µg/L	<2	10 µg/L	110	42	146
EP075: 4.4`-DDE	72-55-9	2	µg/L	<2	10 µg/L	100	41	141
EP075: Dieldrin	60-57-1	2	µg/L	<2	10 µg/L	112	42	144
EP075: Endrin	72-20-8	2	µg/L	<2	10 µg/L	118	41	145
EP075: beta-Endosulfan	33213-65-9	2	µg/L	<2	10 µg/L	108	42	146
EP075: 4.4`-DDD	72-54-8	2	µg/L	<2	10 µg/L	112	40	148
EP075: Endosulfan sulfate	1031-07-8	2	µg/L	<2	10 µg/L	121	38	152
EP075: 4.4`-DDT	50-29-3	4	µg/L	<4	10 µg/L	115	33	145
EP075J: Organophosphorus Pesticides (QCLot: 2474975)								
EP075: Dichlorvos	62-73-7	2	µg/L	<2	10 µg/L	92.5	38	132
EP075: Dimethoate	60-51-5	2	µg/L	<2	10 µg/L	98.6	36	138
EP075: Diazinon	333-41-5	2	µg/L	<2	10 µg/L	109	43	141
EP075: Chlorpyrifos-methyl	5598-13-0	2	µg/L	<2	10 µg/L	112	43	141
EP075: Malathion	121-75-5	2	µg/L	<2	10 µg/L	120	44	148
EP075: Fenthion	55-38-9	2	µg/L	<2	10 µg/L	114	42	144
EP075: Chlorpyrifos	2921-88-2	2	µg/L	<2	10 µg/L	104	42	142
EP075: Pirimphos-ethyl	23505-41-1	2	µg/L	<2	10 µg/L	111	44	142
EP075: Chlorfenvinphos	470-90-6	2	µg/L	<2	10 µg/L	120	44	146
EP075: Prothiofos	34643-46-4	2	µg/L	<2	10 µg/L	106	40	142
EP075: Ethion	563-12-2	2	µg/L	<2	10 µg/L	116	42	146
EP079/070: TPH CWG Aliphatic Hydrocarbon Fractions (QCLot: 2475028)								
EP070-CWG: Aliphatic >C10-C12	TPHCWG-AL E1	50	µg/L	<50	2505 µg/L	85.7	70	130

Sub-Matrix: **WATER**

Method: Compound	CAS Number	LOR	Unit	Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Recovery Limits (%)	
				Result	Concentration	LCS	Low	High
EP079/070: TPH CWG Aliphatic Hydrocarbon Fractions (QCLot: 2475028) - continued								
EP070-CWG: Aliphatic >C12-C16	TPHCWG-AL E2	50	µg/L	<50	10590 µg/L	90.1	70	130
EP070-CWG: Aliphatic >C16-C21	----	50	µg/L	<50	9345 µg/L	106	70	130
EP070-CWG: Aliphatic >C21-C35	----	50	µg/L	<50	2253 µg/L	97.7	70	130
EP079/070: TPH CWG Aliphatic Hydrocarbon Fractions (QCLot: 2485082)								
EP079-CWG: Aliphatic >C5-C6	----	20	µg/L	<20	50 µg/L	98.6	70	130
EP079-CWG: Aliphatic >C6-C8	TPHCWG-AL V2	20	µg/L	<20	100 µg/L	85.7	70	130
EP079-CWG: Aliphatic >C8-C10	TPHCWG-AL V3	20	µg/L	<20	120 µg/L	86.2	70	130
EP079/070: TPH CWG Aromatic Hydrocarbon Fractions (QCLot: 2475028)								
EP070-CWG: Aromatic >C10-C12	TPHCWG-AR E1	50	µg/L	<50	750 µg/L	92.8	70	130
EP070-CWG: Aromatic >C12-C16	TPHCWG-AR E2	50	µg/L	<50	3174 µg/L	107	70	130
EP070-CWG: Aromatic >C16-C21	TPHCWG-AR E3	50	µg/L	<50	2607 µg/L	97.7	70	130
EP070-CWG: Aromatic >C21-C35	TPHCWG-AR E4	50	µg/L	<50	606 µg/L	90.4	70	130
EP079/070: TPH CWG Aromatic Hydrocarbon Fractions (QCLot: 2485082)								
EP079-CWG: Aromatic >C5-C7	----	1	µg/L	<1	20 µg/L	104	70	130
EP079-CWG: Aromatic >C7-C8	TPHCWG-AR V2	2	µg/L	<2	20 µg/L	102	70	130
EP079-CWG: Aromatic >C8-C10	TPHCWG-AR V3	2	µg/L	<2	180 µg/L	75.2	70	130
EP117: Alcohols (QCLot: 2477831)								
EP117: Ethanol	64-17-5	50	µg/L	<50	100 µg/L	92.6	73	121
EP117: Isopropanol	67-63-0	50	µg/L	<50	100 µg/L	92.9	73	113
EP117: n-Propanol	71-23-8	50	µg/L	<50	100 µg/L	88.4	68	116
EP117: Isobutanol	78-83-1	50	µg/L	<50	100 µg/L	93.2	67	117
EP117: n-Butanol	71-36-3	50	µg/L	<50	100 µg/L	91.4	65	119

Matrix Spike (MS) Report

The quality control term Matrix Spike (MS) refers to an intralaboratory split sample spiked with a representative set of target analytes. The purpose of this QC parameter is to monitor potential matrix effects on analyte recoveries. Static Recovery Limits as per laboratory Data Quality Objectives (DQOs). Ideal recovery ranges stated may be waived in the event of sample matrix interference.

Sub-Matrix: **WATER**

				Matrix Spike (MS) Report			
				Spike	Spike Recovery (%)	Recovery Limits (%)	
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Concentration	MS	Low	High
ED009: Anions (QCLot: 2476447)							
EM1209913-001	Anonymous	ED009-X: Bromide	24959-67-9	0.2 mg/L	# Not Determined	70	130
		ED009-X: Iodide	20461-54-5	8 mg/L	102	70	130
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA (QCLot: 2473892)							
EM1209916-010	Anonymous	ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	10 mg/L	93.1	70	130
ED045G: Chloride Discrete analyser (QCLot: 2473894)							
EM1209916-010	Anonymous	ED045G: Chloride	16887-00-6	400 mg/L	112	70	130
EG020F: Dissolved Metals by ICP-MS (QCLot: 2476712)							
EM1209762-001	Anonymous	EG020A-F: Arsenic	7440-38-2	0.2 mg/L	127	89	139
		EG020A-F: Beryllium	7440-41-7	0.2 mg/L	104	64	138
		EG020A-F: Barium	7440-39-3	0.2 mg/L	89.0	80	122
		EG020A-F: Cadmium	7440-43-9	0.05 mg/L	116	75	131
		EG020A-F: Chromium	7440-47-3	0.2 mg/L	121	70	130
		EG020A-F: Cobalt	7440-48-4	0.2 mg/L	119	77	129
		EG020A-F: Copper	7440-50-8	0.2 mg/L	123	71	127
		EG020A-F: Lead	7439-92-1	0.2 mg/L	117	71	123
		EG020A-F: Manganese	7439-96-5	0.2 mg/L	126	66	132
		EG020A-F: Nickel	7440-02-0	0.2 mg/L	112	73	129
		EG020A-F: Vanadium	7440-62-2	0.2 mg/L	96.4	70	130
		EG020A-F: Zinc	7440-66-6	0.2 mg/L	98.5	68	136
EG035F: Dissolved Mercury by FIMS (QCLot: 2476711)							
EM1209762-002	Anonymous	EG035F: Mercury	7439-97-6	0.0100 mg/L	85.8	70	130
EK025G: Free cyanide by Discrete Analyser (QCLot: 2474592)							
EM1209920-003	Anonymous	EK025G: Free Cyanide	----	0.2 mg/L	102	70	130
EK026G: Total Cyanide By Discrete Analyser (QCLot: 2474599)							
EM1209913-002	Anonymous	EK026G: Total Cyanide	57-12-5	0.2 mg/L	101	70	130
EK040P: Fluoride by PC Titrator (QCLot: 2475152)							
EM1209924-001	Tindilpie Pad Pit Flowback frac pit water post flowback	EK040P: Fluoride	16984-48-8	5.0 mg/L	99.8	70	130
EK055G: Ammonia as N by Discrete Analyser (QCLot: 2475171)							
EM1209914-002	Anonymous	EK055G: Ammonia as N	7664-41-7	0.5 mg/L	87.0	70	130
EK057G: Nitrite as N by Discrete Analyser (QCLot: 2473891)							
EM1209916-002	Anonymous	EK057G: Nitrite as N	----	0.5 mg/L	93.8	70	130
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser (QCLot: 2475172)							

Sub-Matrix: **WATER**

Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Matrix Spike (MS) Report: Spike Concentration	Spike Recovery (%): MS	Recovery Limits (%): Low	Recovery Limits (%): High
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser (QCLot: 2475172) - continued							
EM1209937-001	Anonymous	EK059G: Nitrite + Nitrate as N	----	1.0 mg/L	# 66.7	70	130
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser (QCLot: 2475438)							
EM1209916-012	Anonymous	EK061G: Total Kjeldahl Nitrogen as N	----	5 mg/L	129	70	130
EK067G: Total Phosphorus as P by Discrete Analyser (QCLot: 2475439)							
EM1209916-012	Anonymous	EK067G: Total Phosphorus as P	----	1 mg/L	# Not Determined	70	130
EK071G: Reactive Phosphorus as P by discrete analyser (QCLot: 2473890)							
EM1209913-002	Anonymous	EK071G: Reactive Phosphorus as P	----	0.5 mg/L	97.9	70	130
EP005: Total Organic Carbon (TOC) (QCLot: 2488012)							
EM1209762-024	Anonymous	EP005: Total Organic Carbon	----	100 mg/L	103	70	130
EP041A: Nonionic Surfactants (QCLot: 2476292)							
ES1220994-003	Anonymous	EP041A: Nonionic Surfactants as CTAS	----	5 mg/L	78.0	70	130
EP050: Anionic Surfactants as MBAS (QCLot: 2475995)							
ES1220980-001	Anonymous	EP050: Anionic Surfactants as MBAS		1.0 mg/L	80.0	70	130
EP074A: Monocyclic Aromatic Hydrocarbons (QCLot: 2485081)							
EM1210094-015	Anonymous	EP074: Benzene	71-43-2	20 µg/L	91.9	64	121
		EP074: Toluene	108-88-3	20 µg/L	111	63	125
EP074E: Halogenated Aliphatic Compounds (QCLot: 2485081)							
EM1210094-015	Anonymous	EP074: 1.1-Dichloroethene	75-35-4	20 µg/L	76.4	52	104
		EP074: Trichloroethene	79-01-6	20 µg/L	83.8	59	120
EP074F: Halogenated Aromatic Compounds (QCLot: 2485081)							
EM1210094-015	Anonymous	EP074: Chlorobenzene	108-90-7	20 µg/L	109	63	132
EP075A: Phenolic Compounds (QCLot: 2474975)							
EM1209924-001	Tindilpie Pad Pit Flowback frac pit water post flowback	EP075: Phenol	108-95-2	10 µg/L	# Not Determined	10	51
		EP075: 2-Chlorophenol	95-57-8	10 µg/L	# Not Determined	26.1	104
		EP075: 2-Nitrophenol	88-75-5	10 µg/L	# Not Determined	34	118
		EP075: 4-Chloro-3-Methylphenol	59-50-7	10 µg/L	# Not Determined	24.9	135
		EP075: Pentachlorophenol	87-86-5	10 µg/L	# Not Determined	29.9	194
EP075B: Polynuclear Aromatic Hydrocarbons (QCLot: 2474975)							
EM1209924-001	Tindilpie Pad Pit Flowback frac pit water post flowback	EP075: Acenaphthene	83-32-9	10 µg/L	# Not Determined	27	133
		EP075: Pyrene	129-00-0	10 µg/L	# Not Determined	28.1	146
EP075D: Nitrosamines (QCLot: 2474975)							
EM1209924-001	Tindilpie Pad Pit Flowback frac pit water post flowback	EP075: N-Nitrosodi-n-propylamine	621-64-7	10 µg/L	# Not Determined	22.8	125
EP075E: Nitroaromatics and Ketones (QCLot: 2474975)							
EM1209924-001	Tindilpie Pad Pit Flowback frac pit water post flowback	EP075: 2.4-Dinitrotoluene	121-14-2	10 µg/L	# Not Determined	27.9	138

Sub-Matrix: **WATER**

Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Matrix Spike (MS) Report: Spike Concentration	Matrix Spike (MS) Report: Spike Recovery (%) MS	Matrix Spike (MS) Report: Recovery Limits (%) Low	Matrix Spike (MS) Report: Recovery Limits (%) High
EP075G: Chlorinated Hydrocarbons (QCLot: 2474975)							
EM1209924-001	Tindilpie Pad Pit Flowback frac pit water post flowback	EP075: 1.4-Dichlorobenzene	106-46-7	10 µg/L	# Not Determined	22.1	112
		EP075: 1.2.4-Trichlorobenzene	120-82-1	10 µg/L	# Not Determined	15.3	117
EP079/070: TPH CWG Aliphatic Hydrocarbon Fractions (QCLot: 2485082)							
EM1210094-015	Anonymous	EP079-CWG: Aliphatic >C5-C6	----	70 µg/L	113	70	130
		EP079-CWG: Aliphatic >C6-C8	TPHCWG-ALV2	120 µg/L	91.1	70	130
		EP079-CWG: Aliphatic >C8-C10	TPHCWG-ALV3	120 µg/L	# 66.5	70	130
EP079/070: TPH CWG Aromatic Hydrocarbon Fractions (QCLot: 2485082)							
EM1210094-015	Anonymous	EP079-CWG: Aromatic >C5-C7	----	20 µg/L	91.6	70	130
		EP079-CWG: Aromatic >C7-C8	TPHCWG-ARV2	20 µg/L	99.2	70	130
EP117: Alcohols (QCLot: 2477831)							
EM1209924-001	Tindilpie Pad Pit Flowback frac pit water post flowback	EP117: Ethanol	64-17-5	100 µg/L	# Not Determined	70	130
		EP117: Isopropanol	67-63-0	100 µg/L	# Not Determined	70	130
		EP117: n-Propanol	71-23-8	100 µg/L	# Not Determined	70	130
		EP117: Isobutanol	78-83-1	1000 µg/L	99.7	70	130
		EP117: n-Butanol	71-36-3	100 µg/L	# Not Determined	70	130

INTERPRETIVE QUALITY CONTROL REPORT

Work Order	: **EM1209924**	Page	: 1 of 15
Amendment	: **1**		
Client	: SANTOS LTD	Laboratory	: Environmental Division Melbourne
Contact	: MR BARRY RITCHIE	Contact	: Jodie Hancock
Address	: GROUND FLOOR SANTOS CENTRE 60 FLINDERS STREET ADELAIDE SA, AUSTRALIA 5001	Address	: 4 Westall Rd Springvale VIC Australia 3171
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Telephone	: +61 08 8116 5000	Telephone	: +61 7 3243 7128
Facsimile	: +61 08 8116 5050	Facsimile	: +61 7 3243 7218
Project	: HFRA Fluids Sampling - Extended Analysis	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Site	: ----		
C-O-C number	: ----	Date Samples Received	: 28-AUG-2012
Sampler	: BC/AJ	Issue Date	: 12-SEP-2012
Order number	: 879002/538		
		No. of samples received	: 1
Quote number	: EN/039/11	No. of samples analysed	: 1

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Interpretive Quality Control Report contains the following information:

- Analysis Holding Time Compliance
- Quality Control Parameter Frequency Compliance
- Brief Method Summaries
- Summary of Outliers

Analysis Holding Time Compliance

The following report summarises extraction / preparation and analysis times and compares with recommended holding times. Dates reported represent first date of extraction or analysis and precludes subsequent dilutions and reruns. Information is also provided re the sample container (preservative) from which the analysis aliquot was taken. Elapsed period to analysis represents number of days from sampling where no extraction / digestion is involved or period from extraction / digestion where this is present. For composite samples, sampling date is assumed to be that of the oldest sample contributing to the composite. Sample date for laboratory produced leachates is assumed as the completion date of the leaching process. Outliers for holding time are based on USEPA SW 846, APHA, AS and NEPM (1999). A listing of breaches is provided in the Summary of Outliers.

Holding times for leachate methods (excluding elutriates) vary according to the analytes being determined on the resulting solution. For non-volatile analytes, the holding time compliance assessment compares the leach date with the shortest analyte holding time for the equivalent soil method. These soil holding times are: Organics (14 days); Mercury (28 days) & other metals (180 days). A recorded breach therefore does not guarantee a breach for all non-volatile parameters.

Matrix: **WATER**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method / Container / Client Sample ID(s)	Sample Date	Extraction / Preparation			Analysis		
		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EA005: pH							
Clear Plastic Bottle - Natural							
Tindilpie Pad Pit Flowback - frac pit water post flowback	**27-AUG-2012**	**----**	----	----	**31-AUG-2012**	27-AUG-2012	×
EA006: Sodium Adsorption Ratio (SAR)							
Clear Plastic Bottle - Natural							
Tindilpie Pad Pit Flowback - frac pit water post flowback	**27-AUG-2012**	**---**	03-SEP-2012	----	**03-SEP-2012**	03-SEP-2012	✓
EA015: Total Dissolved Solids							
Clear Plastic Bottle - Natural							
Tindilpie Pad Pit Flowback - frac pit water post flowback	**27-AUG-2012**	**----**	----	----	**30-AUG-2012**	03-SEP-2012	✓
ED009: Anions							
Clear Plastic Bottle - Natural							
Tindilpie Pad Pit Flowback - frac pit water post flowback	**27-AUG-2012**	**----**	----	----	**03-SEP-2012**	24-SEP-2012	✓
ED037P: Alkalinity by PC Titrator							
Clear Plastic Bottle - Natural							
Tindilpie Pad Pit Flowback - frac pit water post flowback	**27-AUG-2012**	**---**	10-SEP-2012	----	**30-AUG-2012**	10-SEP-2012	✓
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA							
Clear Plastic Bottle - Natural							
Tindilpie Pad Pit Flowback - frac pit water post flowback	**27-AUG-2012**	**---**	24-SEP-2012	----	**31-AUG-2012**	24-SEP-2012	✓
ED045G: Chloride Discrete analyser							
Clear Plastic Bottle - Natural							
Tindilpie Pad Pit Flowback - frac pit water post flowback	**27-AUG-2012**	**---**	24-SEP-2012	----	**31-AUG-2012**	24-SEP-2012	✓
ED093F: Dissolved Major Cations							
Clear Plastic Bottle - Natural							
Tindilpie Pad Pit Flowback - frac pit water post flowback	**27-AUG-2012**	**---**	03-SEP-2012	----	**03-SEP-2012**	03-SEP-2012	✓
EG020F: Dissolved Metals by ICP-MS							
Clear Plastic Bottle - Natural							
Tindilpie Pad Pit Flowback - frac pit water post flowback	**27-AUG-2012**	**---**	23-FEB-2013	----	**03-SEP-2012**	23-FEB-2013	✓
EG035F: Dissolved Mercury by FIMS							
Clear Plastic Bottle - Natural							
Tindilpie Pad Pit Flowback - frac pit water post flowback	**27-AUG-2012**	**---**	10-SEP-2012	----	**04-SEP-2012**	10-SEP-2012	✓
EK011: Chlorine - Free							
Clear Plastic Bottle - Natural							
Tindilpie Pad Pit Flowback - frac pit water post flowback	**27-AUG-2012**	**----**	----	----	**29-AUG-2012**	27-AUG-2012	×

Matrix: **WATER**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method / Container / Client Sample ID(s)	Sample Date	Extraction / Preparation			Analysis		
		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EK025G: Free cyanide by Discrete Analyser							
White Plastic Bottle-NaOH							
Tindilpie Pad Pit Flowback - frac pit water post flowback	**27-AUG-2012**	**30-AUG-2012**	10-SEP-2012	✓	**30-AUG-2012**	10-SEP-2012	✓
EK026G: Total Cyanide By Discrete Analyser							
White Plastic Bottle-NaOH							
Tindilpie Pad Pit Flowback - frac pit water post flowback	**27-AUG-2012**	**30-AUG-2012**	10-SEP-2012	✓	**30-AUG-2012**	10-SEP-2012	✓
EK040P: Fluoride by PC Titrator							
Clear Plastic Bottle - Natural							
Tindilpie Pad Pit Flowback - frac pit water post flowback	**27-AUG-2012**	**---**	24-SEP-2012	----	**30-AUG-2012**	24-SEP-2012	✓
EK055G: Ammonia as N by Discrete Analyser							
Clear Plastic Bottle - Sulfuric Acid							
Tindilpie Pad Pit Flowback - frac pit water post flowback	**27-AUG-2012**	**---**	24-SEP-2012	----	**03-SEP-2012**	24-SEP-2012	✓
EK057G: Nitrite as N by Discrete Analyser							
Clear Plastic Bottle - Natural							
Tindilpie Pad Pit Flowback - frac pit water post flowback	**27-AUG-2012**	**---**	29-AUG-2012	----	**30-AUG-2012**	29-AUG-2012	×
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser							
Clear Plastic Bottle - Sulfuric Acid							
Tindilpie Pad Pit Flowback - frac pit water post flowback	**27-AUG-2012**	**---**	24-SEP-2012	----	**31-AUG-2012**	24-SEP-2012	✓
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser							
Clear Plastic Bottle - Sulfuric Acid							
Tindilpie Pad Pit Flowback - frac pit water post flowback	**27-AUG-2012**	**31-AUG-2012**	24-SEP-2012	✓	**03-SEP-2012**	24-SEP-2012	✓
EK067G: Total Phosphorus as P by Discrete Analyser							
Clear Plastic Bottle - Sulfuric Acid							
Tindilpie Pad Pit Flowback - frac pit water post flowback	**27-AUG-2012**	**31-AUG-2012**	24-SEP-2012	✓	**03-SEP-2012**	24-SEP-2012	✓
EK071G: Reactive Phosphorus as P by discrete analyser							
Clear Plastic Bottle - Natural							
Tindilpie Pad Pit Flowback - frac pit water post flowback	**27-AUG-2012**	**---**	29-AUG-2012	----	**30-AUG-2012**	29-AUG-2012	×
EP005: Total Organic Carbon (TOC)							
Amber VOC Vial - Sulfuric Acid							
Tindilpie Pad Pit Flowback - frac pit water post flowback	**27-AUG-2012**	**----**	----	----	**07-SEP-2012**	24-SEP-2012	✓
EP010: Formaldehyde							
Clear Plastic Bottle - Natural							
Tindilpie Pad Pit Flowback - frac pit water post flowback	**27-AUG-2012**	**----**	----	----	**29-AUG-2012**	29-AUG-2012	✓
EP041A: Nonionic Surfactants							
Pres. with Formaldehyde on receipt							
Tindilpie Pad Pit Flowback - frac pit water post flowback	**27-AUG-2012**	**----**	----	----	**03-SEP-2012**	24-SEP-2012	✓
EP050: Anionic Surfactants as MBAS							
Pres. with Formaldehyde on receipt							
Tindilpie Pad Pit Flowback - frac pit water post flowback	**27-AUG-2012**	**----**	----	----	**30-AUG-2012**	31-AUG-2012	✓
EP074A: Monocyclic Aromatic Hydrocarbons							
Amber VOC Vial - Sulfuric Acid							
Tindilpie Pad Pit Flowback - frac pit water post flowback	**27-AUG-2012**	**06-SEP-2012**	10-SEP-2012	✓	**07-SEP-2012**	10-SEP-2012	✓

Matrix: **WATER**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method / Container / Client Sample ID(s)	Sample Date	Extraction / Preparation			Analysis		
		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EP074B: Oxygenated Compounds							
Amber VOC Vial - Sulfuric Acid							
Tindilpie Pad Pit Flowback - frac pit water post flowback	**27-AUG-2012**	**06-SEP-2012**	10-SEP-2012	✓	**07-SEP-2012**	10-SEP-2012	✓
EP074C: Sulfonated Compounds							
Amber VOC Vial - Sulfuric Acid							
Tindilpie Pad Pit Flowback - frac pit water post flowback	**27-AUG-2012**	**06-SEP-2012**	10-SEP-2012	✓	**07-SEP-2012**	10-SEP-2012	✓
EP074D: Fumigants							
Amber VOC Vial - Sulfuric Acid							
Tindilpie Pad Pit Flowback - frac pit water post flowback	**27-AUG-2012**	**06-SEP-2012**	10-SEP-2012	✓	**07-SEP-2012**	10-SEP-2012	✓
EP074E: Halogenated Aliphatic Compounds							
Amber VOC Vial - Sulfuric Acid							
Tindilpie Pad Pit Flowback - frac pit water post flowback	**27-AUG-2012**	**06-SEP-2012**	10-SEP-2012	✓	**07-SEP-2012**	10-SEP-2012	✓
EP074F: Halogenated Aromatic Compounds							
Amber VOC Vial - Sulfuric Acid							
Tindilpie Pad Pit Flowback - frac pit water post flowback	**27-AUG-2012**	**06-SEP-2012**	10-SEP-2012	✓	**07-SEP-2012**	10-SEP-2012	✓
EP074G: Trihalomethanes							
Amber VOC Vial - Sulfuric Acid							
Tindilpie Pad Pit Flowback - frac pit water post flowback	**27-AUG-2012**	**06-SEP-2012**	10-SEP-2012	✓	**07-SEP-2012**	10-SEP-2012	✓
EP075A: Phenolic Compounds							
Amber Glass Bottle - Unpreserved							
Tindilpie Pad Pit Flowback - frac pit water post flowback	**27-AUG-2012**	**30-AUG-2012**	03-SEP-2012	✓	**04-SEP-2012**	09-OCT-2012	✓
EP075B: Polynuclear Aromatic Hydrocarbons							
Amber Glass Bottle - Unpreserved							
Tindilpie Pad Pit Flowback - frac pit water post flowback	**27-AUG-2012**	**30-AUG-2012**	03-SEP-2012	✓	**04-SEP-2012**	09-OCT-2012	✓
EP075C: Phthalate Esters							
Amber Glass Bottle - Unpreserved							
Tindilpie Pad Pit Flowback - frac pit water post flowback	**27-AUG-2012**	**30-AUG-2012**	03-SEP-2012	✓	**04-SEP-2012**	09-OCT-2012	✓
EP075D: Nitrosamines							
Amber Glass Bottle - Unpreserved							
Tindilpie Pad Pit Flowback - frac pit water post flowback	**27-AUG-2012**	**30-AUG-2012**	03-SEP-2012	✓	**04-SEP-2012**	09-OCT-2012	✓
EP075E: Nitroaromatics and Ketones							
Amber Glass Bottle - Unpreserved							
Tindilpie Pad Pit Flowback - frac pit water post flowback	**27-AUG-2012**	**30-AUG-2012**	03-SEP-2012	✓	**04-SEP-2012**	09-OCT-2012	✓
EP075F: Haloethers							
Amber Glass Bottle - Unpreserved							
Tindilpie Pad Pit Flowback - frac pit water post flowback	**27-AUG-2012**	**30-AUG-2012**	03-SEP-2012	✓	**04-SEP-2012**	09-OCT-2012	✓
EP075G: Chlorinated Hydrocarbons							
Amber Glass Bottle - Unpreserved							
Tindilpie Pad Pit Flowback - frac pit water post flowback	**27-AUG-2012**	**30-AUG-2012**	03-SEP-2012	✓	**04-SEP-2012**	09-OCT-2012	✓
EP075H: Anilines and Benzidines							
Amber Glass Bottle - Unpreserved							
Tindilpie Pad Pit Flowback - frac pit water post flowback	**27-AUG-2012**	**30-AUG-2012**	03-SEP-2012	✓	**04-SEP-2012**	09-OCT-2012	✓

Matrix: **WATER**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method / Container / Client Sample ID(s)	Sample Date	Extraction / Preparation			Analysis		
		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EP075I: Organochlorine Pesticides							
Amber Glass Bottle - Unpreserved							
Tindilpie Pad Pit Flowback - frac pit water post flowback	**27-AUG-2012**	**30-AUG-2012**	03-SEP-2012	✓	**04-SEP-2012**	09-OCT-2012	✓
EP075J: Organophosphorus Pesticides							
Amber Glass Bottle - Unpreserved							
Tindilpie Pad Pit Flowback - frac pit water post flowback	**27-AUG-2012**	**30-AUG-2012**	03-SEP-2012	✓	**04-SEP-2012**	09-OCT-2012	✓
EP117: Alcohols							
Amber VOC Vial - Sulfuric Acid							
Tindilpie Pad Pit Flowback - frac pit water post flowback	**27-AUG-2012**	**----**	----	----	**31-AUG-2012**	10-SEP-2012	✓
RIVM Aliphatic Hydrocarbon Fractions							
Amber Glass Bottle - Unpreserved							
Tindilpie Pad Pit Flowback - frac pit water post flowback	**27-AUG-2012**	**30-AUG-2012**	03-SEP-2012	✓	**05-SEP-2012**	09-OCT-2012	✓
Amber VOC Vial - Sulfuric Acid							
Tindilpie Pad Pit Flowback - frac pit water post flowback	**27-AUG-2012**	**06-SEP-2012**	10-SEP-2012	✓	**07-SEP-2012**	10-SEP-2012	✓
RIVM Aromatic Hydrocarbon Fractions							
Amber Glass Bottle - Unpreserved							
Tindilpie Pad Pit Flowback - frac pit water post flowback	**27-AUG-2012**	**30-AUG-2012**	03-SEP-2012	✓	**05-SEP-2012**	09-OCT-2012	✓
Amber VOC Vial - Sulfuric Acid							
Tindilpie Pad Pit Flowback - frac pit water post flowback	**27-AUG-2012**	**06-SEP-2012**	10-SEP-2012	✓	**07-SEP-2012**	10-SEP-2012	✓

Quality Control Parameter Frequency Compliance

The following report summarises the frequency of laboratory QC samples analysed within the analytical lot(s) in which the submitted sample(s) was(where) processed. Actual rate should be greater than or equal to the expected rate. A listing of breaches is provided in the Summary of Outliers.

Matrix: **WATER**

Evaluation: × = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	*Method*	*QC*	*Regular*	***Actual***	***Expected***	*Evaluation*	
Laboratory Duplicates (DUP)							
Alcohols by HS-GC-MS	EP117	1	1	**100.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Alkalinity by PC Titrator	ED037-P	2	20	**10.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Ammonia as N by Discrete analyser	EK055G	2	20	**10.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Anionic Surfactants as MBAS	EP050	1	4	**25.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Chloride by Discrete Analyser	ED045G	1	4	**25.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Dissolved Mercury by FIMS	EG035F	2	20	**10.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Dissolved Metals by ICP-MS - Suite A	EG020A-F	2	20	**10.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Dissolved Metals by ICP-MS - Suite B	EG020B-F	2	19	**10.5**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Fluoride by PC Titrator	EK040P	2	20	**10.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Formaldehyde	EP010	1	1	**100.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Free CN by Segmented Flow Analyser	EK025SF	1	6	**16.7**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Major Cations - Dissolved	ED093F	1	4	**25.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	2	17	**11.8**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Nitrite as N by Discrete Analyser	EK057G	2	20	**10.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Nonionic Surfactants as CTAS	EP041A	1	2	**50.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
pH	EA005	2	20	**10.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Reactive Phosphorus as P-By Discrete Analyser	EK071G	2	12	**16.7**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Semivolatile Organic Compounds	EP075	1	1	**100.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Standard Anions -by IC (Extended Method)	ED009-X	1	7	**14.3**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	2	20	**10.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Cyanide by Segmented Flow Analyser	EK026SF	1	8	**12.5**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Dissolved Solids (High Level)	EA015H	2	20	**10.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Kjeldahl Nitrogen as N By Discrete Analyser	EK061G	2	20	**10.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Organic Carbon	EP005	2	20	**10.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Phosphorus as P By Discrete Analyser	EK067G	2	12	**16.7**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
TPH Speciation (TPH CWG RIVM fractions)	EP070-CWG	1	1	**100.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Volatile Hydrocarbon Speciation (TPH CWG fractions)	EP079-CWG	1	3	**33.3**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Volatile Organic Compounds	EP074	1	5	**20.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Laboratory Control Samples (LCS)							
Alcohols by HS-GC-MS	EP117	1	1	**100.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Alkalinity by PC Titrator	ED037-P	1	20	**5.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Ammonia as N by Discrete analyser	EK055G	1	20	**5.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Anionic Surfactants as MBAS	EP050	1	4	**25.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Chloride by Discrete Analyser	ED045G	2	4	**50.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Dissolved Mercury by FIMS	EG035F	1	20	**5.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Dissolved Metals by ICP-MS - Suite A	EG020A-F	1	20	**5.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Dissolved Metals by ICP-MS - Suite B	EG020B-F	1	19	**5.3**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Fluoride by PC Titrator	EK040P	1	20	**5.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Formaldehyde	EP010	1	1	**100.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement

Matrix: **WATER**

Evaluation: × = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	*Method*	*QC*	*Regular*	***Actual***	***Expected***	*Evaluation*	
Laboratory Control Samples (LCS) - Continued							
Free CN by Segmented Flow Analyser	EK025SF	1	6	**16.7**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Major Cations - Dissolved	ED093F	1	4	**25.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	1	17	**5.9**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Nitrite as N by Discrete Analyser	EK057G	1	20	**5.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Nonionic Surfactants as CTAS	EP041A	1	2	**50.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Reactive Phosphorus as P-By Discrete Analyser	EK071G	1	12	**8.3**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Semivolatile Organic Compounds	EP075	1	1	**100.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Standard Anions -by IC (Extended Method)	ED009-X	1	7	**14.3**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	1	20	**5.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Cyanide by Segmented Flow Analyser	EK026SF	1	8	**12.5**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Dissolved Solids (High Level)	EA015H	1	20	**5.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Kjeldahl Nitrogen as N By Discrete Analyser	EK061G	1	20	**5.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Organic Carbon	EP005	1	20	**5.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Phosphorus as P By Discrete Analyser	EK067G	1	12	**8.3**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
TPH Speciation (TPH CWG RIVM fractions)	EP070-CWG	1	1	**100.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Volatile Hydrocarbon Speciation (TPH CWG fractions)	EP079-CWG	1	3	**33.3**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Volatile Organic Compounds	EP074	1	5	**20.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Method Blanks (MB)							
Alcohols by HS-GC-MS	EP117	1	1	**100.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Ammonia as N by Discrete analyser	EK055G	1	20	**5.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Anionic Surfactants as MBAS	EP050	1	4	**25.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Chloride by Discrete Analyser	ED045G	1	4	**25.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Dissolved Mercury by FIMS	EG035F	1	20	**5.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Dissolved Metals by ICP-MS - Suite A	EG020A-F	1	20	**5.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Dissolved Metals by ICP-MS - Suite B	EG020B-F	1	19	**5.3**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Fluoride by PC Titrator	EK040P	1	20	**5.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Formaldehyde	EP010	1	1	**100.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Free CN by Segmented Flow Analyser	EK025SF	1	6	**16.7**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Major Cations - Dissolved	ED093F	1	4	**25.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	1	17	**5.9**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Nitrite as N by Discrete Analyser	EK057G	1	20	**5.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Nonionic Surfactants as CTAS	EP041A	1	2	**50.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Reactive Phosphorus as P-By Discrete Analyser	EK071G	1	12	**8.3**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Semivolatile Organic Compounds	EP075	1	1	**100.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Standard Anions -by IC (Extended Method)	ED009-X	1	7	**14.3**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	1	20	**5.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Cyanide by Segmented Flow Analyser	EK026SF	1	8	**12.5**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Dissolved Solids (High Level)	EA015H	1	20	**5.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Kjeldahl Nitrogen as N By Discrete Analyser	EK061G	1	20	**5.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Organic Carbon	EP005	1	20	**5.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Phosphorus as P By Discrete Analyser	EK067G	1	12	**8.3**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
TPH Speciation (TPH CWG RIVM fractions)	EP070-CWG	1	1	**100.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Volatile Hydrocarbon Speciation (TPH CWG fractions)	EP079-CWG	1	3	**33.3**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement

Matrix: **WATER**

Evaluation: × = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	*Method*	*QC*	*Regular*	***Actual***	***Expected***	*Evaluation*	
Method Blanks (MB) - Continued							
Volatile Organic Compounds	EP074	1	5	**20.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Matrix Spikes (MS)							
Alcohols by HS-GC-MS	EP117	1	1	**100.0**	**5.0**	✓	ALS QCS3 requirement
Ammonia as N by Discrete analyser	EK055G	1	20	**5.0**	**5.0**	✓	ALS QCS3 requirement
Anionic Surfactants as MBAS	EP050	1	4	**25.0**	**5.0**	✓	ALS QCS3 requirement
Chloride by Discrete Analyser	ED045G	1	4	**25.0**	**5.0**	✓	ALS QCS3 requirement
Dissolved Mercury by FIMS	EG035F	1	20	**5.0**	**5.0**	✓	ALS QCS3 requirement
Dissolved Metals by ICP-MS - Suite A	EG020A-F	1	20	**5.0**	**5.0**	✓	ALS QCS3 requirement
Fluoride by PC Titrator	EK040P	1	20	**5.0**	**5.0**	✓	ALS QCS3 requirement
Free CN by Segmented Flow Analyser	EK025SF	1	6	**16.7**	**5.0**	✓	ALS QCS3 requirement
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	1	17	**5.9**	**5.0**	✓	ALS QCS3 requirement
Nitrite as N by Discrete Analyser	EK057G	1	20	**5.0**	**5.0**	✓	ALS QCS3 requirement
Nonionic Surfactants as CTAS	EP041A	1	2	**50.0**	**5.0**	✓	ALS QCS3 requirement
Reactive Phosphorus as P-By Discrete Analyser	EK071G	1	12	**8.3**	**5.0**	✓	ALS QCS3 requirement
Semivolatile Organic Compounds	EP075	1	1	**100.0**	**5.0**	✓	ALS QCS3 requirement
Standard Anions -by IC (Extended Method)	ED009-X	1	7	**14.3**	**5.0**	✓	ALS QCS3 requirement
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	1	20	**5.0**	**5.0**	✓	ALS QCS3 requirement
Total Cyanide by Segmented Flow Analyser	EK026SF	1	8	**12.5**	**5.0**	✓	ALS QCS3 requirement
Total Kjeldahl Nitrogen as N By Discrete Analyser	EK061G	1	20	**5.0**	**5.0**	✓	ALS QCS3 requirement
Total Organic Carbon	EP005	1	20	**5.0**	**5.0**	✓	ALS QCS3 requirement
Total Phosphorus as P By Discrete Analyser	EK067G	1	12	**8.3**	**5.0**	✓	ALS QCS3 requirement
Volatile Hydrocarbon Speciation (TPH CWG fractions)	EP079-CWG	1	3	**33.3**	**5.0**	✓	ALS QCS3 requirement
Volatile Organic Compounds	EP074	1	5	**20.0**	**5.0**	✓	ALS QCS3 requirement

Brief Method Summaries

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the US EPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request. The following report provides brief descriptions of the analytical procedures employed for results reported in the Certificate of Analysis. Sources from which ALS methods have been developed are provided within the Method Descriptions.

Analytical Methods	Method	Matrix	Method Descriptions
pH	EA005	WATER	APHA 21st ed. 4500 H+ B. pH of water samples is determined by ISE either manually or by automated pH meter. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Total Dissolved Solids (High Level)	EA015H	WATER	In-House, APHA 21st ed., 2540C A gravimetric procedure that determines the amount of `filterable` residue in an aqueous sample. A well-mixed sample is filtered through a glass fibre filter (1.2um). The filtrate is evaporated to dryness and dried to constant weight at 180+/-5C. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Hardness as CaCO3	EA065	WATER	APHA 21st ed., 2340 B. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Standard Anions -by IC (Extended Method)	* ED009-X	WATER	APHA 21st ed., 4110. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Alkalinity by PC Titrator	ED037-P	WATER	APHA 21st ed., 2320 B This procedure determines alkalinity by automated measurement (e.g. PC Titrate) using pH 4.5 for indicating the total alkalinity end-point. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Major Anions - Dissolved	ED040F	WATER	APHA 21st ed., 3120. The 0.45um filtered samples are determined by ICP/AES for Sulfur and/or Silcon content and reported as Sulfate and/or Silica after conversion by gravimetric factor.
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	WATER	APHA 21st ed., 4500-SO4 Sulfate ions are converted to a barium sulfate suspension in an acetic acid medium with barium chloride. Light absorbance of the BaSO4 suspension is measured by a photometer and the SO4-2 concentration is determined by comparison of the reading with a standard curve. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Chloride by Discrete Analyser	ED045G	WATER	APHA 21st ed., 4500 Cl - G.The thiocyanate ion is liberated from mercuric thiocyanate through sequestration of mercury by the chloride ion to form non-ionised mercuric chloride.in the presence of ferric ions the librated thiocynate forms highly-coloured ferric thiocynate which is measured at 480 nm APHA 21st edition seal method 2 017-1-L april 2003
Major Cations - Dissolved	ED093F	WATER	Major Cations is determined based on APHA 21st ed., 3120; USEPA SW 846 - 6010 The ICPAES technique ionises the 0.45um filtered sample atoms emitting a characteristic spectrum. This spectrum is then compared against matrix matched standards for quantification. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2) Sodium Absorption Ratio is calculated from Ca, Mg and Na which determined by ALS in house method QWI-EN/ED093F. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2) Hardness parameters are calculated based on APHA 21st ed., 2340 B. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Dissolved Metals by ICP-MS - Suite A	EG020A-F	WATER	(APHA 21st ed., 3125; USEPA SW846 - 6020, ALS QWI-EN/EG020): Samples are 0.45 um filtered prior to analysis. The ICPMS technique utilizes a highly efficient argon plasma to ionize selected elements. Ions are then passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to their measurement by a discrete dynode ion detector.
Dissolved Metals by ICP-MS - Suite B	EG020B-F	WATER	(APHA 21st ed., 3125; USEPA SW846 - 6020, ALS QWI-EN/EG020): Samples are 0.45 um filtered prior to analysis. The ICPMS technique utilizes a highly efficient argon plasma to ionize selected elements. Ions are then passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to their measurement by a discrete dynode ion detector.

Analytical Methods	Method	Matrix	Method Descriptions
Dissolved Mercury by FIMS	EG035F	WATER	AS 3550, APHA 21st ed. 3112 Hg - B (Flow-injection (SnCl2)(Cold Vapour generation) AAS) Samples are 0.45 um filtered prior to analysis. FIM-AAS is an automated flameless atomic absorption technique. A bromate/bromide reagent is used to oxidise any organic mercury compounds in the filtered sample. The ionic mercury is reduced online to atomic mercury vapour by SnCl2 which is then purged into a heated quartz cell. Quantification is by comparing absorbance against a calibration curve. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Silica (Total Dissolved) by ICPAES	EG052F	WATER	APHA 21st ed., 4500-SiO2. Silica (Total) determined by calculation from Silicon by ICPAES.
Residual Chlorine by DPD Colourimetry	EK010-1 (Field)	WATER	Adapted from APHA 21st edition, 4500-Cl G, using Palintest Chlorometer 1000
Free CN by Segmented Flow Analyser	EK025SF	WATER	ASTM D7237: Using an automated segmented flow analyser, a sample at high pH (sodium hydroxide preserved) is buffered to pH 6.0. The hydrogen cyanide present passes across a gas dialysis membrane into an acceptor stream consisting of 0.01 M sodium hydroxide. The acceptor stream mixes with a buffer at pH 5.2 and reacts with chloramine-T to form cyanogen chloride. Cyanogen chloride reacts with 4-pyridine carboxylic acid and 1,3-dimethylbarbituric acid to give a red colour, measured at 600nm. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Total Cyanide by Segmented Flow Analyser	EK026SF	WATER	APHA 4500-CN-O. Sodium hydroxide preserved samples are introduced into an automated segmented flow analyser. Complex bound cyanide is decomposed in a continuously flowing stream, at a pH of 3.8, by the effect of UV light. A UV-B lamp (312 nm) and a decomposition spiral of borosilicate glass are used to filter out UV light with a wavelength of less than 290 nm thus preventing the conversion of thiocyanate into cyanide. The hydrogen cyanide present at a pH of 3.8 is separated by gas dialysis. The hydrogen cyanide is then determined photometrically, based on the reaction of cyanide with chloramine-T to form cyanogen chloride. This then reacts with 4-pyridine carboxylic acid and 1,3-dimethylbarbituric acid to give a red colour which is measured at 600 nm. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Fluoride by PC Titrator	EK040P	WATER	APHA 21st ed., 4500 F--C CDTA is added to the sample to provide a uniform ionic strength background, adjust pH, and break up complexes. Fluoride concentration is determined by either manual or automatic ISE measurement. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Ammonia as N by Discrete analyser	EK055G	WATER	APHA 21st ed., 4500-NH3 G Ammonia is determined by direct colorimetry by Discrete Analyser. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Nitrite as N by Discrete Analyser	EK057G	WATER	APHA 21st ed., 4500-NO2- B. Nitrite is determined by direct colourimetry by Discrete Analyser. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Nitrate as N by Discrete Analyser	EK058G	WATER	APHA 21st ed., 4500-NO3- F. Nitrate is reduced to nitrite by way of a chemical reduction followed by quantification by Discrete Analyser. Nitrite is determined seperately by direct colourimetry and result for Nitrate calculated as the difference between the two results. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	WATER	APHA 21st ed., 4500-NO3- F. Combined oxidised Nitrogen (NO2+NO3) is determined by Chemical Reduction and direct colourimetry by Discrete Analyser. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Total Kjeldahl Nitrogen as N By Discrete Analyser	EK061G	WATER	APHA 21st ed., 4500-Norg D. 25mL water samples are digested using a traditional Kjeldahl digestion followed by determination by Discrete Analyser. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Total Nitrogen as N (TKN + Nox) By Discrete Analyser	EK062G	WATER	APHA 21st ed., 4500-Norg / 4500-NO3-. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Total Phosphorus as P By Discrete Analyser	EK067G	WATER	APHA 21st ed., 4500-P B&F This procedure involves sulphuric acid digestion of a 100mL sample to break phosphorus down to orthophosphate. The orthophosphate reacts with ammonium molybdate and antimony potassium tartrate to form a complex which is then reduced and its concentration measured at 880nm using Discrete Analyser. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)

Analytical Methods	Method	Matrix	Method Descriptions
Reactive Phosphorus as P-By Discrete Analyser	EK071G	WATER	APHA 21st ed., 4500-P F Ammonium molybdate and potassium antimonyl tartrate reacts in acid medium with othophosphate to form a heteropoly acid -phosphomolybdic acid - which is reduced to intensely coloured molybdenum blue by ascorbic acid. Quantification is by Discrete Analyser. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Ionic Balance by PCT DA and Turbi SO4 DA	EN055 - PG	WATER	APHA 21st Ed. 1030F. The Ionic Balance is calculated based on the major Anions and Cations. The major anions include Alkalinity, Chloride and Sulfate which determined by PCT and DA. The Cations are determined by Turbi SO4 by DA. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Total Organic Carbon	EP005	WATER	APHA 21st ed., 5310 B, The automated TOC analyzer determines Total and Inorganic Carbon by IR cell. TOC is calculated as the difference. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Formaldehyde	EP010	WATER	In-house (ASTM D 6303-98) Determined by colourimetry using NASH reagent. The Hantszch reaction method is based on the reaction of acetylacetone with formaldehyde in the presence of excess ammonium acetate to form a coloured compound.
Nonionic Surfactants as CTAS	EP041A	WATER	APHA 21st ed., 5540 B & D This method estimates the non-ionic surfactant content of waters. Sublation transfers all surfactants into a solvent matrix. Cationic and Anionic surfactants are removed by an ion exchange resin column. The remaining surfactant is coloured up with Cobalt Thiocyanate solution and quantified by UV-vis against LAS standards. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Anionic Surfactants as MBAS	EP050	WATER	APHA 21st ed., 5540 B & C This method comprises three successive extractions from acid aqueous medium containing excess methylene blue, into chloroform, followed by an aqueous backwash and measurement of the colour by spectrophotometry at 652nm. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
TPH Speciation (TPH CWG RIVM fractions)	EP070-CWG	WATER	In-house: Determination of TPH following fractionation by GC-FID. Fractions correspond to those outlined in TPHCWG, 1998,Analysis of Petroleum Hydrocarbons in Environmental Media, TPH Criteria Working Group, Toxicity Technical Action Group, vol I and RIVM report 601501021/2004, Environmental Risk Limits for Mineral Oil (Total Petroleum Hydrocarbons). Aliphatic >C21 - C35 is defined by RIVM only.
Volatile Organic Compounds	EP074	WATER	USEPA SW 846 - 8260B Water samples are directly purged prior to analysis by Capillary GC/MS and quantification is by comparison against an established 5 point calibration curve. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Semivolatile Organic Compounds	EP075	WATER	USEPA SW 846 - 8270D Sample extracts are analysed by Capillary GC/MS and quantification is by comparison against an established 5 point calibration curve. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Volatile Hydrocarbon Speciation (TPH CWG fractions)	EP079-CWG	WATER	In-house. Conventional TPH and MAH data are determined by Purge and Trap GCMS analysis. TIC data (as fractions) and target aromatics (or groups of aromatics) are used to compute aliphatic and aromotic hydrocarbon fractions by addition or difference. Fractions conform to those outlined in TPHCWG, 1998,Analysis of Petroleum Hydrocarbons in Environmental Media, TPH Criteria Working Group, Toxicity Technical Action Group, vol I and RIVM report 601501021/2004, Environmental Risk Limits for Mineral Oil (Total Petroleum Hydrocarbons)
Alcohols by HS-GC-MS	* EP117	WATER	In House. A 10 mL aliquot of sample is mixed with 4 g of sodium chloride, equilibrated at 80 degrees C for 10 minutes and the headspace analysed by GCMS in the selected ion monitoring mode.

Preparation Methods	Method	Matrix	Method Descriptions
CN Dummy Prep	CN-DP	WATER	CN Dummy Prep for SFA Determinations
Free Cyanide	EK025-PR	WATER	APHA 21st ed., 4500 CN- C&N. The sample is distilled at natural pH. The CN is trapped in a caustic solution, and quanitified by colourimetry on FIA. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Separatory Funnel Extraction of Liquids	ORG14	WATER	USEPA SW 846 - 3510B 500 mL to 1L of sample is transferred to a separatory funnel and serially extracted three times using 60mL DCM for each extract. The resultant extracts are combined, dehydrated and concentrated for analysis. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2). ALS default excludes sediment which may be resident in the container.

Preparation Methods	Method	Matrix	Method Descriptions
Separatory Funnel Extraction of Liquids	ORG14-HX	WATER	Variation of USEPA SW 846 - 3510B: 500 mL to 0.5L of sample is transferred to a separatory funnel and serially extracted three times using 30mL DCM for each extract. The resultant extracts are combined, dehydrated, and exchanged into 5 mL of hexane for analysis. ALS default excludes sediment which may be resident in the container.
Volatiles Water Preparation	ORG16-W	WATER	A 5 mL aliquot or 5 mL of a diluted sample is added to a 40 mL VOC vial for sparging.

Summary of Outliers

Outliers : Quality Control Samples

The following report highlights outliers flagged in the Quality Control (QC) Report. Surrogate recovery limits are static and based on USEPA SW846 or ALS-QWI/EN/38 (in the absence of specific USEPA limits). This report displays QC Outliers (breaches) only.

Duplicates, Method Blanks, Laboratory Control Samples and Matrix Spikes

Matrix: **WATER**

Compound Group Name	Laboratory Sample ID	Client Sample ID	Analyte	CAS Number	Data	Limits	Comment
Duplicate (DUP) RPDs							
EP075B: Polynuclear Aromatic Hydrocarbons	EM1209924-001	Tindilpie Pad Pit Flowback frac	**2-Methylnaphthalene**	91-57-6	24.3 %	0-20%	**RPD exceeds LOR based limits**
Laboratory Control Spike (LCS) Recoveries							
EP075D: Nitrosamines	2932714-029	----	**Methapyrilene**	91-80-5	116 %	28.1-70%	**Recovery greater than upper control limit**
Matrix Spike (MS) Recoveries							
ED009: Anions	EM1209913-001	Anonymous	**Bromide**	24959-67-9	Not Determined	----	**MS recovery not determined, background level greater than or equal to 4x spike level.**
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Ar	EM1209937-001	Anonymous	**Nitrite + Nitrate as N**	----	66.7 %	70-130%	**Recovery less than lower data quality objective**
EK067G: Total Phosphorus as P by Discrete Analyser	EM1209916-012	Anonymous	**Total Phosphorus as P**	----	Not Determined	----	**MS recovery not determined, background level greater than or equal to 4x spike level.**
EP075A: Phenolic Compounds	EM1209924-001	Tindilpie Pad Pit Flowback frac	**Phenol**	108-95-2	Not Determined	----	**MS recovery not determined, background level greater than or equal to 4x spike level.**
EP075A: Phenolic Compounds	EM1209924-001	Tindilpie Pad Pit Flowback frac	**2-Chlorophenol**	95-57-8	Not Determined	----	**Matrix spike recovery not determined due to sample matrix interference.**
EP075A: Phenolic Compounds	EM1209924-001	Tindilpie Pad Pit Flowback frac	**2-Nitrophenol**	88-75-5	Not Determined	----	**Matrix spike recovery not determined due to sample matrix interference.**
EP075A: Phenolic Compounds	EM1209924-001	Tindilpie Pad Pit Flowback frac	**4-Chloro-3-Methylphenol**	59-50-7	Not Determined	----	**Matrix spike recovery not determined due to sample matrix interference.**
EP075A: Phenolic Compounds	EM1209924-001	Tindilpie Pad Pit Flowback frac	**Pentachlorophenol**	87-86-5	Not Determined	----	**Matrix spike recovery not determined due to sample matrix interference.**
EP075B: Polynuclear Aromatic Hydrocarbons	EM1209924-001	Tindilpie Pad Pit Flowback frac	**Acenaphthene**	83-32-9	Not Determined	----	**Matrix spike recovery not determined due to sample matrix interference.**
EP075B: Polynuclear Aromatic Hydrocarbons	EM1209924-001	Tindilpie Pad Pit Flowback frac	**Pyrene**	129-00-0	Not Determined	----	**Matrix spike recovery not determined due to sample matrix interference.**
EP075D: Nitrosamines	EM1209924-001	Tindilpie Pad Pit Flowback frac	**N-Nitrosodi-n-propylamine**	621-64-7	Not Determined	----	**Matrix spike recovery not determined due to sample matrix interference.**
EP075E: Nitroaromatics and Ketones	EM1209924-001	Tindilpie Pad Pit Flowback frac	**2.4-Dinitrotoluene**	121-14-2	Not Determined	----	**Matrix spike recovery not determined due to sample matrix interference.**
EP075G: Chlorinated Hydrocarbons	EM1209924-001	Tindilpie Pad Pit Flowback frac	**1.4-Dichlorobenzene**	106-46-7	Not Determined	----	**Matrix spike recovery not determined due to sample matrix interference.**
EP075G: Chlorinated Hydrocarbons	EM1209924-001	Tindilpie Pad Pit Flowback frac	**1.2.4-Trichlorobenzene**	120-82-1	Not Determined	----	**Matrix spike recovery not determined due to sample matrix interference.**

Matrix: **WATER**

Compound Group Name	Laboratory Sample ID	Client Sample ID	Analyte	CAS Number	Data	Limits	Comment
Matrix Spike (MS) Recoveries - Continued							
EP079/070: TPH CWG Aliphatic Hydrocarbon Fractions	EM1210094-015	Anonymous	**Aliphatic >C8-C10**	TPHCWG-ALV3	66.5 %	70-130%	**Recovery less than lower data quality objective**
EP117: Alcohols	EM1209924-001	Tindilpie Pad Pit Flowback frac	**Ethanol**	64-17-5	Not Determined	----	**MS recovery not determined, background level greater than or equal to 4x spike level.**
EP117: Alcohols	EM1209924-001	Tindilpie Pad Pit Flowback frac	**Isopropanol**	67-63-0	Not Determined	----	**MS recovery not determined, background level greater than or equal to 4x spike level.**
EP117: Alcohols	EM1209924-001	Tindilpie Pad Pit Flowback frac	**n-Propanol**	71-23-8	Not Determined	----	**MS recovery not determined, background level greater than or equal to 4x spike level.**
EP117: Alcohols	EM1209924-001	Tindilpie Pad Pit Flowback frac	**n-Butanol**	71-36-3	Not Determined	----	**Matrix spike recovery not determined due to sample matrix interference.**

- **For all matrices, no Method Blank value outliers occur.**

Regular Sample Surrogates

Sub-Matrix: **WATER**

Compound Group Name	Laboratory Sample ID	Client Sample ID	Analyte	CAS Number	Data	Limits	Comment
Samples Submitted							
EP075S: Acid Extractable Surrogates	EM1209924-001	Tindilpie Pad Pit Flowback frac	**2-Fluorophenol**	367-12-4	Not Determined	----	**Surrogate recovery not determined due to (target or non-target) matrix interferences**
EP075S: Acid Extractable Surrogates	EM1209924-001	Tindilpie Pad Pit Flowback frac	**Phenol-d6**	13127-88-3	Not Determined	----	**Surrogate recovery not determined due to (target or non-target) matrix interferences**
EP075S: Acid Extractable Surrogates	EM1209924-001	Tindilpie Pad Pit Flowback frac	**2-Chlorophenol-D4**	93951-73-6	Not Determined	----	**Surrogate recovery not determined due to (target or non-target) matrix interferences**
EP075S: Acid Extractable Surrogates	EM1209924-001	Tindilpie Pad Pit Flowback frac	**2.4.6-Tribromophenol**	118-79-6	Not Determined	----	**Surrogate recovery not determined due to (target or non-target) matrix interferences**
EP075T: Base/Neutral Extractable Surrogates	EM1209924-001	Tindilpie Pad Pit Flowback frac	**Nitrobenzene-D5**	4165-60-0	Not Determined	----	**Surrogate recovery not determined due to (target or non-target) matrix interferences**
EP075T: Base/Neutral Extractable Surrogates	EM1209924-001	Tindilpie Pad Pit Flowback frac	**1.2-Dichlorobenzene-D4**	2199-69-1	Not Determined	----	**Surrogate recovery not determined due to (target or non-target) matrix interferences**
EP075T: Base/Neutral Extractable Surrogates	EM1209924-001	Tindilpie Pad Pit Flowback frac	**2-Fluorobiphenyl**	321-60-8	Not Determined	----	**Surrogate recovery not determined due to (target or non-target) matrix interferences**
EP075T: Base/Neutral Extractable Surrogates	EM1209924-001	Tindilpie Pad Pit Flowback frac	**Anthracene-d10**	1719-06-8	Not Determined	----	**Surrogate recovery not determined due to (target or non-target) matrix interferences**
EP075T: Base/Neutral Extractable Surrogates	EM1209924-001	Tindilpie Pad Pit Flowback frac	**4-Terphenyl-d14**	1718-51-0	Not Determined	----	**Surrogate recovery not determined due to (target or non-target) matrix interferences**

Outliers : Analysis Holding Time Compliance

This report displays Holding Time breaches only. Only the respective Extraction / Preparation and/or Analysis component is/are displayed.

Matrix: **WATER**

Method	*Extraction / Preparation*	*Analysis*

Matrix: **WATER**

Container / Client Sample ID(s)	Date extracted	Due for extraction	Days overdue	Date analysed	Due for analysis	Days overdue
EA005: pH						
Clear Plastic Bottle - Natural						
Tindilpie Pad Pit Flowback - frac pit water post flowback	----	----	----	31-AUG-2012	27-AUG-2012	**4**
EK011: Chlorine - Free						
Clear Plastic Bottle - Natural						
Tindilpie Pad Pit Flowback - frac pit water post flowback	----	----	----	29-AUG-2012	27-AUG-2012	**2**
EK057G: Nitrite as N by Discrete Analyser						
Clear Plastic Bottle - Natural						
Tindilpie Pad Pit Flowback - frac pit water post flowback	----	----	----	30-AUG-2012	29-AUG-2012	**1**
EK071G: Reactive Phosphorus as P by discrete analyser						
Clear Plastic Bottle - Natural						
Tindilpie Pad Pit Flowback - frac pit water post flowback	----	----	----	30-AUG-2012	29-AUG-2012	**1**

Outliers : Frequency of Quality Control Samples

The following report highlights breaches in the Frequency of Quality Control Samples.

- **No Quality Control Sample Frequency Outliers exist.**

Raymond Thai

From: Sarah Hodgson
Sent: Tuesday, 28 August 2012 4:06 PM
To: Samples Melbourne
Cc: Kieren Burns
Subject: Santos samples from Tindilpie - no COC

Importance: High

Hi Guys,

I've spoken with Tom Delany who thinks that the sample received today should be analysed as per EM1209245.

He will send through the COC and instructions as soon as he can, but in the meantime just use the ID on the bottles and log the analysis as per the previous work order.

Please note some short holding time analysis pH, Chlorine, nitrate, nitrite, reactive P, formaldehyde.

Thank you,

Regards,
How was your customer experience? Please send us your feedback

Sarah Hodgson

PROJECT MANAGER

ALS | Environmental
Address
4 Westall Road
Springvale VIC 3171
PHONE +61 3 8549 9600
FAX +61 3 8549 9601
www.alsglobal.com
cid:615291706@05102011-231E

(1) BRETT COOK · 27/8/12

Samples sent to lab for
Micro Nitrate BOD pH
Colour Turbidity RP
Other Formaldehyde
Date 29/8/12 BN

Environmental Division
Melbourne
Work Order
EM1209924

Telephone : +61-3-8549 9600

-----Original Message-----
From: Kieren Burns
Sent: Tuesday, 28 August 2012 1:30 PM
To: Sarah Hodgson
Subject: FW: Environmental Visitation - Frac Spread, Tindilpie

Regards
How was your customer experience? Please send us your feedback Kieren Burns ENVIRONMENTAL SERVICES REPRESENTATIVE - SA ALS | Environmental

-----Original Message-----
From: Delaney, Thomas [mailto:Thomas.Delaney@santos.com]
Sent: Monday, 13 August 2012 8:27 AM
To: Samples Melbourne; Kieren Burns
Cc: Johnston, Andrew
Subject: Fwd: Environmental Visitation - Frac $pread, Tindilpie

Als,
There will be 2 sets of 18 samples in a blue esky arriving at you Melbourne lab sometime soon - these were taken this morning and should be flying over there this afternoon. See attached for the COC which is included in the package.

Any queries call my mobile.

Thanks

Tom Delaney
0421312739

Begin forwarded message:

From: Thomas Delaney <thomas.j.delaney@gmail.com<mailto:thomas.j.delaney@gmail.com>>
Date: 12 August 2012 4:30:35 PM ACST
To: "Delaney, Thomas" <thomas.delaney@santos.com<mailto:thomas.delaney@santos.com>>
Subject: Re: FW: Environmental Visitation - Frac Spread, Tindilpie

samples.melbourne@alsenviro.com<mailto:samples.melbourne@alsenviro.com>;
Kieren.burns@alsglobal.com<mailto:Kieren.burns@alsglobal.com>;

On Sat, Aug 11, 2012 at 5:19 PM, Delaney, Thomas
<Thomas.Delaney@santos.com<mailto:Thomas.Delaney@santos.com>> wrote:

From: Delaney, Thomas
Sent: Saturday, 11 August 2012 17:19
To: Completions, Frac Rig Rep
Subject: FW: Environmental Visitation - Frac Spread, Tindilpie
Importance: High

Hey Jeff – any chance you can print these out for me? Just the email and attached chain of custody forms when you get a chance. Thivanka wants me to sort this out with Mr PIC to get it into Moomba by Monday morning – so want to have a read and get our head around it.

Cheers mate
TD

Kind regards,

Tom Delaney | Subsurface Lead
Cooper Basin SIMOPS - EA Drilling & Completions | Santos Limited
Ph +61 8 8116 5358<tel:%2B61%208%208116%C2%A05358> | Fax +61 8 8116 7755<tel:%2B61%208%208116%207755> | Mob: +61 421 312 739<tel:%2B61%C2%A0421%20312%20739> | thomas.delaney@santos.com<mailto:thomas.delaney@santos.com>
Level 8, Santos Centre, 60 Flinders Street, Adelaide SA 5000 | GPO Box 2455, Adelaide SA 5001
Santos

From: Dedigama, Thivanka
Sent: Wednesday, 8 August 2012 12:11
To: Japp, Kenneth; Delaney, Thomas
Cc: Best, William
Subject: FW: Environmental Visitation - Frac Spread, Tindilpie
Importance: High

Hi Ken and Tom,

Here's one that's going to be interesting. Please review the email below. Only wanted to give you a heads-up on what coming. Don't collect samples yet.

This has previously been communicated to Mark and Paul but I'd like you to take the lead on this for Tindilpie.

For now could you please:

1. Review this and see if you have and EHS or operational concerns about this sampling

2. Locate the cool box, ice packs and 3 x 18 bottles that already supposed to be out there

If you can't find these we have another set coming

3. Locate the 'swing sampler' referred to below. No idea what this looks like. Mark may know.

4. Review the attached CoC form. Some changes will need to be made to update names etc.

I am in the process of getting approval for these samples to fly. Also need to work out with our logistics guys how best that can be rushed to Melbourne for testing. Should have answers in a couple of days.

The sampling that Bill Best did yesterday should get us out of trouble for this pad. This is more a longer term thing.

Thivanka Dedigama
Deputy Field Superintendent - Drilling and Petroleum Engineering
Tel: 08 8678 4191<tel:08%208678%204191>
Mob: 0431 375 187<tel:0431%20375%20187>

From: Johnston, Andrew
Sent: Wednesday, 8 August 2012 09:06
To: Dedigama, Thivanka; Ritchie, Barry
Cc: Johnston, Andrew; Swann, Louise; Best, William; Smith, Chris
Subject: FW: Environmental Visitation - Frac Spread, Tindilpie
Importance: High

Thivanka,

A proposed schedule for the HFRA sampling is below, I have received no feedback as yet so I suggest we run with it, unless some FR or Frac fluid samples overlap? If this is the case please advise in which case maybe 4 samples in total.

A water sample representing influent stream in considered essential. We picked up some unexpected contaminants in the SWQ samples (Coonaberry 3) that may have been present in the bore water being used. This data can be used to give us an indication of quality prior to addition of frac chemicals, or reservoir constituents from flowback. The procedure for collection of this could be applying the same methodology as per below, but taking from the Turkey's Nest or similar storage of influent water.

Sample Collection procedure / COC is as follows:

Pre sampling

- Place cooler blocks in freezer the day before sample collection - these are located in esky from ALS

- Use of ALS supplied bottles (as per attached COC) is essential. Once obtained, label each bottle (18 make a full "sample) with Sample ID, sampler name, date time etc, and ensure this is consistent with updated COC (example attached - note this needs amending to suit this and other events)

- Aim to collect sample early in the day, and despatch via Airfreight that day for minimum lab turnaround time

On the day

- Make sure disposable gloves are worn, and other PPE also

- Take care when standing near pit, and choose a steady location

- The "swing" sampler is located at the frac spread, and there are specific sample containers that fit this apparatus. Ensure a clean sampling container (500ml) is fitted for each sampling event (an "event" requiring 18 sub samples - you don't need 18 separate sampling containers!)

- Using sampler, extract sample from approximately 10cm below surface of the fluid. Repeat and purge 3x

- From then, fill all 18 sample containers to the top with fluids collected in a similar manner to above. Aim to lay off air bubbles so as to minimise voids when lids are placed on. Places these containers into bubble wrap and straight into esky with cooler blocks present.

- Record any field observations, such as HC sheen present, presence of condensate, and approximate volume in pit at the time of sample collection directly onto the COC in the final column. Stage of frac operations would be valuable information also.

- Update COC electronically, as this needs to be both emailed to ALS and also printed off and placed inside the esky prior to despatch. Ensure info on sample containers is entirely consistent with info on COC, otherwise ALS will note this and contact us for clarification

- Seal up esky with completed COC and all containers using labels supplied by ALS

- Either clean thoroughly or discard used 500ml sample container as this must not be used for subsequent collection events (to prevent cross contamination)

- Dispose of gloves appropriately also

Despatch

- Complete freight authorisation / declaration and book on flight to go to ALS in Victoria

- Ensure COC is emailed to ALS, and that myself and Barry Ritchie are CC'd into this

- samples.melbourne@alsenviro.com<mailto:samples.melbourne@alsenviro.com>

- Also CC Kieren Burns from ALS when these samples are despatched

- Kieren.burns@alsglobal.com<mailto:Kieren.burns@alsglobal.com>

Please let me know if you have any questions? I really appreciate the support.

Such events would normally be carried out by a field based environmental resource. There is good justification for this and one day we can assume we will get there.

Golder could assist, as too another consultant, though the $ to achieve this are high as the scheduling of sample collection around fluid generation means a lot of uncertainty and potential for standby time.

Regards,

Andrew Johnston
Environmental Adviser
Drilling & Completions, Technical & Engineering BU
Direct Number: (08) 81165687<tel:%2808%29%2081165687>
Mobile Number: 0419 835296<tel:0419%20835296>
Email: andrew.johnston@santos.com<mailto:andrew.johnston@santos.com>

[Santos Logo]

Santos Ltd A.B.N. 80 007 550 923

CHAIN OF CUSTODY

ALS Laboratory: please tick →

☐ **Sydney:** 277 Woodpark Rd, Smithfield NSW 2176 Ph: 02 8784 8555 E:samples.sydney@alsenviro.com
☐ **Newcastle:** 5 Rosegum Rd, Warabrook NSW 2304 Ph:02 4958 9433 E:samples.newcastle@alsenviro.com
☐ **Brisbane:** 32 Shand St Stafford QLD 4053 Ph:07 3243 7222 E:samples.brisbane@alsenviro.com
☐ **Townsville:** 14-15 Desma Ct, Bohle QLD 4818 Ph:07 4796 0600 E: samples.townsville@alsenviro.com
☐ **Melbourne:** 2-4 Westall Rd, Springvale VIC 3171 Ph:03 8549 9600 E: samples.melbourne@alsenviro.com
☐ **Adelaide:** 2-1 Burma Rd, Pooraka SA 5095 Ph: 08 8359 0890 E:adelaide@alsenviro.com
☐ **Perth:** 10 Hod Way, Malaga WA 6090 Ph: 08 9209 7655 E: samples.perth@alsenviro.com
☐ **Launceston:** 27 Wellington St, Launceston TAS 7250 Ph: 03 6331 2158 E: launceston@alsenviro.com

CLIENT:	**SANTOS**	**TURNAROUND REQUIREMENTS :** (Standard TAT may be longer for some tests e.g., Ultra Trace Organics)	[redacted] Standard TAT (List due date): ☐ Non Standard or urgent TAT (List due date):
OFFICE:	**Eastern Australia D&C, 60 Flinders Street, Adelaide SA**		
PROJECT:	**HFRA Fluids Sampling - Extended Analysis**	**ALS QUOTE NO.:**	**EN/039/11**
ORDER NUMBER:	**879002/538**	**COC SEQUENCE NUMBER (Circle)**	COC: [redacted] 2 3 4 5 6 7
PROJECT MANAGER:	**Barry Ritchie**	**CONTACT PH: 8116**	OF: [redacted] 2 3 4 5 6 7
SAMPLER:	**Brett Cook / Andrew Johnston**	**SAMPLER MOBILE:**	
COC emailed to ALS? (YES / NO)		**EDD FORMAT (or default):**	

FOR LABORATORY USE ONLY (Circle):

Custody Seal Intact?	Yes	No	N/A
Free ice / frozen ice bricks present upon receipt?	Yes	No	N/A
Random Sample Temperature on Receipt		°C	
Other comment:			

Email Reports to (will default to PM if no other addresses are listed): andrew.johnston@santos.com; frac.rig.rep.completions@santos.com; barry.ritchie@santos.com; thomas.delaney@santos.com

Email Invoice to (will default to PM if no other addresses are listed): barry.ritchie@santos.com

RELINQUISHED BY:	RECEIVED BY:	RELINQUISHED BY:	RECEIVED BY:
Brett Cook	Ray		
DATE/TIME:	DATE/TIME:	DATE/TIME:	DATE/TIME:
27/8/12 6:15	29/8/12 11:14		

COMMENTS/SPECIAL HANDLING/STORAGE OR DISPOSAL: Dissolved Metals Required are W-3 + Fe, Se, B, Sr, Al, Mo, Sn, U, I

ALS USE ONLY	SAMPLE DETAILS MATRIX: Solid(S) Water(W)			CONTAINER INFORMATION		ANALYSIS REQUIRED including SUITES (NB. Suite Codes must be listed to attract suite price) Where Metals are required, specify Total (unfiltered bottle required) or Dissolved (field filtered bottle required).								Additional Information
LAB ID	SAMPLE ID	DATE / TIME	MATRIX	TYPE & PRESERVATIVE *(refer to codes below)*	TOTAL BOTTLES	EA005, EA015H, EK011	NT-1B, NT-2A, NT-8A	EG052, EN055-DA, ED009X	EA065, EK025, EK026, EP005	W-3 and EG020F (See Additional Info)	EP117, TRH-CWG	EP074A-H, EP075	EP010, EP050, EP041	Comments on likely contaminant levels, dilutions, or samples requiring specific QC analysis etc.
1	"Tindilpie Pad Pit Flowback" - frac pit water post flowback	27/8/12 0615	W	1L plastic / green; 60ml plastic green; 125ml plastic purple; 60ml plastic blue; 40ml vial purple; 60ml plastic red; 2 x 40ml vial purple; 3x 100ml glass orange; 2 x 40ml amber glass maroon; 3 x 100ml glass orange; 2 x 500ml amber brown;	18	X	X	X	X	X	X	X	X	Sample taken from Tindilpie pad Frac Pit after flowback had started. Dissolved Metals Required are W-3 + Fe, Se, B, Sr, Al, Mo, Sn, U, Li
				TOTAL	18									

Water Container Codes: P = Unpreserved Plastic; N = Nitric Preserved Plastic; ORC = Nitric Preserved ORC; SH = Sodium Hydroxide/Cd Preserved; S = Sodium Hydroxide Preserved Plastic; AG = Amber Glass Unpreserved; AP - Airfreight Unpreserved Plastic
V = VOA Vial HCl Preserved; VB = VOA Vial Sodium Bisulphate Preserved; VS = VOA Vial Sulfuric Preserved; AV = Airfreight Unpreserved Vial SG = Sulfuric Preserved Amber Glass; H = HCl preserved Plastic; HS = HCl preserved Speciation bottle; SP = Sulfuric Preserved Plastic; F = Formaldehyde Preserved Glass;
Z = Zinc Acetate Preserved Bottle; E = EDTA Preserved Bottles; ST = Sterile Bottle; ASS = Plastic Bag for Acid Sulphate Soils; B = Unpreserved Bag.

CERTIFICATE OF ANALYSIS

Work Order	: **EM1210360**	Page	: 1 of 13
Client	: **SANTOS LTD**	Laboratory	: Environmental Division Melbourne
Contact	: MR BARRY RITCHIE	Contact	: Jodie Hancock
Address	: GROUND FLOOR SANTOS CENTRE 60 FLINDERS STREET ADELAIDE SA, AUSTRALIA 5001	Address	: 4 Westall Rd Springvale VIC Australia 3171
E-mail	: barry.ritchie@santos.com	E-mail	: Jodie.Hancock@alsenviro.com
Telephone	: +61 08 8116 5000	Telephone	: +61 7 3243 7128
Facsimile	: +61 08 8116 5050	Facsimile	: +61 7 3243 7218
Project	: HFRA Fluids Sampling - Extended Analysis	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Order number	: 879002/538		
C-O-C number	: ----	Date Samples Received	: 06-SEP-2012
Sampler	: JD, AJ	Issue Date	: 20-SEP-2012
Site	: ----		
		No. of samples received	: 2
Quote number	: EN/039/11	No. of samples analysed	: 2

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results
- Surrogate Control Limits

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting

- **Bromide, Iodide, Alcohols, MBAS and CTAS conducted by ALS Sydney, NATA accreditation no. 825, site no 10911.**
- **EG035F: EM1210360 #1 Insufficient sample provided to confirm positive mercury result.**
- **EG035F: Positive mercury result has been confirmed for EM1210360 #2 by repreparation and reanalysis.**
- **EK059G:Nitrite and Nitrate as N was analysed by NOX Vanadium Chloride Method (EK059GV).**
- **EP050: The MBAS reported is calculated as LAS, mol wt 342.**
- **EP074/079-CWG: : Particular sample (EM-1210360-002), Matix spike has been omitted due to high level of contaminant.**
- **EP074/079-CWG: Particular samples (EM-1210360-001,002) required dilution due to the presence of high level contaminants. LOR values have been adjusted accordingly.**
- **EP075: EM1210360-001 & 002 Particular samples required dilution prior to analysis due to matrix interferences. LOR values have been adjusted accordingly.**
- **EP075: Matrix spike not determined due to matrix interferences.**
- **EP075: 'Sum of PAH' is the sum of the USEPA 16 priority PAHs**
- **EP117: Particular samples required dilution due to the presence of high level contaminants. LOR values have been adjusted accordingly.**
- **Ionic balances were calculated using: major anions - chloride, alkalinity, sulfate; and major cations - calcium, magnesium, potassium, sodium and total nitrogen for EM1210360 #1 and #2.**
- **Samples were filtered through a 0.45um filter prior to the dissolved metals analysis.**

NATA Accredited Laboratory 825

Accredited for compliance with ISO/IEC 17025.

Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	Position	Accreditation Category
Dilani Fernando	Senior Inorganic Chemist	Melbourne Inorganics
Eric Chau	Metals Team Leader	Melbourne Inorganics
Herman Lin	Laboratory Coordinator	Melbourne Inorganics
Nancy Wang	Senior Semivolatile Instrument Chemist	Melbourne Organics
Pabi Subba	Senior Organic Chemist	Sydney Organics
Sarah Millington	Senior Inorganic Chemist	Sydney Inorganics
Varsha Ho Wing	Non-Metals Team Leader	Melbourne Inorganics

Analytical Results

Sub-Matrix: **WATER**

Compound	CAS Number	LOR	Unit	Client sample ID	Tildilpie Pad 4-9-2012 Sample1	Tildilpie Pad 4-9-2012 Sample2	----	----	----
				Client sampling date / time	04-SEP-2012 14:00	04-SEP-2012 14:15	----	----	----
					EM1210360-001	EM1210360-002	----	----	----
EA005: pH									
pH Value	----	0.01	pH Unit		**7.50**	**7.49**	----	----	----
EA006: Sodium Adsorption Ratio (SAR)									
Sodium Absorption Ratio	----	0.01	-		**112**	**110**	----	----	----
EA015: Total Dissolved Solids									
Total Dissolved Solids @180°C	GIS-210-010	10	mg/L		**11900**	**11700**	----	----	----
EA065: Total Hardness as CaCO3									
Total Hardness as CaCO3	----	1	mg/L		**174**	**169**	----	----	----
ED009: Anions									
Bromide	24959-67-9	0.010	mg/L		**22.4**	**20.9**	----	----	----
Iodide	20461-54-5	0.010	mg/L		**1.42**	**1.61**	----	----	----
ED037P: Alkalinity by PC Titrator									
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L		<1	<1	----	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L		<1	<1	----	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L		**2270**	**2310**	----	----	----
Total Alkalinity as CaCO3	----	1	mg/L		**2270**	**2310**	----	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA									
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L		**60**	**56**	----	----	----
ED045G: Chloride Discrete analyser									
Chloride	16887-00-6	1	mg/L		**4910**	**4810**	----	----	----
ED093F: Dissolved Major Cations									
Calcium	7440-70-2	1	mg/L		**50**	**48**	----	----	----
Magnesium	7439-95-4	1	mg/L		**12**	**12**	----	----	----
Sodium	7440-23-5	1	mg/L		**3410**	**3300**	----	----	----
Potassium	7440-09-7	1	mg/L		**140**	**135**	----	----	----
EG020F: Dissolved Metals by ICP-MS									
Aluminium	7429-90-5	0.01	mg/L		**0.07**	**0.07**	----	----	----
Arsenic	7440-38-2	0.001	mg/L		**0.216**	**0.210**	----	----	----
Barium	7440-39-3	0.001	mg/L		**6.02**	**5.86**	----	----	----
Beryllium	7440-41-7	0.001	mg/L		<0.001	<0.001	----	----	----
Cadmium	7440-43-9	0.0001	mg/L		**0.0001**	**0.0001**	----	----	----
Cobalt	7440-48-4	0.001	mg/L		**0.009**	**0.009**	----	----	----
Chromium	7440-47-3	0.001	mg/L		**0.040**	**0.040**	----	----	----
Copper	7440-50-8	0.001	mg/L		**0.048**	**0.061**	----	----	----
Manganese	7439-96-5	0.001	mg/L		**3.62**	**3.74**	----	----	----
Nickel	7440-02-0	0.001	mg/L		**0.039**	**0.038**	----	----	----

Analytical Results

Sub-Matrix: **WATER**

Compound	CAS Number	LOR	Unit	Client sample ID	Tildilpie Pad 4-9-2012 Sample1	Tildilpie Pad 4-9-2012 Sample2	-----	-----	-----
				Client sampling date / time	04-SEP-2012 14:00	04-SEP-2012 14:15	----	----	----
					EM1210360-001	EM1210360-002	----	----	----
EG020F: Dissolved Metals by ICP-MS - Continued									
Lead	7439-92-1	0.001	mg/L		**0.068**	**0.068**	----	----	----
Vanadium	7440-62-2	0.01	mg/L		**0.02**	**0.02**	----	----	----
Zinc	7440-66-6	0.005	mg/L		**0.052**	**0.058**	----	----	----
Lithium	7439-93-2	0.001	mg/L		**2.42**	**2.54**	----	----	----
Molybdenum	7439-98-7	0.001	mg/L		**0.023**	**0.023**	----	----	----
Selenium	7782-49-2	0.01	mg/L		<0.01	<0.01	----	----	----
Strontium	7440-24-6	0.001	mg/L		**1.66**	**1.67**	----	----	----
Tin	7440-31-5	0.001	mg/L		<0.001	<0.001	----	----	----
Uranium	7440-61-1	0.001	mg/L		<0.001	<0.001	----	----	----
Boron	7440-42-8	0.05	mg/L		**40.8**	**44.9**	----	----	----
Iron	7439-89-6	0.05	mg/L		**28.4**	**29.4**	----	----	----
EG035F: Dissolved Mercury by FIMS									
Mercury	7439-97-6	0.0001	mg/L		**0.0002**	**0.0003**	----	----	----
EG052F: Dissolved Silica by ICPAES									
Silica	7631-86-9	0.1	mg/L		**141**	**135**	----	----	----
EK010-1: Chlorine (Field Test)									
Free Chlorine	----	0.02	mg/L		<0.02	<0.02	----	----	----
EK025SF: Free CN by Segmented Flow Analyser									
Free Cyanide	----	0.004	mg/L		**0.007**	<0.004	----	----	----
EK026SF: Total CN by Segmented Flow Analyser									
Total Cyanide	57-12-5	0.004	mg/L		**0.008**	<0.004	----	----	----
EK040P: Fluoride by PC Titrator									
Fluoride	16984-48-8	0.1	mg/L		**2.4**	**2.0**	----	----	----
EK055: Ammonia as N									
Ammonia as N	7664-41-7	0.1	mg/L		**90.8**	**95.8**	----	----	----
EK057G: Nitrite as N by Discrete Analyser									
Nitrite as N	----	0.01	mg/L		**0.09**	**0.10**	----	----	----
EK058G: Nitrate as N by Discrete Analyser									
Nitrate as N	14797-55-8	0.01	mg/L		<0.01	<0.01	----	----	----
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N	----	0.01	mg/L		**0.09**	**0.10**	----	----	----
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser									
Total Kjeldahl Nitrogen as N	----	0.1	mg/L		**222**	**271**	----	----	----
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser									

Analytical Results

Sub-Matrix: **WATER**

Compound	CAS Number	LOR	Unit	Client sample ID	Tildilpie Pad 4-9-2012 Sample1	Tildilpie Pad 4-9-2012 Sample2	----	----	----
				Client sampling date / time	04-SEP-2012 14:00	04-SEP-2012 14:15	----	----	----
					EM1210360-001	EM1210360-002	----	----	----
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser - Continued									
^ **Total Nitrogen as N**	----	0.1	mg/L		**222**	**271**	----	----	----
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphorus as P	----	0.01	mg/L		**2.16**	**2.50**	----	----	----
EK071G: Reactive Phosphorus as P by discrete analyser									
Reactive Phosphorus as P	----	0.01	mg/L		**0.11**	**0.12**	----	----	----
EN055: Ionic Balance									
Total Anions	----	0.01	meq/L		**185**	**183**	----	----	----
Total Cations	----	0.01	meq/L		**173**	**172**	----	----	----
Ionic Balance	----	0.01	%		**3.47**	**3.24**	----	----	----
EP005: Total Organic Carbon (TOC)									
Total Organic Carbon	----	1	mg/L		**1930**	**1800**	----	----	----
EP010: Formaldehyde									
Formaldehyde	50-00-0	0.1	mg/L		**4.6**	**4.8**	----	----	----
EP041A: Nonionic Surfactants									
Nonionic Surfactants as CTAS	----	5	mg/L		**17**	**21**	----	----	----
EP050: Anionic Surfactants as MBAS									
Anionic Surfactants as MBAS	----	0.1	mg/L		**0.1**	**0.1**	----	----	----
EP074A: Monocyclic Aromatic Hydrocarbons									
Benzene	71-43-2	1	µg/L		**1160**	**1120**	----	----	----
Toluene	108-88-3	2	µg/L		**7700**	**6380**	----	----	----
Ethylbenzene	100-41-4	2	µg/L		**995**	**571**	----	----	----
meta- & para-Xylene	108-38-3 106-42-3	2	µg/L		**13000**	**8130**	----	----	----
Styrene	100-42-5	5	µg/L		<100	<100	----	----	----
ortho-Xylene	95-47-6	2	µg/L		**2480**	**1630**	----	----	----
Isopropylbenzene	98-82-8	5	µg/L		**313**	**182**	----	----	----
n-Propylbenzene	103-65-1	5	µg/L		**985**	**488**	----	----	----
1.3.5-Trimethylbenzene	108-67-8	5	µg/L		**2480**	**1340**	----	----	----
sec-Butylbenzene	135-98-8	5	µg/L		**114**	<100	----	----	----
1.2.4-Trimethylbenzene	95-63-6	5	µg/L		**4020**	**2180**	----	----	----
tert-Butylbenzene	98-06-6	5	µg/L		<100	<100	----	----	----
p-Isopropyltoluene	99-87-6	5	µg/L		**4190**	**1830**	----	----	----
n-Butylbenzene	104-51-8	5	µg/L		**586**	**288**	----	----	----
EP074B: Oxygenated Compounds									
Vinyl Acetate	108-05-4	50	µg/L		<1000	<1000	----	----	----
2-Butanone (MEK)	78-93-3	50	µg/L		<1000	<1000	----	----	----

Analytical Results

Sub-Matrix: **WATER**

Compound	CAS Number	LOR	Unit	Client sample ID	Tildilpie Pad 4-9-2012 Sample1	Tildilpie Pad 4-9-2012 Sample2	----	----	----
				Client sampling date / time	04-SEP-2012 14:00	04-SEP-2012 14:15	----	----	----
					EM1210360-001	EM1210360-002	----	----	----
EP074B: Oxygenated Compounds - Continued									
4-Methyl-2-pentanone (MIBK)	108-10-1	50	µg/L		<1000	<1000	----	----	----
2-Hexanone (MBK)	591-78-6	50	µg/L		<1000	<1000	----	----	----
EP074C: Sulfonated Compounds									
Carbon disulfide	75-15-0	5	µg/L		<100	<100	----	----	----
EP074D: Fumigants									
2.2-Dichloropropane	594-20-7	5	µg/L		<100	<100	----	----	----
1.2-Dichloropropane	78-87-5	5	µg/L		<100	<100	----	----	----
cis-1.3-Dichloropropylene	10061-01-5	5	µg/L		<100	<100	----	----	----
trans-1.3-Dichloropropylene	10061-02-6	5	µg/L		<100	<100	----	----	----
1.2-Dibromoethane (EDB)	106-93-4	5	µg/L		<100	<100	----	----	----
EP074E: Halogenated Aliphatic Compounds									
Dichlorodifluoromethane	75-71-8	50	µg/L		<1000	<1000	----	----	----
Chloromethane	74-87-3	50	µg/L		<1000	<1000	----	----	----
Vinyl chloride	75-01-4	50	µg/L		<1000	<1000	----	----	----
Bromomethane	74-83-9	50	µg/L		<1000	<1000	----	----	----
Chloroethane	75-00-3	50	µg/L		<1000	<1000	----	----	----
Trichlorofluoromethane	75-69-4	50	µg/L		<1000	<1000	----	----	----
1.1-Dichloroethene	75-35-4	5	µg/L		<100	<100	----	----	----
Iodomethane	74-88-4	5	µg/L		<100	<100	----	----	----
trans-1.2-Dichloroethene	156-60-5	5	µg/L		<100	<100	----	----	----
1.1-Dichloroethane	75-34-3	5	µg/L		<100	<100	----	----	----
cis-1.2-Dichloroethene	156-59-2	5	µg/L		<100	<100	----	----	----
1.1.1-Trichloroethane	71-55-6	5	µg/L		<100	<100	----	----	----
1.1-Dichloropropylene	563-58-6	5	µg/L		<100	<100	----	----	----
Carbon Tetrachloride	56-23-5	5	µg/L		<100	<100	----	----	----
1.2-Dichloroethane	107-06-2	5	µg/L		<100	<100	----	----	----
Trichloroethene	79-01-6	5	µg/L		<100	<100	----	----	----
Dibromomethane	74-95-3	5	µg/L		<100	<100	----	----	----
1.1.2-Trichloroethane	79-00-5	5	µg/L		<100	<100	----	----	----
1.3-Dichloropropane	142-28-9	5	µg/L		<100	<100	----	----	----
Tetrachloroethene	127-18-4	5	µg/L		<100	<100	----	----	----
1.1.1.2-Tetrachloroethane	630-20-6	5	µg/L		<100	<100	----	----	----
trans-1.4-Dichloro-2-butene	110-57-6	5	µg/L		<100	<100	----	----	----
cis-1.4-Dichloro-2-butene	1476-11-5	5	µg/L		<100	<100	----	----	----
1.1.2.2-Tetrachloroethane	79-34-5	5	µg/L		<100	<100	----	----	----

Analytical Results

Sub-Matrix: **WATER**

Compound	CAS Number	LOR	Unit	Client sample ID	Tildilpie Pad 4-9-2012 Sample1	Tildilpie Pad 4-9-2012 Sample2	----	----	----
				Client sampling date / time	04-SEP-2012 14:00	04-SEP-2012 14:15	----	----	----
					EM1210360-001	EM1210360-002	----	----	----
EP074E: Halogenated Aliphatic Compounds - Continued									
1.2.3-Trichloropropane	96-18-4	5	µg/L		<100	<100	----	----	----
Pentachloroethane	76-01-7	5	µg/L		<100	<100	----	----	----
1.2-Dibromo-3-chloropropane	96-12-8	5	µg/L		<100	<100	----	----	----
EP074F: Halogenated Aromatic Compounds									
Chlorobenzene	108-90-7	5	µg/L		<100	<100	----	----	----
Bromobenzene	108-86-1	5	µg/L		<100	<100	----	----	----
2-Chlorotoluene	95-49-8	5	µg/L		<100	<100	----	----	----
4-Chlorotoluene	106-43-4	5	µg/L		<100	<100	----	----	----
1.2.3-Trichlorobenzene	87-61-6	5	µg/L		<100	<100	----	----	----
EP074G: Trihalomethanes									
Chloroform	67-66-3	5	µg/L		<100	<100	----	----	----
Bromodichloromethane	75-27-4	5	µg/L		<100	<100	----	----	----
Dibromochloromethane	124-48-1	5	µg/L		<100	<100	----	----	----
Bromoform	75-25-2	5	µg/L		<100	<100	----	----	----
EP075A: Phenolic Compounds									
Phenol	108-95-2	2	µg/L		**1250**	**735**	----	----	----
2-Chlorophenol	95-57-8	2	µg/L		<200	<200	----	----	----
2-Methylphenol	95-48-7	2	µg/L		**1780**	**1000**	----	----	----
3- & 4-Methylphenol	1319-77-3	4	µg/L		**1430**	**924**	----	----	----
2-Nitrophenol	88-75-5	2	µg/L		<200	<200	----	----	----
2.4-Dimethylphenol	105-67-9	2	µg/L		**1250**	**779**	----	----	----
2.4-Dichlorophenol	120-83-2	2	µg/L		<200	<200	----	----	----
2.6-Dichlorophenol	87-65-0	2	µg/L		<200	<200	----	----	----
4-Chloro-3-Methylphenol	59-50-7	2	µg/L		<200	<200	----	----	----
2.4.6-Trichlorophenol	88-06-2	2	µg/L		<200	<200	----	----	----
2.4.5-Trichlorophenol	95-95-4	2	µg/L		<200	<200	----	----	----
Pentachlorophenol	87-86-5	4	µg/L		<400	<400	----	----	----
EP075B: Polynuclear Aromatic Hydrocarbons									
Naphthalene	91-20-3	2	µg/L		**1200**	**573**	----	----	----
2-Methylnaphthalene	91-57-6	2	µg/L		**2090**	**872**	----	----	----
2-Chloronaphthalene	91-58-7	2	µg/L		<200	<200	----	----	----
Acenaphthylene	208-96-8	2	µg/L		<200	<200	----	----	----
Acenaphthene	83-32-9	2	µg/L		<200	<200	----	----	----
Fluorene	86-73-7	2	µg/L		<200	<200	----	----	----
Phenanthrene	85-01-8	2	µg/L		**268**	<200	----	----	----

Analytical Results

Sub-Matrix: **WATER**

Compound	CAS Number	LOR	Unit	Client sample ID	Tildilpie Pad 4-9-2012 Sample1	Tildilpie Pad 4-9-2012 Sample2	----	----	----
				Client sampling date / time	04-SEP-2012 14:00	04-SEP-2012 14:15	----	----	----
					EM1210360-001	EM1210360-002	----	----	----
EP075B: Polynuclear Aromatic Hydrocarbons - Continued									
Anthracene	120-12-7	2	µg/L		<200	<200	----	----	----
Fluoranthene	206-44-0	2	µg/L		<200	<200	----	----	----
Pyrene	129-00-0	2	µg/L		<200	<200	----	----	----
N-2-Fluorenyl Acetamide	53-96-3	2	µg/L		<200	<200	----	----	----
Benz(a)anthracene	56-55-3	2	µg/L		<200	<200	----	----	----
Chrysene	218-01-9	2	µg/L		<200	<200	----	----	----
Benzo(b) & Benzo(k)fluoranthene	205-99-2 207-08-9	4	µg/L		<400	<400	----	----	----
7.12-Dimethylbenz(a)anthracene	57-97-6	2	µg/L		<200	<200	----	----	----
Benzo(a)pyrene	50-32-8	2	µg/L		<200	<200	----	----	----
3-Methylcholanthrene	56-49-5	2	µg/L		<200	<200	----	----	----
Indeno(1.2.3.cd)pyrene	193-39-5	2	µg/L		<200	<200	----	----	----
Dibenz(a.h)anthracene	53-70-3	2	µg/L		<200	<200	----	----	----
Benzo(g.h.i)perylene	191-24-2	2	µg/L		<200	<200	----	----	----
^ **Sum of PAHs**	----	2	µg/L		**1470**	**573**	----	----	----
^ **Benzo(a)pyrene TEQ (WHO)**	----	2	µg/L		<200	<200	----	----	----
EP075C: Phthalate Esters									
Dimethyl phthalate	131-11-3	2	µg/L		<200	<200	----	----	----
Diethyl phthalate	84-66-2	2	µg/L		<200	<200	----	----	----
Di-n-butyl phthalate	84-74-2	2	µg/L		<200	<200	----	----	----
Butyl benzyl phthalate	85-68-7	2	µg/L		<200	<200	----	----	----
bis(2-ethylhexyl) phthalate	117-81-7	10	µg/L		<1000	<1000	----	----	----
Di-n-octylphthalate	117-84-0	2	µg/L		<200	<200	----	----	----
EP075D: Nitrosamines									
N-Nitrosomethylethylamine	10595-95-6	2	µg/L		<200	<200	----	----	----
N-Nitrosodiethylamine	55-18-5	2	µg/L		<200	<200	----	----	----
N-Nitrosopyrrolidine	930-55-2	4	µg/L		<400	<400	----	----	----
N-Nitrosomorpholine	59-89-2	2	µg/L		<200	<200	----	----	----
N-Nitrosodi-n-propylamine	621-64-7	2	µg/L		<200	<200	----	----	----
N-Nitrosopiperidine	100-75-4	2	µg/L		<200	<200	----	----	----
N-Nitrosodibutylamine	924-16-3	2	µg/L		<200	<200	----	----	----
N-Nitrosodiphenyl & Diphenylamine	86-30-6 122-39-4	4	µg/L		<400	<400	----	----	----
Methapyrilene	91-80-5	2	µg/L		<200	<200	----	----	----
EP075E: Nitroaromatics and Ketones									

Analytical Results

Sub-Matrix: **WATER**

Compound	CAS Number	LOR	Unit	Client sample ID	Tildilpie Pad 4-9-2012 Sample1	Tildilpie Pad 4-9-2012 Sample2	----	----	----
				Client sampling date / time	04-SEP-2012 14:00	04-SEP-2012 14:15	----	----	----
					EM1210360-001	EM1210360-002	----	----	----
EP075E: Nitroaromatics and Ketones - Continued									
2-Picoline	109-06-8	2	µg/L		<200	<200	----	----	----
Acetophenone	98-86-2	2	µg/L		<200	<200	----	----	----
Nitrobenzene	98-95-3	2	µg/L		<200	<200	----	----	----
Isophorone	78-59-1	2	µg/L		<200	<200	----	----	----
2.6-Dinitrotoluene	606-20-2	4	µg/L		<400	<400	----	----	----
2.4-Dinitrotoluene	121-14-2	4	µg/L		<400	<400	----	----	----
1-Naphthylamine	134-32-7	2	µg/L		<200	<200	----	----	----
4-Nitroquinoline-N-oxide	56-57-5	2	µg/L		<200	<200	----	----	----
5-Nitro-o-toluidine	99-55-8	2	µg/L		<200	<200	----	----	----
Azobenzene	103-33-3	2	µg/L		<200	<200	----	----	----
1.3.5-Trinitrobenzene	99-35-4	2	µg/L		<200	<200	----	----	----
Phenacetin	62-44-2	2	µg/L		<200	<200	----	----	----
4-Aminobiphenyl	92-67-1	2	µg/L		<200	<200	----	----	----
Pentachloronitrobenzene	82-68-8	2	µg/L		<200	<200	----	----	----
Pronamide	23950-58-5	2	µg/L		<200	<200	----	----	----
Dimethylaminoazobenzene	60-11-7	2	µg/L		<200	<200	----	----	----
Chlorobenzilate	510-15-6	2	µg/L		<200	<200	----	----	----
EP075F: Haloethers									
Bis(2-chloroethyl) ether	111-44-4	2	µg/L		<200	<200	----	----	----
Bis(2-chloroethoxy) methane	111-91-1	2	µg/L		<200	<200	----	----	----
4-Chlorophenyl phenyl ether	7005-72-3	2	µg/L		<200	<200	----	----	----
4-Bromophenyl phenyl ether	101-55-3	2	µg/L		<200	<200	----	----	----
EP075G: Chlorinated Hydrocarbons									
1.3-Dichlorobenzene	541-73-1	2	µg/L		<200	<200	----	----	----
1.4-Dichlorobenzene	106-46-7	2	µg/L		<200	<200	----	----	----
1.2-Dichlorobenzene	95-50-1	2	µg/L		<200	<200	----	----	----
Hexachloroethane	67-72-1	2	µg/L		<200	<200	----	----	----
1.2.4-Trichlorobenzene	120-82-1	2	µg/L		<200	<200	----	----	----
Hexachloropropylene	1888-71-7	2	µg/L		<200	<200	----	----	----
Hexachlorobutadiene	87-68-3	2	µg/L		<200	<200	----	----	----
Hexachlorocyclopentadiene	77-47-4	10	µg/L		<1000	<1000	----	----	----
Pentachlorobenzene	608-93-5	2	µg/L		<200	<200	----	----	----
Hexachlorobenzene (HCB)	118-74-1	4	µg/L		<400	<400	----	----	----
EP075H: Anilines and Benzidines									
Aniline	62-53-3	2	µg/L		<200	<200	----	----	----

Analytical Results

Sub-Matrix: **WATER**

Compound	CAS Number	LOR	Unit	Client sample ID	Tildilpie Pad 4-9-2012 Sample1	Tildilpie Pad 4-9-2012 Sample2	----	----	----
				Client sampling date / time	04-SEP-2012 14:00	04-SEP-2012 14:15	----	----	----
					EM1210360-001	EM1210360-002	----	----	----
EP075H: Anilines and Benzidines - Continued									
4-Chloroaniline	106-47-8	2	µg/L		<200	<200	----	----	----
2-Nitroaniline	88-74-4	4	µg/L		<400	<400	----	----	----
3-Nitroaniline	99-09-2	4	µg/L		<400	<400	----	----	----
Dibenzofuran	132-64-9	2	µg/L		<200	<200	----	----	----
4-Nitroaniline	100-01-6	2	µg/L		<200	<200	----	----	----
Carbazole	86-74-8	2	µg/L		<200	<200	----	----	----
3.3`-Dichlorobenzidine	91-94-1	2	µg/L		<200	<200	----	----	----
EP075I: Organochlorine Pesticides									
alpha-BHC	319-84-6	2	µg/L		<200	<200	----	----	----
beta-BHC	319-85-7	2	µg/L		<200	<200	----	----	----
gamma-BHC	58-89-9	2	µg/L		<200	<200	----	----	----
delta-BHC	319-86-8	2	µg/L		<200	<200	----	----	----
Heptachlor	76-44-8	2	µg/L		<200	<200	----	----	----
Aldrin	309-00-2	2	µg/L		<200	<200	----	----	----
Heptachlor epoxide	1024-57-3	2	µg/L		<200	<200	----	----	----
alpha-Endosulfan	959-98-8	2	µg/L		<200	<200	----	----	----
4.4`-DDE	72-55-9	2	µg/L		<200	<200	----	----	----
Dieldrin	60-57-1	2	µg/L		<200	<200	----	----	----
Endrin	72-20-8	2	µg/L		<200	<200	----	----	----
beta-Endosulfan	33213-65-9	2	µg/L		<200	<200	----	----	----
4.4`-DDD	72-54-8	2	µg/L		<200	<200	----	----	----
Endosulfan sulfate	1031-07-8	2	µg/L		<200	<200	----	----	----
4.4`-DDT	50-29-3	4	µg/L		<400	<400	----	----	----
^ **Sum of Aldrin + Dieldrin**	309-00-2/60-57-1	4	µg/L		<400	<400	----	----	----
^ **Sum of DDD + DDE + DDT**	----	4	µg/L		<400	<400	----	----	----
EP075J: Organophosphorus Pesticides									
Dichlorvos	62-73-7	2	µg/L		<200	<200	----	----	----
Dimethoate	60-51-5	2	µg/L		<200	<200	----	----	----
Diazinon	333-41-5	2	µg/L		<200	<200	----	----	----
Chlorpyrifos-methyl	5598-13-0	2	µg/L		<200	<200	----	----	----
Malathion	121-75-5	2	µg/L		<200	<200	----	----	----
Fenthion	55-38-9	2	µg/L		<200	<200	----	----	----
Chlorpyrifos	2921-88-2	2	µg/L		<200	<200	----	----	----
Pirimphos-ethyl	23505-41-1	2	µg/L		<200	<200	----	----	----
Chlorfenvinphos	470-90-6	2	µg/L		<200	<200	----	----	----

Analytical Results

Sub-Matrix: **WATER**

Compound	CAS Number	LOR	Unit	Client sample ID	Tildilpie Pad 4-9-2012 Sample1	Tildilpie Pad 4-9-2012 Sample2	----	----	----
				Client sampling date / time	04-SEP-2012 14:00	04-SEP-2012 14:15	----	----	----
					EM1210360-001	EM1210360-002	----	----	----
EP075J: Organophosphorus Pesticides - Continued									
Prothiofos	34643-46-4	2	µg/L		<200	<200	----	----	----
Ethion	563-12-2	2	µg/L		<200	<200	----	----	----
EP117: Alcohols									
Ethanol	64-17-5	50	µg/L		**2460**	**2440**	----	----	----
Isopropanol	67-63-0	50	µg/L		**3950**	**4070**	----	----	----
n-Propanol	71-23-8	50	µg/L		**24900**	**25600**	----	----	----
Isobutanol	78-83-1	50	µg/L		<250	<250	----	----	----
n-Butanol	71-36-3	50	µg/L		<250	<250	----	----	----
RIVM Aliphatic Hydrocarbon Fractions									
Aliphatic >C5-C6	----	20	µg/L		**5300**	**3890**	----	----	----
Aliphatic >C6-C8	TPHCWG-ALV2	20	µg/L		**71400**	**22000**	----	----	----
Aliphatic >C8-C10	TPHCWG-ALV3	20	µg/L		**103000**	**47100**	----	----	----
Aliphatic >C10-C12	TPHCWG-ALE1	50	µg/L		**18000**	**19300**	----	----	----
Aliphatic >C12-C16	TPHCWG-ALE2	50	µg/L		**53600**	**54200**	----	----	----
Aliphatic >C16-C21	----	50	µg/L		**52500**	**52600**	----	----	----
Aliphatic >C21-C35	----	50	µg/L		**24900**	**24200**	----	----	----
RIVM Aromatic Hydrocarbon Fractions									
Aromatic >C5-C7	----	5	µg/L		**1040**	**1000**	----	----	----
Aromatic >C7-C8	TPHCWG-ARV2	5	µg/L		**6490**	**5420**	----	----	----
Aromatic >C8-C10	TPHCWG-ARV3	5	µg/L		**17900**	**10400**	----	----	----
Aromatic >C10-C12	TPHCWG-ARE1	50	µg/L		**6050**	**7070**	----	----	----
Aromatic >C12-C16	TPHCWG-ARE2	50	µg/L		**14900**	**14800**	----	----	----
Aromatic >C16-C21	TPHCWG-ARE3	50	µg/L		**12900**	**12700**	----	----	----
Aromatic >C21-C35	TPHCWG-ARE4	50	µg/L		**3610**	**3410**	----	----	----
EP074S: VOC Surrogates									
1.2-Dichloroethane-D4	17060-07-0	0.1	%		**103**	**71.2**	----	----	----
Toluene-D8	2037-26-5	0.1	%		**114**	**119**	----	----	----
4-Bromofluorobenzene	460-00-4	0.1	%		**118**	**97.2**	----	----	----
EP075S: Acid Extractable Surrogates									
2-Fluorophenol	367-12-4	0.1	%		**Not Determined**	**Not Determined**	----	----	----
Phenol-d6	13127-88-3	0.1	%		**Not Determined**	**Not Determined**	----	----	----
2-Chlorophenol-D4	93951-73-6	0.1	%		**Not Determined**	**Not Determined**	----	----	----
2.4.6-Tribromophenol	118-79-6	0.1	%		**Not Determined**	**Not Determined**	----	----	----
EP075T: Base/Neutral Extractable Surrogates									
Nitrobenzene-D5	4165-60-0	0.1	%		**Not Determined**	**Not Determined**	----	----	----

Analytical Results

Sub-Matrix: WATER				Client sample ID	Tildilpie Pad 4-9-2012 Sample1	Tildilpie Pad 4-9-2012 Sample2	----	----	----
				Client sampling date / time	04-SEP-2012 14:00	04-SEP-2012 14:15	----	----	----
Compound	CAS Number	LOR	Unit		EM1210360-001	EM1210360-002	----	----	----
EP075T: Base/Neutral Extractable Surrogates - Continued									
1.2-Dichlorobenzene-D4	2199-69-1	0.1	%		Not Determined	Not Determined	----	----	----
2-Fluorobiphenyl	321-60-8	0.1	%		Not Determined	Not Determined	----	----	----
Anthracene-d10	1719-06-8	0.1	%		Not Determined	Not Determined	----	----	----
4-Terphenyl-d14	1718-51-0	0.1	%		Not Determined	Not Determined	----	----	----
EP079/EP070S:TPH Surrogates - semivolatile speciation									
2-Fluorobiphenyl	321-60-8	0.1	%		111	114	----	----	----
2-Bromonaphthalene	580-13-2	0.1	%		104	116	----	----	----

Surrogate Control Limits

Sub-Matrix: **WATER**		Recovery Limits (%)	
Compound	*CAS Number*	*Low*	*High*
EP074S: VOC Surrogates			
1.2-Dichloroethane-D4	17060-07-0	72	132
Toluene-D8	2037-26-5	74	128
4-Bromofluorobenzene	460-00-4	70	132
EP075S: Acid Extractable Surrogates			
2-Fluorophenol	367-12-4	10	83
Phenol-d6	13127-88-3	10	49
2-Chlorophenol-D4	93951-73-6	20.3	101
2.4.6-Tribromophenol	118-79-6	19.5	134
EP075T: Base/Neutral Extractable Surrogates			
Nitrobenzene-D5	4165-60-0	18.2	114
1.2-Dichlorobenzene-D4	2199-69-1	18.8	100
2-Fluorobiphenyl	321-60-8	25.3	122
Anthracene-d10	1719-06-8	35	137
4-Terphenyl-d14	1718-51-0	32	136
EP079/EP070S:TPH Surrogates - semivolatile speciation			
2-Fluorobiphenyl	321-60-8	77	127
2-Bromonaphthalene	580-13-2	67	123

QUALITY CONTROL REPORT

Work Order	: **EM1210360**	Page	: 1 of 23
Client	: **SANTOS LTD**	Laboratory	: Environmental Division Melbourne
Contact	: MR BARRY RITCHIE	Contact	: Jodie Hancock
Address	: GROUND FLOOR SANTOS CENTRE 60 FLINDERS STREET ADELAIDE SA, AUSTRALIA 5001	Address	: 4 Westall Rd Springvale VIC Australia 3171
E-mail	: barry.ritchie@santos.com	E-mail	: Jodie.Hancock@alsenviro.com
Telephone	: +61 08 8116 5000	Telephone	: +61 7 3243 7128
Facsimile	: +61 08 8116 5050	Facsimile	: +61 7 3243 7218
Project	: HFRA Fluids Sampling - Extended Analysis	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Site	: ----		
C-O-C number	: ----	Date Samples Received	: 06-SEP-2012
Sampler	: JD, AJ	Issue Date	: 20-SEP-2012
Order number	: 879002/538		
		No. of samples received	: 2
Quote number	: EN/039/11	No. of samples analysed	: 2

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Method Blank (MB) and Laboratory Control Spike (LCS) Report; Recovery and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits

NATA Accredited Laboratory 825

Accredited for compliance with ISO/IEC 17025.

Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Dilani Fernando	Senior Inorganic Chemist	Melbourne Inorganics
Eric Chau	Metals Team Leader	Melbourne Inorganics
Herman Lin	Laboratory Coordinator	Melbourne Inorganics
Nancy Wang	Senior Semivolatile Instrument Chemist	Melbourne Organics
Pabi Subba	Senior Organic Chemist	Sydney Organics
Sarah Millington	Senior Inorganic Chemist	Sydney Inorganics
Varsha Ho Wing	Non-Metals Team Leader	Melbourne Inorganics

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

Key : Anonymous = Refers to samples which are not specifically part of this work order but formed part of the QC process lot
CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
RPD = Relative Percentage Difference
# = Indicates failed QC

Laboratory Duplicate (DUP) Report

The quality control term Laboratory Duplicate refers to a randomly selected intralaboratory split. Laboratory duplicates provide information regarding method precision and sample heterogeneity. The permitted ranges for the Relative Percent Deviation (RPD) of Laboratory Duplicates are specified in ALS Method QWI-EN/38 and are dependent on the magnitude of results in comparison to the level of reporting: Result < 10 times LOR:- No Limit; Result between 10 and 20 times LOR:- 0% - 50%; Result > 20 times LOR:- 0% - 20%.

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
EA005: pH (QC Lot: 2487664)									
EM1210350-001	Anonymous	EA005: pH Value	----	0.01	pH Unit	8.77	8.72	0.6	0% - 20%
EA015: Total Dissolved Solids (QC Lot: 2487120)									
EM1210242-001	Anonymous	EA015H: Total Dissolved Solids @180°C	GIS-210-010	10	mg/L	2940	2920	0.8	0% - 20%
EM1210334-001	Anonymous	EA015H: Total Dissolved Solids @180°C	GIS-210-010	10	mg/L	3610	3540	2.0	0% - 20%
ED009: Anions (QC Lot: 2489720)									
EM1210339-001	Anonymous	ED009-X: Bromide	24959-67-9	0.010	mg/L	19.5	20.2	3.3	0% - 20%
		ED009-X: Iodide	20461-54-5	0.010	mg/L	0.801	0.934	15.3	0% - 20%
ED037P: Alkalinity by PC Titrator (QC Lot: 2487642)									
EM1210291-005	Anonymous	ED037-P: Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	996	996	0.0	0% - 20%
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	996	996	0.0	0% - 20%
EM1210360-001	Tildilpie Pad 4-9-2012 Sample1	ED037-P: Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	2270	2320	2.4	0% - 20%
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	2270	2320	2.4	0% - 20%
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA (QC Lot: 2486620)									
EM1210291-005	Anonymous	ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	1140	1150	0.7	0% - 20%
EM1210334-001	Anonymous	ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	150	157	4.1	0% - 20%
ED045G: Chloride Discrete analyser (QC Lot: 2486619)									
EM1210291-005	Anonymous	ED045G: Chloride	16887-00-6	1	mg/L	5120	5170	1.0	0% - 20%
EM1210334-001	Anonymous	ED045G: Chloride	16887-00-6	1	mg/L	1600	1620	1.4	0% - 20%
ED093F: Dissolved Major Cations (QC Lot: 2486618)									
EM1210291-005	Anonymous	ED093F: Calcium	7440-70-2	1	mg/L	91	94	2.7	0% - 20%
		ED093F: Magnesium	7439-95-4	1	mg/L	400	406	1.3	0% - 20%
		ED093F: Sodium	7440-23-5	1	mg/L	2920	2930	0.5	0% - 20%
		ED093F: Potassium	7440-09-7	1	mg/L	69	70	1.5	0% - 20%
EM1210334-001	Anonymous	ED093F: Calcium	7440-70-2	1	mg/L	175	177	1.2	0% - 20%
		ED093F: Magnesium	7439-95-4	1	mg/L	173	172	0.6	0% - 20%
		ED093F: Sodium	7440-23-5	1	mg/L	768	764	0.5	0% - 20%
		ED093F: Potassium	7440-09-7	1	mg/L	27	27	0.0	0% - 20%
EG020F: Dissolved Metals by ICP-MS (QC Lot: 2494881)									
EM1210286-010	Anonymous	EG020A-F: Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	0.0	No Limit

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
EG020F: Dissolved Metals by ICP-MS (QC Lot: 2494881) - continued									
EM1210286-010	Anonymous	EG020A-F: Arsenic	7440-38-2	0.001	mg/L	0.001	0.001	0.0	No Limit
		EG020A-F: Beryllium	7440-41-7	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-F: Barium	7440-39-3	0.001	mg/L	0.054	0.054	0.0	0% - 20%
		EG020A-F: Chromium	7440-47-3	0.001	mg/L	<0.001	0.002	0.0	No Limit
		EG020A-F: Cobalt	7440-48-4	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-F: Copper	7440-50-8	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-F: Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-F: Lithium	7439-93-2	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-F: Manganese	7439-96-5	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-F: Molybdenum	7439-98-7	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-F: Nickel	7440-02-0	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-F: Tin	7440-31-5	0.001	mg/L	0.008	0.008	0.0	No Limit
		EG020A-F: Zinc	7440-66-6	0.005	mg/L	<0.005	<0.005	0.0	No Limit
		EG020A-F: Aluminium	7429-90-5	0.01	mg/L	0.15	0.15	0.0	0% - 50%
		EG020A-F: Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	0.0	No Limit
		EG020A-F: Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	0.0	No Limit
		EG020A-F: Boron	7440-42-8	0.05	mg/L	<0.05	<0.05	0.0	No Limit
		EG020A-F: Iron	7439-89-6	0.05	mg/L	<0.05	<0.05	0.0	No Limit
EM1210484-002	Anonymous	EG020A-F: Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	0.0	No Limit
		EG020A-F: Arsenic	7440-38-2	0.001	mg/L	0.018	0.019	6.5	0% - 50%
		EG020A-F: Beryllium	7440-41-7	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-F: Barium	7440-39-3	0.001	mg/L	0.108	0.115	6.3	0% - 20%
		EG020A-F: Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-F: Cobalt	7440-48-4	0.001	mg/L	0.014	0.014	0.0	0% - 50%
		EG020A-F: Copper	7440-50-8	0.001	mg/L	0.004	0.005	0.0	No Limit
		EG020A-F: Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-F: Lithium	7439-93-2	0.001	mg/L	0.106	0.104	2.4	0% - 20%
		EG020A-F: Manganese	7439-96-5	0.001	mg/L	0.042	0.045	7.4	0% - 20%
		EG020A-F: Molybdenum	7439-98-7	0.001	mg/L	0.001	0.001	0.0	No Limit
		EG020A-F: Nickel	7440-02-0	0.001	mg/L	0.038	0.040	4.0	0% - 20%
		EG020A-F: Tin	7440-31-5	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-F: Zinc	7440-66-6	0.005	mg/L	0.028	0.027	0.0	No Limit
		EG020A-F: Aluminium	7429-90-5	0.01	mg/L	0.13	0.13	0.0	0% - 50%
		EG020A-F: Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	0.0	No Limit
		EG020A-F: Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	0.0	No Limit
		EG020A-F: Boron	7440-42-8	0.05	mg/L	0.34	0.34	0.0	No Limit
		EG020A-F: Iron	7439-89-6	0.05	mg/L	<0.05	<0.05	0.0	No Limit
EG020F: Dissolved Metals by ICP-MS (QC Lot: 2494882)									
EM1210484-002	Anonymous	EG020B-F: Strontium	7440-24-6	0.001	mg/L	2.68	2.88	7.0	0% - 20%

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
EG020F: Dissolved Metals by ICP-MS (QC Lot: 2494882) - continued									
EM1210484-002	Anonymous	EG020B-F: Uranium	7440-61-1	0.001	mg/L	<0.001	<0.001	0.0	No Limit
EG035F: Dissolved Mercury by FIMS (QC Lot: 2494880)									
EM1210286-010	Anonymous	EG035F: Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	0.0	No Limit
EM1210484-002	Anonymous	EG035F: Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	0.0	No Limit
EK025SF: Free CN by Segmented Flow Analyser (QC Lot: 2487961)									
EM1210095-017	Anonymous	EK025SF: Free Cyanide	----	0.004	mg/L	<0.004	<0.004	0.0	No Limit
EK026SF: Total CN by Segmented Flow Analyser (QC Lot: 2487962)									
EM1210095-017	Anonymous	EK026SF: Total Cyanide	57-12-5	0.004	mg/L	<0.004	<0.004	0.0	No Limit
EM1210342-007	Anonymous	EK026SF: Total Cyanide	57-12-5	0.004	mg/L	0.017	0.017	0.0	No Limit
EK040P: Fluoride by PC Titrator (QC Lot: 2487643)									
EM1210350-001	Anonymous	EK040P: Fluoride	16984-48-8	0.1	mg/L	0.4	0.5	0.0	No Limit
EP1207391-005	Anonymous	EK040P: Fluoride	16984-48-8	0.1	mg/L	0.5	0.4	0.0	No Limit
EK055: Ammonia as N (QC Lot: 2498816)									
EM1210360-001	Tildilpie Pad 4-9-2012 Sample1	EK055: Ammonia as N	7664-41-7	0.1	mg/L	90.8	90.8	0.0	0% - 20%
EM1210656-001	Anonymous	EK055: Ammonia as N	7664-41-7	0.1	mg/L	18.9	18.9	0.0	0% - 20%
EK057G: Nitrite as N by Discrete Analyser (QC Lot: 2486617)									
EM1210291-005	Anonymous	EK057G: Nitrite as N	----	0.01	mg/L	0.16	0.16	0.0	0% - 50%
EM1210334-001	Anonymous	EK057G: Nitrite as N	----	0.01	mg/L	0.06	0.06	0.0	No Limit
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser (QC Lot: 2487853)									
EM1210342-011	Anonymous	EK059G: Nitrite + Nitrate as N	----	0.01	mg/L	2.16	2.40	10.6	0% - 20%
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser (QC Lot: 2487602)									
EM1210338-006	Anonymous	EK061G: Total Kjeldahl Nitrogen as N	----	0.1	mg/L	<0.1	0.1	0.0	No Limit
EM1210350-007	Anonymous	EK061G: Total Kjeldahl Nitrogen as N	----	0.1	mg/L	15.2	13.1	14.6	0% - 20%
EK067G: Total Phosphorus as P by Discrete Analyser (QC Lot: 2487603)									
EM1210338-006	Anonymous	EK067G: Total Phosphorus as P	----	0.01	mg/L	<0.01	<0.01	0.0	No Limit
EK071G: Reactive Phosphorus as P by discrete analyser (QC Lot: 2486621)									
EM1210334-001	Anonymous	EK071G: Reactive Phosphorus as P	----	0.01	mg/L	0.89	0.99	9.7	0% - 20%
EP005: Total Organic Carbon (TOC) (QC Lot: 2496921)									
EM1210360-001	Tildilpie Pad 4-9-2012 Sample1	EP005: Total Organic Carbon	----	1	mg/L	1930	1830	5.5	0% - 20%
EM1210572-002	Anonymous	EP005: Total Organic Carbon	----	1	mg/L	8	7	0.0	No Limit
EP010: Formaldehyde (QC Lot: 2487151)									
EM1210360-001	Tildilpie Pad 4-9-2012 Sample1	EP010: Formaldehyde	50-00-0	0.1	mg/L	4.6	4.7	3.9	0% - 20%
EP041A: Nonionic Surfactants (QC Lot: 2488667)									
ES1221506-001	Anonymous	EP041A: Nonionic Surfactants as CTAS	----	5	mg/L	6	6	0.0	No Limit
EP050: Anionic Surfactants as MBAS (QC Lot: 2488597)									

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
EP050: Anionic Surfactants as MBAS (QC Lot: 2488597) - continued									
EP1207391-001	Anonymous	EP050: Anionic Surfactants as MBAS		0.1	mg/L	0.1	0.1	0.0	No Limit
ES1221499-001	Anonymous	EP050: Anionic Surfactants as MBAS		0.1	mg/L	0.1	0.1	0.0	No Limit
EP074A: Monocyclic Aromatic Hydrocarbons (QC Lot: 2496299)									
EM1210360-001	Tildilpie Pad 4-9-2012 Sample1	EP074: Benzene	71-43-2	1	µg/L	1160	1040	11.1	0% - 20%
		EP074: Toluene	108-88-3	2	µg/L	7700	7270	5.8	0% - 20%
		EP074: Ethylbenzene	100-41-4	2	µg/L	995	981	1.4	0% - 20%
		EP074: meta- & para-Xylene	108-38-3 106-42-3	2	µg/L	13000	13400	3.2	0% - 20%
		EP074: ortho-Xylene	95-47-6	2	µg/L	2480	2610	4.9	0% - 20%
		EP074: Styrene	100-42-5	5	µg/L	<100	<100	0.0	No Limit
		EP074: Isopropylbenzene	98-82-8	5	µg/L	313	326	4.0	0% - 20%
		EP074: n-Propylbenzene	103-65-1	5	µg/L	985	957	2.8	0% - 20%
		EP074: 1.3.5-Trimethylbenzene	108-67-8	5	µg/L	2480	2660	6.9	0% - 20%
		EP074: sec-Butylbenzene	135-98-8	5	µg/L	114	175	41.6	0% - 20%
		EP074: 1.2.4-Trimethylbenzene	95-63-6	5	µg/L	4020	4290	6.6	0% - 20%
		EP074: tert-Butylbenzene	98-06-6	5	µg/L	<100	<100	0.0	No Limit
		EP074: p-Isopropyltoluene	99-87-6	5	µg/L	4190	3310	# 23.6	0% - 20%
		EP074: n-Butylbenzene	104-51-8	5	µg/L	586	616	5.1	0% - 20%
EP074B: Oxygenated Compounds (QC Lot: 2496299)									
EM1210360-001	Tildilpie Pad 4-9-2012 Sample1	EP074: Vinyl Acetate	108-05-4	50	µg/L	<1000	<1000	0.0	No Limit
		EP074: 2-Butanone (MEK)	78-93-3	50	µg/L	<1000	<1000	0.0	No Limit
		EP074: 4-Methyl-2-pentanone (MIBK)	108-10-1	50	µg/L	<1000	<1000	0.0	No Limit
		EP074: 2-Hexanone (MBK)	591-78-6	50	µg/L	<1000	<1000	0.0	No Limit
EP074C: Sulfonated Compounds (QC Lot: 2496299)									
EM1210360-001	Tildilpie Pad 4-9-2012 Sample1	EP074: Carbon disulfide	75-15-0	5	µg/L	<100	<100	0.0	No Limit
EP074D: Fumigants (QC Lot: 2496299)									
EM1210360-001	Tildilpie Pad 4-9-2012 Sample1	EP074: 2.2-Dichloropropane	594-20-7	5	µg/L	<100	<100	0.0	No Limit
		EP074: 1.2-Dichloropropane	78-87-5	5	µg/L	<100	<100	0.0	No Limit
		EP074: cis-1.3-Dichloropropylene	10061-01-5	5	µg/L	<100	<100	0.0	No Limit
		EP074: trans-1.3-Dichloropropylene	10061-02-6	5	µg/L	<100	<100	0.0	No Limit
		EP074: 1.2-Dibromoethane (EDB)	106-93-4	5	µg/L	<100	<100	0.0	No Limit
EP074E: Halogenated Aliphatic Compounds (QC Lot: 2496299)									
EM1210360-001	Tildilpie Pad 4-9-2012 Sample1	EP074: 1.1-Dichloroethene	75-35-4	5	µg/L	<100	<100	0.0	No Limit
		EP074: Iodomethane	74-88-4	5	µg/L	<100	<100	0.0	No Limit

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
EP074E: Halogenated Aliphatic Compounds (QC Lot: 2496299) - continued									
EM1210360-001	Tildilpie Pad 4-9-2012 Sample1	EP074: trans-1.2-Dichloroethene	156-60-5	5	µg/L	<100	<100	0.0	No Limit
		EP074: 1.1-Dichloroethane	75-34-3	5	µg/L	<100	<100	0.0	No Limit
		EP074: cis-1.2-Dichloroethene	156-59-2	5	µg/L	<100	<100	0.0	No Limit
		EP074: 1.1.1-Trichloroethane	71-55-6	5	µg/L	<100	<100	0.0	No Limit
		EP074: 1.1-Dichloropropylene	563-58-6	5	µg/L	<100	<100	0.0	No Limit
		EP074: Carbon Tetrachloride	56-23-5	5	µg/L	<100	<100	0.0	No Limit
		EP074: 1.2-Dichloroethane	107-06-2	5	µg/L	<100	<100	0.0	No Limit
		EP074: Trichloroethene	79-01-6	5	µg/L	<100	<100	0.0	No Limit
		EP074: Dibromomethane	74-95-3	5	µg/L	<100	<100	0.0	No Limit
		EP074: 1.1.2-Trichloroethane	79-00-5	5	µg/L	<100	<100	0.0	No Limit
		EP074: 1.3-Dichloropropane	142-28-9	5	µg/L	<100	<100	0.0	No Limit
		EP074: Tetrachloroethene	127-18-4	5	µg/L	<100	<100	0.0	No Limit
		EP074: 1.1.1.2-Tetrachloroethane	630-20-6	5	µg/L	<100	<100	0.0	No Limit
		EP074: trans-1.4-Dichloro-2-butene	110-57-6	5	µg/L	<100	<100	0.0	No Limit
		EP074: cis-1.4-Dichloro-2-butene	1476-11-5	5	µg/L	<100	<100	0.0	No Limit
		EP074: 1.1.2.2-Tetrachloroethane	79-34-5	5	µg/L	<100	<100	0.0	No Limit
		EP074: 1.2.3-Trichloropropane	96-18-4	5	µg/L	<100	<100	0.0	No Limit
		EP074: Pentachloroethane	76-01-7	5	µg/L	<100	<100	0.0	No Limit
		EP074: 1.2-Dibromo-3-chloropropane	96-12-8	5	µg/L	<100	<100	0.0	No Limit
		EP074: Dichlorodifluoromethane	75-71-8	50	µg/L	<1000	<1000	0.0	No Limit
		EP074: Chloromethane	74-87-3	50	µg/L	<1000	<1000	0.0	No Limit
		EP074: Vinyl chloride	75-01-4	50	µg/L	<1000	<1000	0.0	No Limit
		EP074: Bromomethane	74-83-9	50	µg/L	<1000	<1000	0.0	No Limit
		EP074: Chloroethane	75-00-3	50	µg/L	<1000	<1000	0.0	No Limit
		EP074: Trichlorofluoromethane	75-69-4	50	µg/L	<1000	<1000	0.0	No Limit
EP074F: Halogenated Aromatic Compounds (QC Lot: 2496299)									
EM1210360-001	Tildilpie Pad 4-9-2012 Sample1	EP074: Chlorobenzene	108-90-7	5	µg/L	<100	<100	0.0	No Limit
		EP074: Bromobenzene	108-86-1	5	µg/L	<100	<100	0.0	No Limit
		EP074: 2-Chlorotoluene	95-49-8	5	µg/L	<100	<100	0.0	No Limit
		EP074: 4-Chlorotoluene	106-43-4	5	µg/L	<100	<100	0.0	No Limit
		EP074: 1.2.3-Trichlorobenzene	87-61-6	5	µg/L	<100	<100	0.0	No Limit
EP074G: Trihalomethanes (QC Lot: 2496299)									
EM1210360-001	Tildilpie Pad 4-9-2012 Sample1	EP074: Chloroform	67-66-3	5	µg/L	<100	<100	0.0	No Limit
		EP074: Bromodichloromethane	75-27-4	5	µg/L	<100	<100	0.0	No Limit
		EP074: Dibromochloromethane	124-48-1	5	µg/L	<100	<100	0.0	No Limit
		EP074: Bromoform	75-25-2	5	µg/L	<100	<100	0.0	No Limit

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
EP075A: Phenolic Compounds (QC Lot: 2487865)									
EM1210360-001	Tildilpie Pad 4-9-2012 Sample1	EP075: Phenol	108-95-2	2	µg/L	1250	807	42.8	0% - 20%
		EP075: 2-Chlorophenol	95-57-8	2	µg/L	<200	<200	0.0	No Limit
		EP075: 2-Methylphenol	95-48-7	2	µg/L	1780	1090	48.5	0% - 20%
		EP075: 2-Nitrophenol	88-75-5	2	µg/L	<200	<200	0.0	No Limit
		EP075: 2.4-Dimethylphenol	105-67-9	2	µg/L	1250	749	49.9	0% - 20%
		EP075: 2.4-Dichlorophenol	120-83-2	2	µg/L	<200	<200	0.0	No Limit
		EP075: 2.6-Dichlorophenol	87-65-0	2	µg/L	<200	<200	0.0	No Limit
		EP075: 4-Chloro-3-Methylphenol	59-50-7	2	µg/L	<200	<200	0.0	No Limit
		EP075: 2.4.6-Trichlorophenol	88-06-2	2	µg/L	<200	<200	0.0	No Limit
		EP075: 2.4.5-Trichlorophenol	95-95-4	2	µg/L	<200	<200	0.0	No Limit
		EP075: 3- & 4-Methylphenol	1319-77-3	4	µg/L	1430	871	48.4	0% - 20%
		EP075: Pentachlorophenol	87-86-5	4	µg/L	<400	<400	0.0	No Limit
EP075B: Polynuclear Aromatic Hydrocarbons (QC Lot: 2487865)									
EM1210360-001	Tildilpie Pad 4-9-2012 Sample1	EP075: Naphthalene	91-20-3	2	µg/L	1200	542	75.7	0% - 20%
		EP075: 2-Methylnaphthalene	91-57-6	2	µg/L	2090	863	# 83.1	0% - 20%
		EP075: 2-Chloronaphthalene	91-58-7	2	µg/L	<200	<200	0.0	No Limit
		EP075: Acenaphthylene	208-96-8	2	µg/L	<200	<200	0.0	No Limit
		EP075: Acenaphthene	83-32-9	2	µg/L	<200	<200	0.0	No Limit
		EP075: Fluorene	86-73-7	2	µg/L	<200	<200	0.0	No Limit
		EP075: Phenanthrene	85-01-8	2	µg/L	268	<200	28.9	No Limit
		EP075: Anthracene	120-12-7	2	µg/L	<200	<200	0.0	No Limit
		EP075: Fluoranthene	206-44-0	2	µg/L	<200	<200	0.0	No Limit
		EP075: Pyrene	129-00-0	2	µg/L	<200	<200	0.0	No Limit
		EP075: N-2-Fluorenyl Acetamide	53-96-3	2	µg/L	<200	<200	0.0	No Limit
		EP075: Benz(a)anthracene	56-55-3	2	µg/L	<200	<200	0.0	No Limit
		EP075: Chrysene	218-01-9	2	µg/L	<200	<200	0.0	No Limit
		EP075: 7.12-Dimethylbenz(a)anthracene	57-97-6	2	µg/L	<200	<200	0.0	No Limit
		EP075: Benzo(a)pyrene	50-32-8	2	µg/L	<200	<200	0.0	No Limit
		EP075: 3-Methylcholanthrene	56-49-5	2	µg/L	<200	<200	0.0	No Limit
		EP075: Indeno(1.2.3.cd)pyrene	193-39-5	2	µg/L	<200	<200	0.0	No Limit
		EP075: Dibenz(a.h)anthracene	53-70-3	2	µg/L	<200	<200	0.0	No Limit
		EP075: Benzo(g.h.i)perylene	191-24-2	2	µg/L	<200	<200	0.0	No Limit
		EP075: Sum of PAHs	----	2	µg/L	1470	542	92.1	0% - 20%
		EP075: Benzo(b) & Benzo(k)fluoranthene	205-99-2 207-08-9	4	µg/L	<400	<400	0.0	No Limit
EP075C: Phthalate Esters (QC Lot: 2487865)									
EM1210360-001	Tildilpie Pad 4-9-2012 Sample1	EP075: bis(2-ethylhexyl) phthalate	117-81-7	10	µg/L	<1000	<1000	0.0	No Limit

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
EP075C: Phthalate Esters (QC Lot: 2487865) - continued									
EM1210360-001	Tildilpie Pad 4-9-2012 Sample1	EP075: Dimethyl phthalate	131-11-3	2	µg/L	<200	<200	0.0	No Limit
		EP075: Diethyl phthalate	84-66-2	2	µg/L	<200	<200	0.0	No Limit
		EP075: Di-n-butyl phthalate	84-74-2	2	µg/L	<200	<200	0.0	No Limit
		EP075: Butyl benzyl phthalate	85-68-7	2	µg/L	<200	<200	0.0	No Limit
		EP075: Di-n-octylphthalate	117-84-0	2	µg/L	<200	<200	0.0	No Limit
EP075D: Nitrosamines (QC Lot: 2487865)									
EM1210360-001	Tildilpie Pad 4-9-2012 Sample1	EP075: N-Nitrosomethylethylamine	10595-95-6	2	µg/L	<200	<200	0.0	No Limit
		EP075: N-Nitrosodiethylamine	55-18-5	2	µg/L	<200	<200	0.0	No Limit
		EP075: N-Nitrosomorpholine	59-89-2	2	µg/L	<200	<200	0.0	No Limit
		EP075: N-Nitrosodi-n-propylamine	621-64-7	2	µg/L	<200	<200	0.0	No Limit
		EP075: N-Nitrosopiperidine	100-75-4	2	µg/L	<200	<200	0.0	No Limit
		EP075: N-Nitrosodibutylamine	924-16-3	2	µg/L	<200	<200	0.0	No Limit
		EP075: Methapyrilene	91-80-5	2	µg/L	<200	<200	0.0	No Limit
		EP075: N-Nitrosopyrrolidine	930-55-2	4	µg/L	<400	<400	0.0	No Limit
		EP075: N-Nitrosodiphenyl & Diphenylamine	86-30-6 122-39-4	4	µg/L	<400	<400	0.0	No Limit
EP075E: Nitroaromatics and Ketones (QC Lot: 2487865)									
EM1210360-001	Tildilpie Pad 4-9-2012 Sample1	EP075: 2-Picoline	109-06-8	2	µg/L	<200	<200	0.0	No Limit
		EP075: Acetophenone	98-86-2	2	µg/L	<200	<200	0.0	No Limit
		EP075: Nitrobenzene	98-95-3	2	µg/L	<200	<200	0.0	No Limit
		EP075: Isophorone	78-59-1	2	µg/L	<200	<200	0.0	No Limit
		EP075: 1-Naphthylamine	134-32-7	2	µg/L	<200	<200	0.0	No Limit
		EP075: 4-Nitroquinoline-N-oxide	56-57-5	2	µg/L	<200	<200	0.0	No Limit
		EP075: 5-Nitro-o-toluidine	99-55-8	2	µg/L	<200	<200	0.0	No Limit
		EP075: Azobenzene	103-33-3	2	µg/L	<200	<200	0.0	No Limit
		EP075: 1.3.5-Trinitrobenzene	99-35-4	2	µg/L	<200	<200	0.0	No Limit
		EP075: Phenacetin	62-44-2	2	µg/L	<200	<200	0.0	No Limit
		EP075: 4-Aminobiphenyl	92-67-1	2	µg/L	<200	<200	0.0	No Limit
		EP075: Pentachloronitrobenzene	82-68-8	2	µg/L	<200	<200	0.0	No Limit
		EP075: Pronamide	23950-58-5	2	µg/L	<200	<200	0.0	No Limit
		EP075: Dimethylaminoazobenzene	60-11-7	2	µg/L	<200	<200	0.0	No Limit
		EP075: Chlorobenzilate	510-15-6	2	µg/L	<200	<200	0.0	No Limit
		EP075: 2.6-Dinitrotoluene	606-20-2	4	µg/L	<400	<400	0.0	No Limit
		EP075: 2.4-Dinitrotoluene	121-14-2	4	µg/L	<400	<400	0.0	No Limit
EP075F: Haloethers (QC Lot: 2487865)									
EM1210360-001	Tildilpie Pad 4-9-2012 Sample1	EP075: Bis(2-chloroethyl) ether	111-44-4	2	µg/L	<200	<200	0.0	No Limit

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
EP075F: Haloethers (QC Lot: 2487865) - continued									
EM1210360-001	Tildilpie Pad 4-9-2012 Sample1	EP075: Bis(2-chloroethoxy) methane	111-91-1	2	µg/L	<200	<200	0.0	No Limit
		EP075: 4-Chlorophenyl phenyl ether	7005-72-3	2	µg/L	<200	<200	0.0	No Limit
		EP075: 4-Bromophenyl phenyl ether	101-55-3	2	µg/L	<200	<200	0.0	No Limit
EP075G: Chlorinated Hydrocarbons (QC Lot: 2487865)									
EM1210360-001	Tildilpie Pad 4-9-2012 Sample1	EP075: Hexachlorocyclopentadiene	77-47-4	10	µg/L	<1000	<1000	0.0	No Limit
		EP075: 1.4-Dichlorobenzene	106-46-7	2	µg/L	<200	<200	0.0	No Limit
		EP075: 1.3-Dichlorobenzene	541-73-1	2	µg/L	<200	<200	0.0	No Limit
		EP075: 1.2-Dichlorobenzene	95-50-1	2	µg/L	<200	<200	0.0	No Limit
		EP075: Hexachloroethane	67-72-1	2	µg/L	<200	<200	0.0	No Limit
		EP075: 1.2.4-Trichlorobenzene	120-82-1	2	µg/L	<200	<200	0.0	No Limit
		EP075: Hexachloropropylene	1888-71-7	2	µg/L	<200	<200	0.0	No Limit
		EP075: Hexachlorobutadiene	87-68-3	2	µg/L	<200	<200	0.0	No Limit
		EP075: Pentachlorobenzene	608-93-5	2	µg/L	<200	<200	0.0	No Limit
		EP075: Hexachlorobenzene (HCB)	118-74-1	4	µg/L	<400	<400	0.0	No Limit
EP075H: Anilines and Benzidines (QC Lot: 2487865)									
EM1210360-001	Tildilpie Pad 4-9-2012 Sample1	EP075: Aniline	62-53-3	2	µg/L	<200	<200	0.0	No Limit
		EP075: 4-Chloroaniline	106-47-8	2	µg/L	<200	<200	0.0	No Limit
		EP075: Dibenzofuran	132-64-9	2	µg/L	<200	<200	0.0	No Limit
		EP075: 4-Nitroaniline	100-01-6	2	µg/L	<200	<200	0.0	No Limit
		EP075: Carbazole	86-74-8	2	µg/L	<200	<200	0.0	No Limit
		EP075: 3.3`-Dichlorobenzidine	91-94-1	2	µg/L	<200	<200	0.0	No Limit
		EP075: 2-Nitroaniline	88-74-4	4	µg/L	<400	<400	0.0	No Limit
		EP075: 3-Nitroaniline	99-09-2	4	µg/L	<400	<400	0.0	No Limit
EP075I: Organochlorine Pesticides (QC Lot: 2487865)									
EM1210360-001	Tildilpie Pad 4-9-2012 Sample1	EP075: alpha-BHC	319-84-6	2	µg/L	<200	<200	0.0	No Limit
		EP075: beta-BHC	319-85-7	2	µg/L	<200	<200	0.0	No Limit
		EP075: gamma-BHC	58-89-9	2	µg/L	<200	<200	0.0	No Limit
		EP075: delta-BHC	319-86-8	2	µg/L	<200	<200	0.0	No Limit
		EP075: Heptachlor	76-44-8	2	µg/L	<200	<200	0.0	No Limit
		EP075: Aldrin	309-00-2	2	µg/L	<200	<200	0.0	No Limit
		EP075: Heptachlor epoxide	1024-57-3	2	µg/L	<200	<200	0.0	No Limit
		EP075: alpha-Endosulfan	959-98-8	2	µg/L	<200	<200	0.0	No Limit
		EP075: 4.4`-DDE	72-55-9	2	µg/L	<200	<200	0.0	No Limit
		EP075: Dieldrin	60-57-1	2	µg/L	<200	<200	0.0	No Limit
		EP075: Endrin	72-20-8	2	µg/L	<200	<200	0.0	No Limit

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
EP075I: Organochlorine Pesticides (QC Lot: 2487865) - continued									
EM1210360-001	Tildilpie Pad 4-9-2012 Sample1	EP075: beta-Endosulfan	33213-65-9	2	µg/L	<200	<200	0.0	No Limit
		EP075: 4.4`-DDD	72-54-8	2	µg/L	<200	<200	0.0	No Limit
		EP075: Endosulfan sulfate	1031-07-8	2	µg/L	<200	<200	0.0	No Limit
		EP075: 4.4`-DDT	50-29-3	4	µg/L	<400	<400	0.0	No Limit
EP075J: Organophosphorus Pesticides (QC Lot: 2487865)									
EM1210360-001	Tildilpie Pad 4-9-2012 Sample1	EP075: Dichlorvos	62-73-7	2	µg/L	<200	<200	0.0	No Limit
		EP075: Dimethoate	60-51-5	2	µg/L	<200	<200	0.0	No Limit
		EP075: Diazinon	333-41-5	2	µg/L	<200	<200	0.0	No Limit
		EP075: Chlorpyrifos-methyl	5598-13-0	2	µg/L	<200	<200	0.0	No Limit
		EP075: Malathion	121-75-5	2	µg/L	<200	<200	0.0	No Limit
		EP075: Fenthion	55-38-9	2	µg/L	<200	<200	0.0	No Limit
		EP075: Chlorpyrifos	2921-88-2	2	µg/L	<200	<200	0.0	No Limit
		EP075: Pirimphos-ethyl	23505-41-1	2	µg/L	<200	<200	0.0	No Limit
		EP075: Chlorfenvinphos	470-90-6	2	µg/L	<200	<200	0.0	No Limit
		EP075: Prothiofos	34643-46-4	2	µg/L	<200	<200	0.0	No Limit
		EP075: Ethion	563-12-2	2	µg/L	<200	<200	0.0	No Limit
EP079/070: TPH CWG Aliphatic Hydrocarbon Fractions (QC Lot: 2487874)									
EM1210360-001	Tildilpie Pad 4-9-2012 Sample1	EP070-CWG: Aliphatic >C10-C12	TPHCWG-ALE1	50	µg/L	18000	19500	8.0	0% - 20%
		EP070-CWG: Aliphatic >C12-C16	TPHCWG-ALE2	50	µg/L	53600	55100	2.6	0% - 20%
		EP070-CWG: Aliphatic >C16-C21	----	50	µg/L	52500	54500	3.7	0% - 20%
		EP070-CWG: Aliphatic >C21-C35	----	50	µg/L	24900	24700	0.6	0% - 20%
EP079/070: TPH CWG Aliphatic Hydrocarbon Fractions (QC Lot: 2496300)									
EM1210360-001	Tildilpie Pad 4-9-2012 Sample1	EP079-CWG: Aliphatic >C5-C6	----	20	µg/L	5300	6300	17.2	0% - 20%
		EP079-CWG: Aliphatic >C6-C8	TPHCWG-ALV2	20	µg/L	71400	63800	11.3	0% - 20%
		EP079-CWG: Aliphatic >C8-C10	TPHCWG-ALV3	20	µg/L	103000	101000	2.2	0% - 20%
EP079/070: TPH CWG Aromatic Hydrocarbon Fractions (QC Lot: 2487874)									
EM1210360-001	Tildilpie Pad 4-9-2012 Sample1	EP070-CWG: Aromatic >C10-C12	TPHCWG-ARE1	50	µg/L	6050	7150	16.6	0% - 20%
		EP070-CWG: Aromatic >C12-C16	TPHCWG-ARE2	50	µg/L	14900	15700	5.2	0% - 20%
		EP070-CWG: Aromatic >C16-C21	TPHCWG-ARE3	50	µg/L	12900	13600	5.1	0% - 20%
		EP070-CWG: Aromatic >C21-C35	TPHCWG-ARE4	50	µg/L	3610	3920	8.2	0% - 20%
EP079/070: TPH CWG Aromatic Hydrocarbon Fractions (QC Lot: 2496300)									
EM1210360-001	Tildilpie Pad 4-9-2012 Sample1	EP079-CWG: Aromatic >C5-C7	----	5	µg/L	1040	930	10.7	0% - 20%

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
EP079/070: TPH CWG Aromatic Hydrocarbon Fractions (QC Lot: 2496300) - continued									
EM1210360-001	Tildilpie Pad 4-9-2012 Sample1	EP079-CWG: Aromatic >C7-C8	TPHCWG-ARV 2	5	µg/L	6490	6140	5.5	0% - 20%
		EP079-CWG: Aromatic >C8-C10	TPHCWG-ARV 3	5	µg/L	17900	18000	0.5	0% - 20%
EP117: Alcohols (QC Lot: 2489354)									
ER1200015-001	Anonymous	EP117: Ethanol	64-17-5	50	µg/L	<50	<50	0.0	No Limit
		EP117: Isopropanol	67-63-0	50	µg/L	<50	<50	0.0	No Limit
		EP117: n-Propanol	71-23-8	50	µg/L	<50	<50	0.0	No Limit
		EP117: Isobutanol	78-83-1	50	µg/L	<50	<50	0.0	No Limit
		EP117: n-Butanol	71-36-3	50	µg/L	<50	<50	0.0	No Limit
ER1200015-003	Anonymous	EP117: Ethanol	64-17-5	50	µg/L	<50	<50	0.0	No Limit
		EP117: Isopropanol	67-63-0	50	µg/L	58	59	2.2	No Limit
		EP117: n-Propanol	71-23-8	50	µg/L	<50	<50	0.0	No Limit
		EP117: Isobutanol	78-83-1	50	µg/L	<50	<50	0.0	No Limit
		EP117: n-Butanol	71-36-3	50	µg/L	<50	<50	0.0	No Limit

Method Blank (MB) and Laboratory Control Spike (LCS) Report

The quality control term Method / Laboratory Blank refers to an analyte free matrix to which all reagents are added in the same volumes or proportions as used in standard sample preparation. The purpose of this QC parameter is to monitor potential laboratory contamination. The quality control term Laboratory Control Sample (LCS) refers to a certified reference material, or a known interference free matrix spiked with target analytes. The purpose of this QC parameter is to monitor method precision and accuracy independent of sample matrix. Dynamic Recovery Limits are based on statistical evaluation of processed LCS.

Sub-Matrix: **WATER**

				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Recovery Limits (%)	
Method: Compound	CAS Number	LOR	Unit	Result	Concentration	LCS	Low	High
EA015: Total Dissolved Solids (QCLot: 2487120)								
EA015H: Total Dissolved Solids @180°C	GIS-210-010	10	mg/L	<10	2000 mg/L	99.5	98	104
ED009: Anions (QCLot: 2489720)								
ED009-X: Bromide	24959-67-9	0.01	mg/L	<0.010	2 mg/L	99.6	90	110
ED009-X: Iodide	20461-54-5	0.01	mg/L	<0.010	0.5 mg/L	89.6	73	125
ED037P: Alkalinity by PC Titrator (QCLot: 2487642)								
ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	----	200 mg/L	98.9	77	127
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA (QCLot: 2486620)								
ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	<1	12.5 mg/L	114	81	125
ED045G: Chloride Discrete analyser (QCLot: 2486619)								
ED045G: Chloride	16887-00-6	1	mg/L	<1	1000 mg/L	99.3	89	117
ED093F: Dissolved Major Cations (QCLot: 2486618)								
ED093F: Calcium	7440-70-2	1	mg/L	<1	5 mg/L	104	83	129
ED093F: Magnesium	7439-95-4	1	mg/L	<1	5 mg/L	101	80	124
ED093F: Sodium	7440-23-5	1	mg/L	<1	50 mg/L	98.6	77	125
ED093F: Potassium	7440-09-7	1	mg/L	<1	50 mg/L	96.8	77	123
EG020F: Dissolved Metals by ICP-MS (QCLot: 2494881)								
EG020A-F: Aluminium	7429-90-5	0.01	mg/L	<0.01	0.5 mg/L	109	80	120
EG020A-F: Arsenic	7440-38-2	0.001	mg/L	<0.001	0.1 mg/L	96.0	87	109
EG020A-F: Beryllium	7440-41-7	0.001	mg/L	<0.001	0.1 mg/L	104	70	124
EG020A-F: Barium	7440-39-3	0.001	mg/L	<0.001	0.1 mg/L	96.9	88	110
EG020A-F: Cadmium	7440-43-9	0.0001	mg/L	<0.0001	0.1 mg/L	98.5	88	110
EG020A-F: Chromium	7440-47-3	0.001	mg/L	<0.001	0.1 mg/L	104	86	112
EG020A-F: Cobalt	7440-48-4	0.001	mg/L	<0.001	0.1 mg/L	98.1	87	111
EG020A-F: Copper	7440-50-8	0.001	mg/L	<0.001	0.1 mg/L	101	86	108
EG020A-F: Lead	7439-92-1	0.001	mg/L	<0.001	0.1 mg/L	95.1	90	110
EG020A-F: Lithium	7439-93-2	0.001	mg/L	<0.001	0.1 mg/L	100	60	130
EG020A-F: Manganese	7439-96-5	0.001	mg/L	<0.001	0.1 mg/L	101	87	111
EG020A-F: Molybdenum	7439-98-7	0.001	mg/L	<0.001	0.1 mg/L	103	84	108
EG020A-F: Nickel	7440-02-0	0.001	mg/L	<0.001	0.1 mg/L	107	86	112
EG020A-F: Selenium	7782-49-2	0.01	mg/L	<0.01	0.1 mg/L	98.0	83	111
EG020A-F: Tin	7440-31-5	0.001	mg/L	<0.001	0.1 mg/L	104	83	111
EG020A-F: Vanadium	7440-62-2	0.01	mg/L	<0.01	0.1 mg/L	104	85	113
EG020A-F: Zinc	7440-66-6	0.005	mg/L	<0.005	0.1 mg/L	97.6	86	120
EG020A-F: Boron	7440-42-8	0.05	mg/L	<0.05	0.1 mg/L	100	61	133

Sub-Matrix: **WATER**

Method: Compound	CAS Number	LOR	Unit	Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Recovery Limits (%)	
				Result	Concentration	LCS	Low	High
EG020F: Dissolved Metals by ICP-MS (QCLot: 2494881) - continued								
EG020A-F: Iron	7439-89-6	0.05	mg/L	<0.05	0.5 mg/L	103	79	119
EG020F: Dissolved Metals by ICP-MS (QCLot: 2494882)								
EG020B-F: Strontium	7440-24-6	0.001	mg/L	<0.001	0.1 mg/L	98.7	88	108
EG020B-F: Uranium	7440-61-1	0.001	mg/L	<0.001	----	----	----	----
EG035F: Dissolved Mercury by FIMS (QCLot: 2494880)								
EG035F: Mercury	7439-97-6	0.0001	mg/L	<0.0001	0.0100 mg/L	108	71	125
EK025SF: Free CN by Segmented Flow Analyser (QCLot: 2487961)								
EK025SF: Free Cyanide	----	0.004	mg/L	<0.004	0.2 mg/L	87.9	73	111
EK026SF: Total CN by Segmented Flow Analyser (QCLot: 2487962)								
EK026SF: Total Cyanide	57-12-5	0.004	mg/L	<0.004	0.2 mg/L	91.8	85	125
EK040P: Fluoride by PC Titrator (QCLot: 2487643)								
EK040P: Fluoride	16984-48-8	0.1	mg/L	<0.1	5 mg/L	101	78	120
EK055: Ammonia as N (QCLot: 2498816)								
EK055: Ammonia as N	7664-41-7	0.1	mg/L	<0.1	25 mg/L	101	80	120
EK057G: Nitrite as N by Discrete Analyser (QCLot: 2486617)								
EK057G: Nitrite as N	----	0.01	mg/L	<0.01	0.5 mg/L	90.8	84	112
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser (QCLot: 2487853)								
EK059G: Nitrite + Nitrate as N	----	0.01	mg/L	<0.01	0.5 mg/L	97.3	73	127
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser (QCLot: 2487602)								
EK061G: Total Kjeldahl Nitrogen as N	----	0.1	mg/L	<0.1	10 mg/L	75.8	63	117
EK067G: Total Phosphorus as P by Discrete Analyser (QCLot: 2487603)								
EK067G: Total Phosphorus as P	----	0.01	mg/L	<0.01	4.42 mg/L	87.8	73	117
EK071G: Reactive Phosphorus as P by discrete analyser (QCLot: 2486621)								
EK071G: Reactive Phosphorus as P	----	0.01	mg/L	<0.01	0.5 mg/L	106	84	108
EP005: Total Organic Carbon (TOC) (QCLot: 2496921)								
EP005: Total Organic Carbon	----	1	mg/L	<1	100 mg/L	87.4	81	111
EP010: Formaldehyde (QCLot: 2487151)								
EP010: Formaldehyde	50-00-0	0.1	mg/L	<0.1	5.0 mg/L	107	91	117
EP041A: Nonionic Surfactants (QCLot: 2488667)								
EP041A: Nonionic Surfactants as CTAS	----	5	mg/L	<5	10 mg/L	107	70	128
EP050: Anionic Surfactants as MBAS (QCLot: 2488597)								
EP050: Anionic Surfactants as MBAS		0.1	mg/L	<0.1	1.0 mg/L	100	74	120
EP074A: Monocyclic Aromatic Hydrocarbons (QCLot: 2496299)								
EP074: Benzene	71-43-2	1	µg/L	<1	20 µg/L	117	79	121
EP074: Toluene	108-88-3	2	µg/L	<2	20 µg/L	113	80	124
EP074: Ethylbenzene	100-41-4	2	µg/L	<2	20 µg/L	98.9	79	121

Sub-Matrix: **WATER**

Method: Compound	CAS Number	LOR	Unit	Method Blank (MB) Report	Laboratory Control Spike (LCS) Report		
					Spike	Spike Recovery (%)	Recovery Limits (%)
				Result	Concentration	LCS	Low	High
EP074A: Monocyclic Aromatic Hydrocarbons (QCLot: 2496299) - continued								
EP074: meta- & para-Xylene	108-38-3 106-42-3	2	µg/L	<2	40 µg/L	104	80	122
EP074: Styrene	100-42-5	5	µg/L	<5	20 µg/L	100	74	122
EP074: ortho-Xylene	95-47-6	2	µg/L	<2	20 µg/L	109	81	123
EP074: Isopropylbenzene	98-82-8	5	µg/L	<5	20 µg/L	106	80	120
EP074: n-Propylbenzene	103-65-1	5	µg/L	<5	20 µg/L	85.0	70	120
EP074: 1.3.5-Trimethylbenzene	108-67-8	5	µg/L	<5	20 µg/L	86.6	71	119
EP074: sec-Butylbenzene	135-98-8	5	µg/L	<5	20 µg/L	88.9	72	120
EP074: 1.2.4-Trimethylbenzene	95-63-6	5	µg/L	<5	20 µg/L	88.8	73	119
EP074: tert-Butylbenzene	98-06-6	5	µg/L	<5	20 µg/L	90.1	73	119
EP074: p-Isopropyltoluene	99-87-6	5	µg/L	<5	20 µg/L	86.1	71	121
EP074: n-Butylbenzene	104-51-8	5	µg/L	<5	20 µg/L	78.0	65	121
EP074B: Oxygenated Compounds (QCLot: 2496299)								
EP074: Vinyl Acetate	108-05-4	50	µg/L	<50	200 µg/L	104	57	131
EP074: 2-Butanone (MEK)	78-93-3	50	µg/L	<50	200 µg/L	108	69	135
EP074: 4-Methyl-2-pentanone (MIBK)	108-10-1	50	µg/L	<50	200 µg/L	108	68	136
EP074: 2-Hexanone (MBK)	591-78-6	50	µg/L	<50	200 µg/L	103	68	138
EP074C: Sulfonated Compounds (QCLot: 2496299)								
EP074: Carbon disulfide	75-15-0	5	µg/L	<5	20 µg/L	100	67	127
EP074D: Fumigants (QCLot: 2496299)								
EP074: 2.2-Dichloropropane	594-20-7	5	µg/L	<5	20 µg/L	101	59	128
EP074: 1.2-Dichloropropane	78-87-5	5	µg/L	<5	20 µg/L	112	77	121
EP074: cis-1.3-Dichloropropylene	10061-01-5	5	µg/L	<5	20 µg/L	88.2	70	118
EP074: trans-1.3-Dichloropropylene	10061-02-6	5	µg/L	<5	20 µg/L	84.5	66	120
EP074: 1.2-Dibromoethane (EDB)	106-93-4	5	µg/L	<5	20 µg/L	104	78	124
EP074E: Halogenated Aliphatic Compounds (QCLot: 2496299)								
EP074: Dichlorodifluoromethane	75-71-8	50	µg/L	<50	200 µg/L	108	58	148
EP074: Chloromethane	74-87-3	50	µg/L	<50	200 µg/L	93.6	62	142
EP074: Vinyl chloride	75-01-4	50	µg/L	<50	200 µg/L	79.8	61	141
EP074: Bromomethane	74-83-9	50	µg/L	<50	200 µg/L	64.2	57	131
EP074: Chloroethane	75-00-3	50	µg/L	<50	200 µg/L	120	64	138
EP074: Trichlorofluoromethane	75-69-4	50	µg/L	<50	200 µg/L	105	67	131
EP074: 1.1-Dichloroethene	75-35-4	5	µg/L	<5	20 µg/L	110	71	125
EP074: Iodomethane	74-88-4	5	µg/L	<5	20 µg/L	62.0	61	135
EP074: trans-1.2-Dichloroethene	156-60-5	5	µg/L	<5	20 µg/L	109	75	121
EP074: 1.1-Dichloroethane	75-34-3	5	µg/L	<5	20 µg/L	112	77	121
EP074: cis-1.2-Dichloroethene	156-59-2	5	µg/L	<5	20 µg/L	112	78	122
EP074: 1.1.1-Trichloroethane	71-55-6	5	µg/L	<5	20 µg/L	103	70	120
EP074: 1.1-Dichloropropylene	563-58-6	5	µg/L	<5	20 µg/L	104	74	122

Sub-Matrix: **WATER**

Method: Compound	CAS Number	LOR	Unit	Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Recovery Limits (%)	
				Result	Concentration	LCS	Low	High
EP074E: Halogenated Aliphatic Compounds (QCLot: 2496299) - continued								
EP074: Carbon Tetrachloride	56-23-5	5	µg/L	<5	20 µg/L	96.0	57	123
EP074: 1.2-Dichloroethane	107-06-2	5	µg/L	<5	20 µg/L	107	75	125
EP074: Trichloroethene	79-01-6	5	µg/L	<5	20 µg/L	111	77	121
EP074: Dibromomethane	74-95-3	5	µg/L	<5	20 µg/L	114	76	122
EP074: 1.1.2-Trichloroethane	79-00-5	5	µg/L	<5	20 µg/L	113	78	126
EP074: 1.3-Dichloropropane	142-28-9	5	µg/L	<5	20 µg/L	114	79	125
EP074: Tetrachloroethene	127-18-4	5	µg/L	<5	20 µg/L	96.4	76	122
EP074: 1.1.1.2-Tetrachloroethane	630-20-6	5	µg/L	<5	20 µg/L	102	65	119
EP074: trans-1.4-Dichloro-2-butene	110-57-6	5	µg/L	<5	20 µg/L	76.0	46	126
EP074: cis-1.4-Dichloro-2-butene	1476-11-5	5	µg/L	<5	20 µg/L	67.6	54	132
EP074: 1.1.2.2-Tetrachloroethane	79-34-5	5	µg/L	<5	20 µg/L	114	75	131
EP074: 1.2.3-Trichloropropane	96-18-4	5	µg/L	<5	20 µg/L	107	75	133
EP074: Pentachloroethane	76-01-7	5	µg/L	<5	20 µg/L	88.0	46	118
EP074: 1.2-Dibromo-3-chloropropane	96-12-8	5	µg/L	<5	20 µg/L	78.1	54	124
EP074F: Halogenated Aromatic Compounds (QCLot: 2496299)								
EP074: Chlorobenzene	108-90-7	5	µg/L	<5	20 µg/L	111	81	121
EP074: Bromobenzene	108-86-1	5	µg/L	<5	20 µg/L	99.0	75	119
EP074: 2-Chlorotoluene	95-49-8	5	µg/L	<5	20 µg/L	92.2	73	121
EP074: 4-Chlorotoluene	106-43-4	5	µg/L	<5	20 µg/L	88.2	72	120
EP074: 1.2.3-Trichlorobenzene	87-61-6	5	µg/L	<5	20 µg/L	92.6	69	123
EP074G: Trihalomethanes (QCLot: 2496299)								
EP074: Chloroform	67-66-3	5	µg/L	<5	20 µg/L	107	77	121
EP074: Bromodichloromethane	75-27-4	5	µg/L	<5	20 µg/L	100	69	117
EP074: Dibromochloromethane	124-48-1	5	µg/L	<5	20 µg/L	92.8	59	119
EP074: Bromoform	75-25-2	5	µg/L	<5	20 µg/L	88.0	49	121
EP075A: Phenolic Compounds (QCLot: 2487865)								
EP075: Phenol	108-95-2	2	µg/L	<2	10 µg/L	23.2	10	65
EP075: 2-Chlorophenol	95-57-8	2	µg/L	<2	10 µg/L	53.1	29.8	108
EP075: 2-Methylphenol	95-48-7	2	µg/L	<2	10 µg/L	62.1	21.9	110
EP075: 3- & 4-Methylphenol	1319-77-3	2	µg/L	----	20 µg/L	21.4	10	108
		4	µg/L	<4	----	----	----	----
EP075: 2-Nitrophenol	88-75-5	2	µg/L	<2	10 µg/L	52.3	31.2	123
EP075: 2.4-Dimethylphenol	105-67-9	2	µg/L	<2	10 µg/L	56.3	36	124
EP075: 2.4-Dichlorophenol	120-83-2	2	µg/L	<2	10 µg/L	52.7	31.2	125
EP075: 2.6-Dichlorophenol	87-65-0	2	µg/L	<2	10 µg/L	46.1	33	123
EP075: 4-Chloro-3-Methylphenol	59-50-7	2	µg/L	<2	10 µg/L	58.4	39	125
EP075: 2.4.6-Trichlorophenol	88-06-2	2	µg/L	<2	10 µg/L	49.7	23.9	134
EP075: 2.4.5-Trichlorophenol	95-95-4	2	µg/L	<2	10 µg/L	66.3	31.6	136

Sub-Matrix: **WATER**

Method: Compound	CAS Number	LOR	Unit	Method Blank (MB) Report: Result	Laboratory Control Spike (LCS) Report: Spike Concentration	Spike Recovery (%): LCS	Recovery Limits (%): Low	Recovery Limits (%): High
EP075A: Phenolic Compounds (QCLot: 2487865) - continued								
EP075: Pentachlorophenol	87-86-5	2	µg/L	----	10 µg/L	# 10.1	47	153
		4	µg/L	<4	----	----	----	----
EP075B: Polynuclear Aromatic Hydrocarbons (QCLot: 2487865)								
EP075: Naphthalene	91-20-3	2	µg/L	<2	10 µg/L	53.9	33	117
EP075: 2-Methylnaphthalene	91-57-6	2	µg/L	<2	10 µg/L	50.8	33	123
EP075: 2-Chloronaphthalene	91-58-7	2	µg/L	<2	10 µg/L	65.0	22.6	133
EP075: Acenaphthylene	208-96-8	2	µg/L	<2	10 µg/L	67.5	35	131
EP075: Acenaphthene	83-32-9	2	µg/L	<2	10 µg/L	59.7	37	127
EP075: Fluorene	86-73-7	2	µg/L	<2	10 µg/L	58.1	39	133
EP075: Phenanthrene	85-01-8	2	µg/L	<2	10 µg/L	65.4	42	134
EP075: Anthracene	120-12-7	2	µg/L	<2	10 µg/L	63.8	41	135
EP075: Fluoranthene	206-44-0	2	µg/L	<2	10 µg/L	61.1	40	146
EP075: Pyrene	129-00-0	2	µg/L	<2	10 µg/L	64.8	42	142
EP075: N-2-Fluorenyl Acetamide	53-96-3	2	µg/L	<2	10 µg/L	69.0	40	146
EP075: Benz(a)anthracene	56-55-3	2	µg/L	<2	10 µg/L	59.6	41	143
EP075: Chrysene	218-01-9	2	µg/L	<2	10 µg/L	67.5	40	146
EP075: Benzo(b) & Benzo(k)fluoranthene	205-99-2 207-08-9	4	µg/L	<4	20 µg/L	79.8	21	151
EP075: 7.12-Dimethylbenz(a)anthracene	57-97-6	2	µg/L	<2	10 µg/L	83.1	39	151
EP075: Benzo(a)pyrene	50-32-8	2	µg/L	<2	10 µg/L	84.2	39	141
EP075: 3-Methylcholanthrene	56-49-5	2	µg/L	<2	10 µg/L	66.8	33	139
EP075: Indeno(1.2.3.cd)pyrene	193-39-5	2	µg/L	<2	10 µg/L	67.9	31.5	139
EP075: Dibenz(a.h)anthracene	53-70-3	2	µg/L	<2	10 µg/L	67.8	30.1	140
EP075: Benzo(g.h.i)perylene	191-24-2	2	µg/L	<2	10 µg/L	74.2	29.5	138
EP075C: Phthalate Esters (QCLot: 2487865)								
EP075: Dimethyl phthalate	131-11-3	2	µg/L	<2	10 µg/L	73.7	41	141
EP075: Diethyl phthalate	84-66-2	2	µg/L	<2	10 µg/L	68.4	45	139
EP075: Di-n-butyl phthalate	84-74-2	2	µg/L	<2	10 µg/L	87.5	42	150
EP075: Butyl benzyl phthalate	85-68-7	2	µg/L	<2	10 µg/L	68.4	36	152
EP075: bis(2-ethylhexyl) phthalate	117-81-7	10	µg/L	<10	----	----	----	----
		20	µg/L	----	10 µg/L	74.1	42	158
EP075: Di-n-octylphthalate	117-84-0	2	µg/L	<2	10 µg/L	81.5	43	141
EP075D: Nitrosamines (QCLot: 2487865)								
EP075: N-Nitrosomethylethylamine	10595-95-6	2	µg/L	<2	10 µg/L	51.2	10	109
EP075: N-Nitrosodiethylamine	55-18-5	2	µg/L	<2	10 µg/L	49.8	23.5	124
EP075: N-Nitrosopyrrolidine	930-55-2	4	µg/L	<4	10 µg/L	43.1	18.8	97
EP075: N-Nitrosomorpholine	59-89-2	2	µg/L	<2	10 µg/L	50.3	18.3	94
EP075: N-Nitrosodi-n-propylamine	621-64-7	2	µg/L	<2	10 µg/L	59.0	30.6	129
EP075: N-Nitrosopiperidine	100-75-4	2	µg/L	<2	10 µg/L	58.0	32	126

Sub-Matrix: **WATER**

Method: Compound	CAS Number	LOR	Unit	Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Recovery Limits (%)	
				Result	Concentration	LCS	Low	High
EP075D: Nitrosamines (QCLot: 2487865) - continued								
EP075: N-Nitrosodibutylamine	924-16-3	2	µg/L	<2	10 µg/L	54.6	29.1	135
EP075: N-Nitrosodiphenyl & Diphenylamine	86-30-6 122-39-4	4	µg/L	<4	10 µg/L	63.6	39	139
EP075: Methapyrilene	91-80-5	2	µg/L	<2	10 µg/L	33.8	28.1	70
EP075E: Nitroaromatics and Ketones (QCLot: 2487865)								
EP075: 2-Picoline	109-06-8	2	µg/L	<2	10 µg/L	# 19.0	28.4	57
EP075: Acetophenone	98-86-2	2	µg/L	<2	10 µg/L	54.9	34	126
EP075: Nitrobenzene	98-95-3	2	µg/L	<2	10 µg/L	55.8	36	120
EP075: Isophorone	78-59-1	2	µg/L	<2	10 µg/L	59.1	38	124
EP075: 2.6-Dinitrotoluene	606-20-2	4	µg/L	<4	10 µg/L	76.1	38	142
EP075: 2.4-Dinitrotoluene	121-14-2	4	µg/L	<4	10 µg/L	65.5	44	138
EP075: 1-Naphthylamine	134-32-7	2	µg/L	<2	10 µg/L	45.0	29.8	152
EP075: 4-Nitroquinoline-N-oxide	56-57-5	2	µg/L	<2	10 µg/L	99.7	25.9	168
EP075: 5-Nitro-o-toluidine	99-55-8	2	µg/L	<2	10 µg/L	62.1	26.2	138
EP075: Azobenzene	103-33-3	2	µg/L	<2	10 µg/L	74.1	43	135
EP075: 1.3.5-Trinitrobenzene	99-35-4	2	µg/L	<2	10 µg/L	56.8	10	158
EP075: Phenacetin	62-44-2	2	µg/L	<2	10 µg/L	60.8	37	131
EP075: 4-Aminobiphenyl	92-67-1	2	µg/L	<2	10 µg/L	100	10	150
EP075: Pentachloronitrobenzene	82-68-8	2	µg/L	<2	10 µg/L	68.4	38	146
EP075: Pronamide	23950-58-5	2	µg/L	<2	10 µg/L	71.1	45	139
EP075: Dimethylaminoazobenzene	60-11-7	2	µg/L	<2	10 µg/L	70.3	37	147
EP075: Chlorobenzilate	510-15-6	2	µg/L	<2	10 µg/L	63.2	42	148
EP075F: Haloethers (QCLot: 2487865)								
EP075: Bis(2-chloroethyl) ether	111-44-4	2	µg/L	<2	10 µg/L	48.8	10	142
EP075: Bis(2-chloroethoxy) methane	111-91-1	2	µg/L	<2	10 µg/L	55.5	34	126
EP075: 4-Chlorophenyl phenyl ether	7005-72-3	2	µg/L	<2	10 µg/L	58.0	39	133
EP075: 4-Bromophenyl phenyl ether	101-55-3	2	µg/L	<2	10 µg/L	63.2	39	137
EP075G: Chlorinated Hydrocarbons (QCLot: 2487865)								
EP075: 1.4-Dichlorobenzene	106-46-7	2	µg/L	<2	10 µg/L	51.8	23	109
EP075: 1.3-Dichlorobenzene	541-73-1	2	µg/L	<2	10 µg/L	50.6	19.8	112
EP075: 1.2-Dichlorobenzene	95-50-1	2	µg/L	<2	10 µg/L	48.0	25.2	109
EP075: Hexachloroethane	67-72-1	2	µg/L	<2	10 µg/L	50.6	17.4	115
EP075: 1.2.4-Trichlorobenzene	120-82-1	2	µg/L	<2	10 µg/L	50.4	25.7	112
EP075: Hexachloropropylene	1888-71-7	2	µg/L	<2	10 µg/L	46.7	19.1	115
EP075: Hexachlorobutadiene	87-68-3	2	µg/L	<2	10 µg/L	50.3	21.1	117
EP075: Hexachlorocyclopentadiene	77-47-4	10	µg/L	<10	10 µg/L	32.5	10	120
EP075: Pentachlorobenzene	608-93-5	2	µg/L	<2	10 µg/L	59.0	36	130
EP075: Hexachlorobenzene (HCB)	118-74-1	4	µg/L	<4	20 µg/L	56.9	11.1	135
EP075H: Anilines and Benzidines (QCLot: 2487865)								

Sub-Matrix: **WATER**

Method: Compound	CAS Number	LOR	Unit	Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Recovery Limits (%)	
				Result	Concentration	LCS	Low	High
EP075H: Anilines and Benzidines (QCLot: 2487865) - continued								
EP075: Aniline	62-53-3	2	µg/L	<2	10 µg/L	29.8	19.8	96
EP075: 4-Chloroaniline	106-47-8	2	µg/L	<2	10 µg/L	33.0	16.4	130
EP075: 2-Nitroaniline	88-74-4	4	µg/L	<4	10 µg/L	75.2	38	138
EP075: 3-Nitroaniline	99-09-2	4	µg/L	<4	10 µg/L	48.0	10	135
EP075: Dibenzofuran	132-64-9	2	µg/L	<2	10 µg/L	60.7	39	129
EP075: 4-Nitroaniline	100-01-6	2	µg/L	<2	10 µg/L	58.3	22.8	133
EP075: Carbazole	86-74-8	2	µg/L	<2	10 µg/L	67.4	44	138
EP075: 3.3`-Dichlorobenzidine	91-94-1	2	µg/L	<2	10 µg/L	59.6	14.6	107
EP075I: Organochlorine Pesticides (QCLot: 2487865)								
EP075: alpha-BHC	319-84-6	2	µg/L	<2	10 µg/L	66.1	41	143
EP075: beta-BHC	319-85-7	2	µg/L	<2	10 µg/L	57.1	39	145
EP075: gamma-BHC	58-89-9	2	µg/L	<2	10 µg/L	72.5	39	143
EP075: delta-BHC	319-86-8	2	µg/L	<2	10 µg/L	72.7	42	142
EP075: Heptachlor	76-44-8	2	µg/L	<2	10 µg/L	61.0	39	139
EP075: Aldrin	309-00-2	2	µg/L	<2	10 µg/L	61.9	40	142
EP075: Heptachlor epoxide	1024-57-3	2	µg/L	<2	10 µg/L	66.2	37	147
EP075: alpha-Endosulfan	959-98-8	2	µg/L	<2	10 µg/L	88.4	42	146
EP075: 4.4`-DDE	72-55-9	2	µg/L	<2	10 µg/L	54.1	41	141
EP075: Dieldrin	60-57-1	2	µg/L	<2	10 µg/L	69.6	42	144
EP075: Endrin	72-20-8	2	µg/L	<2	10 µg/L	69.1	41	145
EP075: beta-Endosulfan	33213-65-9	2	µg/L	<2	10 µg/L	70.4	42	146
EP075: 4.4`-DDD	72-54-8	2	µg/L	<2	10 µg/L	68.7	40	148
EP075: Endosulfan sulfate	1031-07-8	2	µg/L	<2	10 µg/L	70.0	38	152
EP075: 4.4`-DDT	50-29-3	4	µg/L	<4	10 µg/L	55.9	33	145
EP075J: Organophosphorus Pesticides (QCLot: 2487865)								
EP075: Dichlorvos	62-73-7	2	µg/L	<2	10 µg/L	61.3	38	132
EP075: Dimethoate	60-51-5	2	µg/L	<2	10 µg/L	72.3	36	138
EP075: Diazinon	333-41-5	2	µg/L	<2	10 µg/L	62.5	43	141
EP075: Chlorpyrifos-methyl	5598-13-0	2	µg/L	<2	10 µg/L	66.0	43	141
EP075: Malathion	121-75-5	2	µg/L	<2	10 µg/L	69.5	44	148
EP075: Fenthion	55-38-9	2	µg/L	<2	10 µg/L	66.7	42	144
EP075: Chlorpyrifos	2921-88-2	2	µg/L	<2	10 µg/L	65.9	42	142
EP075: Pirimphos-ethyl	23505-41-1	2	µg/L	<2	10 µg/L	66.1	44	142
EP075: Chlorfenvinphos	470-90-6	2	µg/L	<2	10 µg/L	62.8	44	146
EP075: Prothiofos	34643-46-4	2	µg/L	<2	10 µg/L	65.1	40	142
EP075: Ethion	563-12-2	2	µg/L	<2	10 µg/L	66.7	42	146
EP079/070: TPH CWG Aliphatic Hydrocarbon Fractions (QCLot: 2487874)								
EP070-CWG: Aliphatic >C10-C12	TPHCWG-AL E1	50	µg/L	<50	2505 µg/L	81.8	70	130

Sub-Matrix: **WATER**

Method: Compound	CAS Number	LOR	Unit	Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Recovery Limits (%)	
				Result	Concentration	LCS	Low	High
EP079/070: TPH CWG Aliphatic Hydrocarbon Fractions (QCLot: 2487874) - continued								
EP070-CWG: Aliphatic >C12-C16	TPHCWG-AL E2	50	µg/L	<50	10590 µg/L	96.0	70	130
EP070-CWG: Aliphatic >C16-C21	----	50	µg/L	<50	9345 µg/L	117	70	130
EP070-CWG: Aliphatic >C21-C35	----	50	µg/L	<50	2253 µg/L	118	70	130
EP079/070: TPH CWG Aliphatic Hydrocarbon Fractions (QCLot: 2496300)								
EP079-CWG: Aliphatic >C5-C6	----	20	µg/L	<20	50 µg/L	92.1	70	130
EP079-CWG: Aliphatic >C6-C8	TPHCWG-AL V2	20	µg/L	<20	100 µg/L	89.5	70	130
EP079-CWG: Aliphatic >C8-C10	TPHCWG-AL V3	20	µg/L	<20	120 µg/L	# 69.4	70	130
EP079/070: TPH CWG Aromatic Hydrocarbon Fractions (QCLot: 2487874)								
EP070-CWG: Aromatic >C10-C12	TPHCWG-AR E1	50	µg/L	<50	750 µg/L	80.6	70	130
EP070-CWG: Aromatic >C12-C16	TPHCWG-AR E2	50	µg/L	<50	3174 µg/L	102	70	130
EP070-CWG: Aromatic >C16-C21	TPHCWG-AR E3	50	µg/L	<50	2607 µg/L	94.1	70	130
EP070-CWG: Aromatic >C21-C35	TPHCWG-AR E4	50	µg/L	<50	606 µg/L	90.3	70	130
EP079/070: TPH CWG Aromatic Hydrocarbon Fractions (QCLot: 2496300)								
EP079-CWG: Aromatic >C5-C7	----	1	µg/L	<1	20 µg/L	96.6	70	130
EP079-CWG: Aromatic >C7-C8	TPHCWG-AR V2	2	µg/L	<2	20 µg/L	101	70	130
EP079-CWG: Aromatic >C8-C10	TPHCWG-AR V3	2	µg/L	<2	180 µg/L	77.6	70	130
EP117: Alcohols (QCLot: 2489354)								
EP117: Ethanol	64-17-5	50	µg/L	<50	100 µg/L	104	73	121
EP117: Isopropanol	67-63-0	50	µg/L	<50	100 µg/L	109	73	113
EP117: n-Propanol	71-23-8	50	µg/L	<50	100 µg/L	104	68	116
EP117: Isobutanol	78-83-1	50	µg/L	<50	100 µg/L	95.9	67	117
EP117: n-Butanol	71-36-3	50	µg/L	<50	100 µg/L	98.6	65	119

Matrix Spike (MS) Report

The quality control term Matrix Spike (MS) refers to an intralaboratory split sample spiked with a representative set of target analytes. The purpose of this QC parameter is to monitor potential matrix effects on analyte recoveries. Static Recovery Limits as per laboratory Data Quality Objectives (DQOs). Ideal recovery ranges stated may be waived in the event of sample matrix interference.

Sub-Matrix: **WATER**

				Matrix Spike (MS) Report			
				Spike	Spike Recovery (%)	Recovery Limits (%)	
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Concentration	MS	Low	High
ED009: Anions (QCLot: 2489720)							
EM1210339-001	Anonymous	ED009-X: Bromide	24959-67-9	0.2 mg/L	# Not Determined	70	130
		ED009-X: Iodide	20461-54-5	10 mg/L	110	70	130
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA (QCLot: 2486620)							
EM1210291-005	Anonymous	ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	10 mg/L	# Not Determined	70	130
ED045G: Chloride Discrete analyser (QCLot: 2486619)							
EM1210291-005	Anonymous	ED045G: Chloride	16887-00-6	400 mg/L	# Not Determined	70	130
EG020F: Dissolved Metals by ICP-MS (QCLot: 2494881)							
EM1210286-010	Anonymous	EG020A-F: Arsenic	7440-38-2	0.2 mg/L	98.2	89	139
		EG020A-F: Beryllium	7440-41-7	0.2 mg/L	101	64	138
		EG020A-F: Barium	7440-39-3	0.2 mg/L	99.2	80	122
		EG020A-F: Cadmium	7440-43-9	0.05 mg/L	100	75	131
		EG020A-F: Chromium	7440-47-3	0.2 mg/L	98.0	70	130
		EG020A-F: Cobalt	7440-48-4	0.2 mg/L	99.6	77	129
		EG020A-F: Copper	7440-50-8	0.2 mg/L	104	71	127
		EG020A-F: Lead	7439-92-1	0.2 mg/L	93.4	71	123
		EG020A-F: Manganese	7439-96-5	0.2 mg/L	93.9	66	132
		EG020A-F: Nickel	7440-02-0	0.2 mg/L	96.7	73	129
		EG020A-F: Vanadium	7440-62-2	0.2 mg/L	98.5	70	130
		EG020A-F: Zinc	7440-66-6	0.2 mg/L	101	68	136
EG035F: Dissolved Mercury by FIMS (QCLot: 2494880)							
EM1210360-001	Tildilpie Pad 4-9-2012 Sample1	EG035F: Mercury	7439-97-6	0.0100 mg/L	86.2	70	130
EK025SF: Free CN by Segmented Flow Analyser (QCLot: 2487961)							
EM1210342-009	Anonymous	EK025SF: Free Cyanide	----	0.2 mg/L	88.6	70	130
EK026SF: Total CN by Segmented Flow Analyser (QCLot: 2487962)							
EM1210242-001	Anonymous	EK026SF: Total Cyanide	57-12-5	0.2 mg/L	109	70	130
EK040P: Fluoride by PC Titrator (QCLot: 2487643)							
EM1210350-002	Anonymous	EK040P: Fluoride	16984-48-8	5.0 mg/L	101	70	130
EK055: Ammonia as N (QCLot: 2498816)							
EM1210576-002	Anonymous	EK055: Ammonia as N	7664-41-7	25 mg/L	101	70	130
EK057G: Nitrite as N by Discrete Analyser (QCLot: 2486617)							
EM1210291-005	Anonymous	EK057G: Nitrite as N	----	0.5 mg/L	104	70	130
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser (QCLot: 2487853)							
EM1210342-012	Anonymous	EK059G: Nitrite + Nitrate as N	----	0.5 mg/L	# Not Determined	70	130

Sub-Matrix: **WATER**

Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Matrix Spike (MS) Report: Spike Concentration	Spike Recovery (%): MS	Recovery Limits (%): Low	Recovery Limits (%): High
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser (QCLot: 2487602)							
EM1210340-001	Anonymous	EK061G: Total Kjeldahl Nitrogen as N	----	5 mg/L	84.0	70	130
EK067G: Total Phosphorus as P by Discrete Analyser (QCLot: 2487603)							
EM1210340-001	Anonymous	EK067G: Total Phosphorus as P	----	1 mg/L	# Not Determined	70	130
EK071G: Reactive Phosphorus as P by discrete analyser (QCLot: 2486621)							
EM1210360-001	Tildilpie Pad 4-9-2012 Sample1	EK071G: Reactive Phosphorus as P	----	0.5 mg/L	80.6	70	130
EP005: Total Organic Carbon (TOC) (QCLot: 2496921)							
EM1210360-002	Tildilpie Pad 4-9-2012 Sample2	EP005: Total Organic Carbon	----	2000 mg/L	109	70	130
EP010: Formaldehyde (QCLot: 2487151)							
EM1210360-002	Tildilpie Pad 4-9-2012 Sample2	EP010: Formaldehyde	50-00-0	5.0 mg/L	108	70	130
EP041A: Nonionic Surfactants (QCLot: 2488667)							
ES1221506-001	Anonymous	EP041A: Nonionic Surfactants as CTAS	----	5 mg/L	102	70	130
EP050: Anionic Surfactants as MBAS (QCLot: 2488597)							
EP1207391-002	Anonymous	EP050: Anionic Surfactants as MBAS		1.0 mg/L	90.0	70	130
EP074A: Monocyclic Aromatic Hydrocarbons (QCLot: 2496299)							
EM1210360-002	Tildilpie Pad 4-9-2012 Sample2	EP074: Benzene	71-43-2	20 µg/L	# Not Determined	64	121
		EP074: Toluene	108-88-3	20 µg/L	# Not Determined	63	125
EP074E: Halogenated Aliphatic Compounds (QCLot: 2496299)							
EM1210360-002	Tildilpie Pad 4-9-2012 Sample2	EP074: 1.1-Dichloroethene	75-35-4	20 µg/L	# Not Determined	52	104
		EP074: Trichloroethene	79-01-6	20 µg/L	# Not Determined	59	120
EP074F: Halogenated Aromatic Compounds (QCLot: 2496299)							
EM1210360-002	Tildilpie Pad 4-9-2012 Sample2	EP074: Chlorobenzene	108-90-7	20 µg/L	# Not Determined	63	132
EP075A: Phenolic Compounds (QCLot: 2487865)							
EM1210360-002	Tildilpie Pad 4-9-2012 Sample2	EP075: Phenol	108-95-2	10 µg/L	# Not Determined	10	51
		EP075: 2-Chlorophenol	95-57-8	10 µg/L	# Not Determined	26.1	104
		EP075: 2-Nitrophenol	88-75-5	10 µg/L	# Not Determined	34	118
		EP075: 4-Chloro-3-Methylphenol	59-50-7	10 µg/L	# Not Determined	24.9	135
		EP075: Pentachlorophenol	87-86-5	10 µg/L	# Not Determined	29.9	194
EP075B: Polynuclear Aromatic Hydrocarbons (QCLot: 2487865)							
EM1210360-002	Tildilpie Pad 4-9-2012 Sample2	EP075: Acenaphthene	83-32-9	10 µg/L	# Not Determined	27	133
		EP075: Pyrene	129-00-0	10 µg/L	# Not Determined	28.1	146
EP075D: Nitrosamines (QCLot: 2487865)							
EM1210360-002	Tildilpie Pad 4-9-2012 Sample2	EP075: N-Nitrosodi-n-propylamine	621-64-7	10 µg/L	# Not Determined	22.8	125
EP075E: Nitroaromatics and Ketones (QCLot: 2487865)							
EM1210360-002	Tildilpie Pad 4-9-2012 Sample2	EP075: 2.4-Dinitrotoluene	121-14-2	10 µg/L	# Not Determined	27.9	138
EP075G: Chlorinated Hydrocarbons (QCLot: 2487865)							

Sub-Matrix: **WATER**

Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Matrix Spike (MS) Report: Spike Concentration	Spike Recovery (%): MS	Recovery Limits (%): Low	Recovery Limits (%): High
EP075G: Chlorinated Hydrocarbons (QCLot: 2487865) - continued							
EM1210360-002	Tildilpie Pad 4-9-2012 Sample2	EP075: 1.4-Dichlorobenzene	106-46-7	10 µg/L	# Not Determined	22.1	112
		EP075: 1.2.4-Trichlorobenzene	120-82-1	10 µg/L	# Not Determined	15.3	117
EP079/070: TPH CWG Aliphatic Hydrocarbon Fractions (QCLot: 2496300)							
EM1210360-002	Tildilpie Pad 4-9-2012 Sample2	EP079-CWG: Aliphatic >C5-C6	----	70 µg/L	# Not Determined	70	130
		EP079-CWG: Aliphatic >C6-C8	TPHCWG-ALV2	120 µg/L	# Not Determined	70	130
		EP079-CWG: Aliphatic >C8-C10	TPHCWG-ALV3	120 µg/L	# Not Determined	70	130
EP079/070: TPH CWG Aromatic Hydrocarbon Fractions (QCLot: 2496300)							
EM1210360-002	Tildilpie Pad 4-9-2012 Sample2	EP079-CWG: Aromatic >C5-C7	----	20 µg/L	# Not Determined	70	130
		EP079-CWG: Aromatic >C7-C8	TPHCWG-ARV2	20 µg/L	# Not Determined	70	130
EP117: Alcohols (QCLot: 2489354)							
ER1200015-002	Anonymous	EP117: Ethanol	64-17-5	100 µg/L	93.6	70	130
		EP117: Isopropanol	67-63-0	100 µg/L	97.1	70	130
		EP117: n-Propanol	71-23-8	100 µg/L	92.6	70	130
		EP117: Isobutanol	78-83-1	100 µg/L	91.0	70	130
		EP117: n-Butanol	71-36-3	100 µg/L	93.1	70	130

INTERPRETIVE QUALITY CONTROL REPORT

Work Order	: **EM1210360**	Page	: 1 of 16
Client	: SANTOS LTD	Laboratory	: Environmental Division Melbourne
Contact	: MR BARRY RITCHIE	Contact	: Jodie Hancock
Address	: GROUND FLOOR SANTOS CENTRE 60 FLINDERS STREET ADELAIDE SA, AUSTRALIA 5001	Address	: 4 Westall Rd Springvale VIC Australia 3171
E-mail	: barry.ritchie@santos.com	E-mail	: Jodie.Hancock@alsenviro.com
Telephone	: +61 08 8116 5000	Telephone	: +61 7 3243 7128
Facsimile	: +61 08 8116 5050	Facsimile	: +61 7 3243 7218
Project	: HFRA Fluids Sampling - Extended Analysis	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Site	: ----		
C-O-C number	: ----	Date Samples Received	: 06-SEP-2012
Sampler	: JD, AJ	Issue Date	: 20-SEP-2012
Order number	: 879002/538		
		No. of samples received	: 2
Quote number	: EN/039/11	No. of samples analysed	: 2

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Interpretive Quality Control Report contains the following information:

- Analysis Holding Time Compliance
- Quality Control Parameter Frequency Compliance
- Brief Method Summaries
- Summary of Outliers

Analysis Holding Time Compliance

The following report summarises extraction / preparation and analysis times and compares with recommended holding times. Dates reported represent first date of extraction or analysis and precludes subsequent dilutions and reruns. Information is also provided re the sample container (preservative) from which the analysis aliquot was taken. Elapsed period to analysis represents number of days from sampling where no extraction / digestion is involved or period from extraction / digestion where this is present. For composite samples, sampling date is assumed to be that of the oldest sample contributing to the composite. Sample date for laboratory produced leachates is assumed as the completion date of the leaching process. Outliers for holding time are based on USEPA SW 846, APHA, AS and NEPM (1999). A listing of breaches is provided in the Summary of Outliers.

Holding times for leachate methods (excluding elutriates) vary according to the analytes being determined on the resulting solution. For non-volatile analytes, the holding time compliance assessment compares the leach date with the shortest analyte holding time for the equivalent soil method. These soil holding times are: Organics (14 days); Mercury (28 days) & other metals (180 days). A recorded breach therefore does not guarantee a breach for all non-volatile parameters.

Matrix: **WATER**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method / Container / Client Sample ID(s)	Sample Date	Extraction / Preparation			Analysis		
		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EA005: pH							
Clear Plastic Bottle - Natural							
Tildilpie Pad 4-9-2012 Sample1, Tildilpie Pad 4-9-2012 Sample2	**04-SEP-2012**	**----**	----	----	**07-SEP-2012**	04-SEP-2012	×
EA006: Sodium Adsorption Ratio (SAR)							
Clear Plastic Bottle - Natural							
Tildilpie Pad 4-9-2012 Sample1, Tildilpie Pad 4-9-2012 Sample2	**04-SEP-2012**	**---**	11-SEP-2012	----	**07-SEP-2012**	11-SEP-2012	✓
EA015: Total Dissolved Solids							
Clear Plastic Bottle - Natural							
Tildilpie Pad 4-9-2012 Sample1, Tildilpie Pad 4-9-2012 Sample2	**04-SEP-2012**	**----**	----	----	**07-SEP-2012**	11-SEP-2012	✓
ED009: Anions							
Clear Plastic Bottle - Natural							
Tildilpie Pad 4-9-2012 Sample1, Tildilpie Pad 4-9-2012 Sample2	**04-SEP-2012**	**----**	----	----	**12-SEP-2012**	02-OCT-2012	✓
ED037P: Alkalinity by PC Titrator							
Clear Plastic Bottle - Natural							
Tildilpie Pad 4-9-2012 Sample1, Tildilpie Pad 4-9-2012 Sample2	**04-SEP-2012**	**---**	18-SEP-2012	----	**07-SEP-2012**	18-SEP-2012	✓
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA							
Clear Plastic Bottle - Natural							
Tildilpie Pad 4-9-2012 Sample1, Tildilpie Pad 4-9-2012 Sample2	**04-SEP-2012**	**---**	02-OCT-2012	----	**07-SEP-2012**	02-OCT-2012	✓
ED045G: Chloride Discrete analyser							
Clear Plastic Bottle - Natural							
Tildilpie Pad 4-9-2012 Sample1, Tildilpie Pad 4-9-2012 Sample2	**04-SEP-2012**	**---**	02-OCT-2012	----	**07-SEP-2012**	02-OCT-2012	✓
ED093F: Dissolved Major Cations							
Clear Plastic Bottle - Natural							
Tildilpie Pad 4-9-2012 Sample1, Tildilpie Pad 4-9-2012 Sample2	**04-SEP-2012**	**---**	11-SEP-2012	----	**07-SEP-2012**	11-SEP-2012	✓
EG020F: Dissolved Metals by ICP-MS							
Clear Plastic Bottle - Unspecified; Lab-acidified							
Tildilpie Pad 4-9-2012 Sample1, Tildilpie Pad 4-9-2012 Sample2	**04-SEP-2012**	**---**	03-MAR-2013	----	**13-SEP-2012**	03-MAR-2013	✓
EG035F: Dissolved Mercury by FIMS							
Clear Plastic Bottle - Unspecified; Lab-acidified							
Tildilpie Pad 4-9-2012 Sample1, Tildilpie Pad 4-9-2012 Sample2	**04-SEP-2012**	**---**	18-SEP-2012	----	**14-SEP-2012**	18-SEP-2012	✓
EK010-1: Chlorine (Field Test)							
Clear Plastic Bottle - Natural							
Tildilpie Pad 4-9-2012 Sample1, Tildilpie Pad 4-9-2012 Sample2	**04-SEP-2012**	**----**	----	----	**07-SEP-2012**	04-SEP-2012	×

Matrix: **WATER**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method / Container / Client Sample ID(s)		Sample Date	Extraction / Preparation			Analysis		
			Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EK025SF: Free CN by Segmented Flow Analyser								
White Plastic Bottle-NaOH								
Tildilpie Pad 4-9-2012 Sample1,	Tildilpie Pad 4-9-2012 Sample2	**04-SEP-2012**	---	18-SEP-2012	----	**07-SEP-2012**	18-SEP-2012	✓
EK026SF: Total CN by Segmented Flow Analyser								
White Plastic Bottle-NaOH								
Tildilpie Pad 4-9-2012 Sample1,	Tildilpie Pad 4-9-2012 Sample2	**04-SEP-2012**	---	18-SEP-2012	----	**07-SEP-2012**	18-SEP-2012	✓
EK040P: Fluoride by PC Titrator								
Clear Plastic Bottle - Natural								
Tildilpie Pad 4-9-2012 Sample1,	Tildilpie Pad 4-9-2012 Sample2	**04-SEP-2012**	---	02-OCT-2012	----	**07-SEP-2012**	02-OCT-2012	✓
EK055: Ammonia as N								
Clear Plastic Bottle - Sulfuric Acid								
Tildilpie Pad 4-9-2012 Sample1,	Tildilpie Pad 4-9-2012 Sample2	**04-SEP-2012**	**----**	----	----	**14-SEP-2012**	02-OCT-2012	✓
EK057G: Nitrite as N by Discrete Analyser								
Clear Plastic Bottle - Natural								
Tildilpie Pad 4-9-2012 Sample1,	Tildilpie Pad 4-9-2012 Sample2	**04-SEP-2012**	---	06-SEP-2012	----	**06-SEP-2012**	06-SEP-2012	✓
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Clear Plastic Bottle - Sulfuric Acid								
Tildilpie Pad 4-9-2012 Sample1,	Tildilpie Pad 4-9-2012 Sample2	**04-SEP-2012**	---	02-OCT-2012	----	**07-SEP-2012**	02-OCT-2012	✓
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser								
Clear Plastic Bottle - Sulfuric Acid								
Tildilpie Pad 4-9-2012 Sample1,	Tildilpie Pad 4-9-2012 Sample2	**04-SEP-2012**	**10-SEP-2012**	02-OCT-2012	✓	**10-SEP-2012**	02-OCT-2012	✓
EK067G: Total Phosphorus as P by Discrete Analyser								
Clear Plastic Bottle - Sulfuric Acid								
Tildilpie Pad 4-9-2012 Sample1,	Tildilpie Pad 4-9-2012 Sample2	**04-SEP-2012**	**10-SEP-2012**	02-OCT-2012	✓	**10-SEP-2012**	02-OCT-2012	✓
EK071G: Reactive Phosphorus as P by discrete analyser								
Clear Plastic Bottle - Natural								
Tildilpie Pad 4-9-2012 Sample1,	Tildilpie Pad 4-9-2012 Sample2	**04-SEP-2012**	---	06-SEP-2012	----	**06-SEP-2012**	06-SEP-2012	✓
EP005: Total Organic Carbon (TOC)								
Amber TOC Vial - Sulfuric Acid								
Tildilpie Pad 4-9-2012 Sample1,	Tildilpie Pad 4-9-2012 Sample2	**04-SEP-2012**	**----**	----	----	**13-SEP-2012**	02-OCT-2012	✓
EP010: Formaldehyde								
Clear Plastic Bottle - Natural								
Tildilpie Pad 4-9-2012 Sample1,	Tildilpie Pad 4-9-2012 Sample2	**04-SEP-2012**	**----**	----	----	**06-SEP-2012**	06-SEP-2012	✓
EP041A: Nonionic Surfactants								
Pres. with Formaldehyde on receipt								
Tildilpie Pad 4-9-2012 Sample1,	Tildilpie Pad 4-9-2012 Sample2	**04-SEP-2012**	**----**	----	----	**07-SEP-2012**	02-OCT-2012	✓
EP050: Anionic Surfactants as MBAS								
Pres. with Formaldehyde on receipt								
Tildilpie Pad 4-9-2012 Sample1,	Tildilpie Pad 4-9-2012 Sample2	**04-SEP-2012**	**----**	----	----	**07-SEP-2012**	08-SEP-2012	✓
EP074A: Monocyclic Aromatic Hydrocarbons								
Amber VOC Vial - Sulfuric Acid								
Tildilpie Pad 4-9-2012 Sample1,	Tildilpie Pad 4-9-2012 Sample2	**04-SEP-2012**	**13-SEP-2012**	18-SEP-2012	✓	**14-SEP-2012**	18-SEP-2012	✓

Matrix: **WATER**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method / Container / Client Sample ID(s)	Sample Date	Extraction / Preparation			Analysis		
		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EP074B: Oxygenated Compounds							
Amber VOC Vial - Sulfuric Acid							
Tildilpie Pad 4-9-2012 Sample1, Tildilpie Pad 4-9-2012 Sample2	**04-SEP-2012**	**13-SEP-2012**	18-SEP-2012	✓	**14-SEP-2012**	18-SEP-2012	✓
EP074C: Sulfonated Compounds							
Amber VOC Vial - Sulfuric Acid							
Tildilpie Pad 4-9-2012 Sample1, Tildilpie Pad 4-9-2012 Sample2	**04-SEP-2012**	**13-SEP-2012**	18-SEP-2012	✓	**14-SEP-2012**	18-SEP-2012	✓
EP074D: Fumigants							
Amber VOC Vial - Sulfuric Acid							
Tildilpie Pad 4-9-2012 Sample1, Tildilpie Pad 4-9-2012 Sample2	**04-SEP-2012**	**13-SEP-2012**	18-SEP-2012	✓	**14-SEP-2012**	18-SEP-2012	✓
EP074E: Halogenated Aliphatic Compounds							
Amber VOC Vial - Sulfuric Acid							
Tildilpie Pad 4-9-2012 Sample1, Tildilpie Pad 4-9-2012 Sample2	**04-SEP-2012**	**13-SEP-2012**	18-SEP-2012	✓	**14-SEP-2012**	18-SEP-2012	✓
EP074F: Halogenated Aromatic Compounds							
Amber VOC Vial - Sulfuric Acid							
Tildilpie Pad 4-9-2012 Sample1, Tildilpie Pad 4-9-2012 Sample2	**04-SEP-2012**	**13-SEP-2012**	18-SEP-2012	✓	**14-SEP-2012**	18-SEP-2012	✓
EP074G: Trihalomethanes							
Amber VOC Vial - Sulfuric Acid							
Tildilpie Pad 4-9-2012 Sample1, Tildilpie Pad 4-9-2012 Sample2	**04-SEP-2012**	**13-SEP-2012**	18-SEP-2012	✓	**14-SEP-2012**	18-SEP-2012	✓
EP075A: Phenolic Compounds							
Amber Glass Bottle - Unpreserved							
Tildilpie Pad 4-9-2012 Sample1, Tildilpie Pad 4-9-2012 Sample2	**04-SEP-2012**	**11-SEP-2012**	11-SEP-2012	✓	**13-SEP-2012**	17-OCT-2012	✓
EP075B: Polynuclear Aromatic Hydrocarbons							
Amber Glass Bottle - Unpreserved							
Tildilpie Pad 4-9-2012 Sample1, Tildilpie Pad 4-9-2012 Sample2	**04-SEP-2012**	**11-SEP-2012**	11-SEP-2012	✓	**13-SEP-2012**	17-OCT-2012	✓
EP075C: Phthalate Esters							
Amber Glass Bottle - Unpreserved							
Tildilpie Pad 4-9-2012 Sample1, Tildilpie Pad 4-9-2012 Sample2	**04-SEP-2012**	**11-SEP-2012**	11-SEP-2012	✓	**13-SEP-2012**	17-OCT-2012	✓
EP075D: Nitrosamines							
Amber Glass Bottle - Unpreserved							
Tildilpie Pad 4-9-2012 Sample1, Tildilpie Pad 4-9-2012 Sample2	**04-SEP-2012**	**11-SEP-2012**	11-SEP-2012	✓	**13-SEP-2012**	17-OCT-2012	✓
EP075E: Nitroaromatics and Ketones							
Amber Glass Bottle - Unpreserved							
Tildilpie Pad 4-9-2012 Sample1, Tildilpie Pad 4-9-2012 Sample2	**04-SEP-2012**	**11-SEP-2012**	11-SEP-2012	✓	**13-SEP-2012**	17-OCT-2012	✓
EP075F: Haloethers							
Amber Glass Bottle - Unpreserved							
Tildilpie Pad 4-9-2012 Sample1, Tildilpie Pad 4-9-2012 Sample2	**04-SEP-2012**	**11-SEP-2012**	11-SEP-2012	✓	**13-SEP-2012**	17-OCT-2012	✓
EP075G: Chlorinated Hydrocarbons							
Amber Glass Bottle - Unpreserved							
Tildilpie Pad 4-9-2012 Sample1, Tildilpie Pad 4-9-2012 Sample2	**04-SEP-2012**	**11-SEP-2012**	11-SEP-2012	✓	**13-SEP-2012**	17-OCT-2012	✓
EP075H: Anilines and Benzidines							
Amber Glass Bottle - Unpreserved							
Tildilpie Pad 4-9-2012 Sample1, Tildilpie Pad 4-9-2012 Sample2	**04-SEP-2012**	**11-SEP-2012**	11-SEP-2012	✓	**13-SEP-2012**	17-OCT-2012	✓

Matrix: **WATER**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method / Container / Client Sample ID(s)	Sample Date	Extraction / Preparation			Analysis		
		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EP075I: Organochlorine Pesticides							
Amber Glass Bottle - Unpreserved							
Tildilpie Pad 4-9-2012 Sample1, Tildilpie Pad 4-9-2012 Sample2	**04-SEP-2012**	**11-SEP-2012**	11-SEP-2012	✓	**13-SEP-2012**	17-OCT-2012	✓
EP075J: Organophosphorus Pesticides							
Amber Glass Bottle - Unpreserved							
Tildilpie Pad 4-9-2012 Sample1, Tildilpie Pad 4-9-2012 Sample2	**04-SEP-2012**	**11-SEP-2012**	11-SEP-2012	✓	**13-SEP-2012**	17-OCT-2012	✓
EP117: Alcohols							
Amber VOC Vial - Sulfuric Acid							
Tildilpie Pad 4-9-2012 Sample1, Tildilpie Pad 4-9-2012 Sample2	**04-SEP-2012**	**----**	----	----	**09-SEP-2012**	18-SEP-2012	✓
RIVM Aliphatic Hydrocarbon Fractions							
Amber Glass Bottle - Unpreserved							
Tildilpie Pad 4-9-2012 Sample1, Tildilpie Pad 4-9-2012 Sample2	**04-SEP-2012**	**11-SEP-2012**	11-SEP-2012	✓	**17-SEP-2012**	21-OCT-2012	✓
Amber VOC Vial - Sulfuric Acid							
Tildilpie Pad 4-9-2012 Sample1, Tildilpie Pad 4-9-2012 Sample2	**04-SEP-2012**	**13-SEP-2012**	18-SEP-2012	✓	**14-SEP-2012**	18-SEP-2012	✓
RIVM Aromatic Hydrocarbon Fractions							
Amber Glass Bottle - Unpreserved							
Tildilpie Pad 4-9-2012 Sample1, Tildilpie Pad 4-9-2012 Sample2	**04-SEP-2012**	**11-SEP-2012**	11-SEP-2012	✓	**17-SEP-2012**	21-OCT-2012	✓
Amber VOC Vial - Sulfuric Acid							
Tildilpie Pad 4-9-2012 Sample1, Tildilpie Pad 4-9-2012 Sample2	**04-SEP-2012**	**13-SEP-2012**	18-SEP-2012	✓	**14-SEP-2012**	18-SEP-2012	✓

Quality Control Parameter Frequency Compliance

The following report summarises the frequency of laboratory QC samples analysed within the analytical lot(s) in which the submitted sample(s) was(where) processed. Actual rate should be greater than or equal to the expected rate. A listing of breaches is provided in the Summary of Outliers.

Matrix: **WATER**

Evaluation: × = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	*Method*	*QC*	*Regular*	***Actual***	***Expected***	*Evaluation*	
Laboratory Duplicates (DUP)							
Alcohols by HS-GC-MS	EP117	2	17	**11.8**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Alkalinity by PC Titrator	ED037-P	2	11	**18.2**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Ammonia as N by Discrete analyser	EK055G	2	10	**20.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Anionic Surfactants as MBAS	EP050	2	11	**18.2**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Chloride by Discrete Analyser	ED045G	2	12	**16.7**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Dissolved Mercury by FIMS	EG035F	2	19	**10.5**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Dissolved Metals by ICP-MS - Suite A	EG020A-F	2	19	**10.5**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Dissolved Metals by ICP-MS - Suite B	EG020B-F	1	4	**25.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Fluoride by PC Titrator	EK040P	2	12	**16.7**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Formaldehyde	EP010	1	2	**50.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Free CN by Segmented Flow Analyser	EK025SF	1	5	**20.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Major Cations - Dissolved	ED093F	2	13	**15.4**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	1	4	**25.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Nitrite as N by Discrete Analyser	EK057G	2	12	**16.7**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Nonionic Surfactants as CTAS	EP041A	1	3	**33.3**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
pH	EA005	1	9	**11.1**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Reactive Phosphorus as P-By Discrete Analyser	EK071G	1	3	**33.3**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Semivolatile Organic Compounds	EP075	1	3	**33.3**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Standard Anions -by IC (Extended Method)	ED009-X	1	6	**16.7**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	2	13	**15.4**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Ammonia as N	EK055	2	10	**20.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Cyanide by Segmented Flow Analyser	EK026SF	2	15	**13.3**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Dissolved Solids (High Level)	EA015H	2	16	**12.5**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Kjeldahl Nitrogen as N By Discrete Analyser	EK061G	2	12	**16.7**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Organic Carbon	EP005	2	17	**11.8**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Phosphorus as P By Discrete Analyser	EK067G	1	7	**14.3**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
TPH Speciation (TPH CWG RIVM fractions)	EP070-CWG	1	2	**50.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Volatile Hydrocarbon Speciation (TPH CWG fractions)	EP079-CWG	1	2	**50.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Volatile Organic Compounds	EP074	1	2	**50.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Laboratory Control Samples (LCS)							
Alcohols by HS-GC-MS	EP117	1	17	**5.9**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Alkalinity by PC Titrator	ED037-P	1	11	**9.1**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Ammonia as N by Discrete analyser	EK055G	1	10	**10.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Anionic Surfactants as MBAS	EP050	1	11	**9.1**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Chloride by Discrete Analyser	ED045G	2	12	**16.7**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Dissolved Mercury by FIMS	EG035F	1	19	**5.3**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Dissolved Metals by ICP-MS - Suite A	EG020A-F	1	19	**5.3**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Dissolved Metals by ICP-MS - Suite B	EG020B-F	1	4	**25.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Fluoride by PC Titrator	EK040P	1	12	**8.3**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement

Matrix: **WATER**

Evaluation: × = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	*Method*	*QC*	*Regular*	***Actual***	***Expected***	*Evaluation*	
Laboratory Control Samples (LCS) - Continued							
Formaldehyde	EP010	1	2	**50.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Free CN by Segmented Flow Analyser	EK025SF	1	5	**20.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Major Cations - Dissolved	ED093F	1	13	**7.7**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	1	4	**25.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Nitrite as N by Discrete Analyser	EK057G	1	12	**8.3**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Nonionic Surfactants as CTAS	EP041A	1	3	**33.3**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Reactive Phosphorus as P-By Discrete Analyser	EK071G	1	3	**33.3**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Semivolatile Organic Compounds	EP075	1	3	**33.3**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Standard Anions -by IC (Extended Method)	ED009-X	1	6	**16.7**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	1	13	**7.7**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Ammonia as N	EK055	1	10	**10.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Cyanide by Segmented Flow Analyser	EK026SF	1	15	**6.7**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Dissolved Solids (High Level)	EA015H	1	16	**6.3**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Kjeldahl Nitrogen as N By Discrete Analyser	EK061G	1	12	**8.3**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Organic Carbon	EP005	1	17	**5.9**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Phosphorus as P By Discrete Analyser	EK067G	1	7	**14.3**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
TPH Speciation (TPH CWG RIVM fractions)	EP070-CWG	1	2	**50.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Volatile Hydrocarbon Speciation (TPH CWG fractions)	EP079-CWG	1	2	**50.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Volatile Organic Compounds	EP074	1	2	**50.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Method Blanks (MB)							
Alcohols by HS-GC-MS	EP117	1	17	**5.9**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Ammonia as N by Discrete analyser	EK055G	1	10	**10.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Anionic Surfactants as MBAS	EP050	1	11	**9.1**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Chloride by Discrete Analyser	ED045G	1	12	**8.3**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Dissolved Mercury by FIMS	EG035F	1	19	**5.3**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Dissolved Metals by ICP-MS - Suite A	EG020A-F	1	19	**5.3**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Dissolved Metals by ICP-MS - Suite B	EG020B-F	1	4	**25.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Fluoride by PC Titrator	EK040P	1	12	**8.3**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Formaldehyde	EP010	1	2	**50.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Free CN by Segmented Flow Analyser	EK025SF	1	5	**20.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Major Cations - Dissolved	ED093F	1	13	**7.7**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	1	4	**25.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Nitrite as N by Discrete Analyser	EK057G	1	12	**8.3**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Nonionic Surfactants as CTAS	EP041A	1	3	**33.3**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Reactive Phosphorus as P-By Discrete Analyser	EK071G	1	3	**33.3**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Semivolatile Organic Compounds	EP075	1	3	**33.3**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Standard Anions -by IC (Extended Method)	ED009-X	1	6	**16.7**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	1	13	**7.7**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Ammonia as N	EK055	1	10	**10.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Cyanide by Segmented Flow Analyser	EK026SF	1	15	**6.7**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Dissolved Solids (High Level)	EA015H	1	16	**6.3**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Kjeldahl Nitrogen as N By Discrete Analyser	EK061G	1	12	**8.3**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Organic Carbon	EP005	1	17	**5.9**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement

Matrix: **WATER**

Evaluation: × = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	*Method*	*QC*	*Regular*	***Actual***	***Expected***	*Evaluation*	
Method Blanks (MB) - Continued							
Total Phosphorus as P By Discrete Analyser	EK067G	1	7	**14.3**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
TPH Speciation (TPH CWG RIVM fractions)	EP070-CWG	1	2	**50.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Volatile Hydrocarbon Speciation (TPH CWG fractions)	EP079-CWG	1	2	**50.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Volatile Organic Compounds	EP074	1	2	**50.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Matrix Spikes (MS)							
Alcohols by HS-GC-MS	EP117	1	17	**5.9**	**5.0**	✓	ALS QCS3 requirement
Ammonia as N by Discrete analyser	EK055G	1	10	**10.0**	**5.0**	✓	ALS QCS3 requirement
Anionic Surfactants as MBAS	EP050	1	11	**9.1**	**5.0**	✓	ALS QCS3 requirement
Chloride by Discrete Analyser	ED045G	1	12	**8.3**	**5.0**	✓	ALS QCS3 requirement
Dissolved Mercury by FIMS	EG035F	1	19	**5.3**	**5.0**	✓	ALS QCS3 requirement
Dissolved Metals by ICP-MS - Suite A	EG020A-F	1	19	**5.3**	**5.0**	✓	ALS QCS3 requirement
Fluoride by PC Titrator	EK040P	1	12	**8.3**	**5.0**	✓	ALS QCS3 requirement
Formaldehyde	EP010	1	2	**50.0**	**5.0**	✓	ALS QCS3 requirement
Free CN by Segmented Flow Analyser	EK025SF	1	5	**20.0**	**5.0**	✓	ALS QCS3 requirement
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	1	4	**25.0**	**5.0**	✓	ALS QCS3 requirement
Nitrite as N by Discrete Analyser	EK057G	1	12	**8.3**	**5.0**	✓	ALS QCS3 requirement
Nonionic Surfactants as CTAS	EP041A	1	3	**33.3**	**5.0**	✓	ALS QCS3 requirement
Reactive Phosphorus as P-By Discrete Analyser	EK071G	1	3	**33.3**	**5.0**	✓	ALS QCS3 requirement
Semivolatile Organic Compounds	EP075	1	3	**33.3**	**5.0**	✓	ALS QCS3 requirement
Standard Anions -by IC (Extended Method)	ED009-X	1	6	**16.7**	**5.0**	✓	ALS QCS3 requirement
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	1	13	**7.7**	**5.0**	✓	ALS QCS3 requirement
Total Ammonia as N	EK055	1	10	**10.0**	**5.0**	✓	ALS QCS3 requirement
Total Cyanide by Segmented Flow Analyser	EK026SF	1	15	**6.7**	**5.0**	✓	ALS QCS3 requirement
Total Kjeldahl Nitrogen as N By Discrete Analyser	EK061G	1	12	**8.3**	**5.0**	✓	ALS QCS3 requirement
Total Organic Carbon	EP005	1	17	**5.9**	**5.0**	✓	ALS QCS3 requirement
Total Phosphorus as P By Discrete Analyser	EK067G	1	7	**14.3**	**5.0**	✓	ALS QCS3 requirement
Volatile Hydrocarbon Speciation (TPH CWG fractions)	EP079-CWG	1	2	**50.0**	**5.0**	✓	ALS QCS3 requirement
Volatile Organic Compounds	EP074	1	2	**50.0**	**5.0**	✓	ALS QCS3 requirement

Brief Method Summaries

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the US EPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request. The following report provides brief descriptions of the analytical procedures employed for results reported in the Certificate of Analysis. Sources from which ALS methods have been developed are provided within the Method Descriptions.

Analytical Methods	Method	Matrix	Method Descriptions
pH	EA005	WATER	APHA 21st ed. 4500 H+ B. pH of water samples is determined by ISE either manually or by automated pH meter. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Total Dissolved Solids (High Level)	EA015H	WATER	In-House, APHA 21st ed., 2540C A gravimetric procedure that determines the amount of `filterable` residue in an aqueous sample. A well-mixed sample is filtered through a glass fibre filter (1.2um). The filtrate is evaporated to dryness and dried to constant weight at 180+/-5C. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Hardness as CaCO3	EA065	WATER	APHA 21st ed., 2340 B. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Standard Anions -by IC (Extended Method)	* ED009-X	WATER	APHA 21st ed., 4110. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Alkalinity by PC Titrator	ED037-P	WATER	APHA 21st ed., 2320 B This procedure determines alkalinity by automated measurement (e.g. PC Titrate) using pH 4.5 for indicating the total alkalinity end-point. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Major Anions - Dissolved	ED040F	WATER	APHA 21st ed., 3120. The 0.45um filtered samples are determined by ICP/AES for Sulfur and/or Silcon content and reported as Sulfate and/or Silica after conversion by gravimetric factor.
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	WATER	APHA 21st ed., 4500-SO4 Sulfate ions are converted to a barium sulfate suspension in an acetic acid medium with barium chloride. Light absorbance of the BaSO4 suspension is measured by a photometer and the SO4-2 concentration is determined by comparison of the reading with a standard curve. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Chloride by Discrete Analyser	ED045G	WATER	APHA 21st ed., 4500 Cl - G.The thiocyanate ion is liberated from mercuric thiocyanate through sequestration of mercury by the chloride ion to form non-ionised mercuric chloride.in the presence of ferric ions the librated thiocynate forms highly-coloured ferric thiocynate which is measured at 480 nm APHA 21st edition seal method 2 017-1-L april 2003
Major Cations - Dissolved	ED093F	WATER	Major Cations is determined based on APHA 21st ed., 3120; USEPA SW 846 - 6010 The ICPAES technique ionises the 0.45um filtered sample atoms emitting a characteristic spectrum. This spectrum is then compared against matrix matched standards for quantification. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2) Sodium Absorption Ratio is calculated from Ca, Mg and Na which determined by ALS in house method QWI-EN/ED093F. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2) Hardness parameters are calculated based on APHA 21st ed., 2340 B. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Dissolved Metals by ICP-MS - Suite A	EG020A-F	WATER	(APHA 21st ed., 3125; USEPA SW846 - 6020, ALS QWI-EN/EG020): Samples are 0.45 um filtered prior to analysis. The ICPMS technique utilizes a highly efficient argon plasma to ionize selected elements. Ions are then passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to their measurement by a discrete dynode ion detector.
Dissolved Metals by ICP-MS - Suite B	EG020B-F	WATER	(APHA 21st ed., 3125; USEPA SW846 - 6020, ALS QWI-EN/EG020): Samples are 0.45 um filtered prior to analysis. The ICPMS technique utilizes a highly efficient argon plasma to ionize selected elements. Ions are then passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to their measurement by a discrete dynode ion detector.

Analytical Methods	Method	Matrix	Method Descriptions
Dissolved Mercury by FIMS	EG035F	WATER	AS 3550, APHA 21st ed. 3112 Hg - B (Flow-injection (SnCl2)(Cold Vapour generation) AAS) Samples are 0.45 um filtered prior to analysis. FIM-AAS is an automated flameless atomic absorption technique. A bromate/bromide reagent is used to oxidise any organic mercury compounds in the filtered sample. The ionic mercury is reduced online to atomic mercury vapour by SnCl2 which is then purged into a heated quartz cell. Quantification is by comparing absorbance against a calibration curve. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Silica (Total Dissolved) by ICPAES	EG052F	WATER	APHA 21st ed., 4500-SiO2. Silica (Total) determined by calculation from Silicon by ICPAES.
Residual Chlorine by DPD Colourimetry	EK010-1 (Field)	WATER	Adapted from APHA 21st edition, 4500-Cl G, using Palintest Chlorometer 1000
Free CN by Segmented Flow Analyser	EK025SF	WATER	ASTM D7237: Using an automated segmented flow analyser, a sample at high pH (sodium hydroxide preserved) is buffered to pH 6.0. The hydrogen cyanide present passes across a gas dialysis membrane into an acceptor stream consisting of 0.01 M sodium hydroxide. The acceptor stream mixes with a buffer at pH 5.2 and reacts with chloramine-T to form cyanogen chloride. Cyanogen chloride reacts with 4-pyridine carboxylic acid and 1,3-dimethylbarbituric acid to give a red colour, measured at 600nm. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Total Cyanide by Segmented Flow Analyser	EK026SF	WATER	APHA 4500-CN-O. Sodium hydroxide preserved samples are introduced into an automated segmented flow analyser. Complex bound cyanide is decomposed in a continuously flowing stream, at a pH of 3.8, by the effect of UV light. A UV-B lamp (312 nm) and a decomposition spiral of borosilicate glass are used to filter out UV light with a wavelength of less than 290 nm thus preventing the conversion of thiocyanate into cyanide. The hydrogen cyanide present at a pH of 3.8 is separated by gas dialysis. The hydrogen cyanide is then determined photometrically, based on the reaction of cyanide with chloramine-T to form cyanogen chloride. This then reacts with 4-pyridine carboxylic acid and 1,3-dimethylbarbituric acid to give a red colour which is measured at 600 nm. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Fluoride by PC Titrator	EK040P	WATER	APHA 21st ed., 4500 F--C CDTA is added to the sample to provide a uniform ionic strength background, adjust pH, and break up complexes. Fluoride concentration is determined by either manual or automatic ISE measurement. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Total Ammonia as N	EK055	WATER	APHA 21st ed., 4500-NH3 H. This procedure involves a Buchi steam distillation followed by a titrimetric finish to determine ammonia in solid wastes, water and wastewater. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Ammonia as N by Discrete analyser	EK055G	WATER	APHA 21st ed., 4500-NH3 G Ammonia is determined by direct colorimetry by Discrete Analyser. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Nitrite as N by Discrete Analyser	EK057G	WATER	APHA 21st ed., 4500-NO2- B. Nitrite is determined by direct colourimetry by Discrete Analyser. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Nitrate as N by Discrete Analyser	EK058G	WATER	APHA 21st ed., 4500-NO3- F. Nitrate is reduced to nitrite by way of a chemical reduction followed by quantification by Discrete Analyser. Nitrite is determined seperately by direct colourimetry and result for Nitrate calculated as the difference between the two results. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	WATER	APHA 21st ed., 4500-NO3- F. Combined oxidised Nitrogen (NO2+NO3) is determined by Chemical Reduction and direct colourimetry by Discrete Analyser. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Total Kjeldahl Nitrogen as N By Discrete Analyser	EK061G	WATER	APHA 21st ed., 4500-Norg D. 25mL water samples are digested using a traditional Kjeldahl digestion followed by determination by Discrete Analyser. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Total Nitrogen as N (TKN + Nox) By Discrete Analyser	EK062G	WATER	APHA 21st ed., 4500-Norg / 4500-NO3-. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Total Phosphorus as P By Discrete Analyser	EK067G	WATER	APHA 21st ed., 4500-P B&F This procedure involves sulphuric acid digestion of a 100mL sample to break phosphorus down to orthophosphate. The orthophosphate reacts with ammonium molybdate and antimony potassium tartrate to form a complex which is then reduced and its concentration measured at 880nm using Discrete Analyser. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)

Analytical Methods	Method	Matrix	Method Descriptions
Reactive Phosphorus as P-By Discrete Analyser	EK071G	WATER	APHA 21st ed., 4500-P F Ammonium molybdate and potassium antimonyl tartrate reacts in acid medium with othophosphate to form a heteropoly acid -phosphomolybdic acid - which is reduced to intensely coloured molybdenum blue by ascorbic acid. Quantification is by Discrete Analyser. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Ionic Balance by PCT DA and Turbi SO4 DA	EN055 - PG	WATER	APHA 21st Ed. 1030F. The Ionic Balance is calculated based on the major Anions and Cations. The major anions include Alkalinity, Chloride and Sulfate which determined by PCT and DA. The Cations are determined by Turbi SO4 by DA. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Total Organic Carbon	EP005	WATER	APHA 21st ed., 5310 B, The automated TOC analyzer determines Total and Inorganic Carbon by IR cell. TOC is calculated as the difference. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Formaldehyde	EP010	WATER	In-house (ASTM D 6303-98) Determined by colourimetry using NASH reagent. The Hantszch reaction method is based on the reaction of acetylacetone with formaldehyde in the presence of excess ammonium acetate to form a coloured compound.
Nonionic Surfactants as CTAS	EP041A	WATER	APHA 21st ed., 5540 B & D This method estimates the non-ionic surfactant content of waters. Sublation transfers all surfactants into a solvent matrix. Cationic and Anionic surfactants are removed by an ion exchange resin column. The remaining surfactant is coloured up with Cobalt Thiocyanate solution and quantified by UV-vis against LAS standards. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Anionic Surfactants as MBAS	EP050	WATER	APHA 21st ed., 5540 B & C This method comprises three successive extractions from acid aqueous medium containing excess methylene blue, into chloroform, followed by an aqueous backwash and measurement of the colour by spectrophotometry at 652nm. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
TPH Speciation (TPH CWG RIVM fractions)	EP070-CWG	WATER	In-house: Determination of TPH following fractionation by GC-FID. Fractions correspond to those outlined in TPHCWG, 1998,Analysis of Petroleum Hydrocarbons in Environmental Media, TPH Criteria Working Group, Toxicity Technical Action Group, vol I and RIVM report 601501021/2004, Environmental Risk Limits for Mineral Oil (Total Petroleum Hydrocarbons). Aliphatic >C21 - C35 is defined by RIVM only.
Volatile Organic Compounds	EP074	WATER	USEPA SW 846 - 8260B Water samples are directly purged prior to analysis by Capillary GC/MS and quantification is by comparison against an established 5 point calibration curve. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Semivolatile Organic Compounds	EP075	WATER	USEPA SW 846 - 8270D Sample extracts are analysed by Capillary GC/MS and quantification is by comparison against an established 5 point calibration curve. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Volatile Hydrocarbon Speciation (TPH CWG fractions)	EP079-CWG	WATER	In-house. Conventional TPH and MAH data are determined by Purge and Trap GCMS analysis. TIC data (as fractions) and target aromatics (or groups of aromatics) are used to compute aliphatic and aromotic hydrocarbon fractions by addition or difference. Fractions conform to those outlined in TPHCWG, 1998,Analysis of Petroleum Hydrocarbons in Environmental Media, TPH Criteria Working Group, Toxicity Technical Action Group, vol I and RIVM report 601501021/2004, Environmental Risk Limits for Mineral Oil (Total Petroleum Hydrocarbons)
Alcohols by HS-GC-MS	* EP117	WATER	In House. A 10 mL aliquot of sample is mixed with 4 g of sodium chloride, equilibrated at 80 degrees C for 10 minutes and the headspace analysed by GCMS in the selected ion monitoring mode.

Preparation Methods	Method	Matrix	Method Descriptions
Separatory Funnel Extraction of Liquids	ORG14	WATER	USEPA SW 846 - 3510B 500 mL to 1L of sample is transferred to a separatory funnel and serially extracted three times using 60mL DCM for each extract. The resultant extracts are combined, dehydrated and concentrated for analysis. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2). ALS default excludes sediment which may be resident in the container.

Preparation Methods	Method	Matrix	Method Descriptions
Separatory Funnel Extraction of Liquids	ORG14-HX	WATER	Variation of USEPA SW 846 - 3510B: 500 mL to 0.5L of sample is transferred to a separatory funnel and serially extracted three times using 30mL DCM for each extract. The resultant extracts are combined, dehydrated, and exchanged into 5 mL of hexane for analysis. ALS default excludes sediment which may be resident in the container.

Summary of Outliers

Outliers : Quality Control Samples

The following report highlights outliers flagged in the Quality Control (QC) Report. Surrogate recovery limits are static and based on USEPA SW846 or ALS-QWI/EN/38 (in the absence of specific USEPA limits). This report displays QC Outliers (breaches) only.

Duplicates, Method Blanks, Laboratory Control Samples and Matrix Spikes

Matrix: **WATER**

Compound Group Name	Laboratory Sample ID	Client Sample ID	Analyte	CAS Number	Data	Limits	Comment
Duplicate (DUP) RPDs							
EP074A: Monocyclic Aromatic Hydrocarbons	EM1210360-001	Tildilpie Pad 4-9-2012 Sample1	**p-Isopropyltoluene**	99-87-6	23.6 %	0-20%	**RPD exceeds LOR based limits**
EP075B: Polynuclear Aromatic Hydrocarbons	EM1210360-001	Tildilpie Pad 4-9-2012 Sample1	**2-Methylnaphthalene**	91-57-6	83.1 %	0-20%	**RPD exceeds LOR based limits**
Laboratory Control Spike (LCS) Recoveries							
EP075A: Phenolic Compounds	2948505-001	----	**Pentachlorophenol**	87-86-5	10.1 %	47-153%	**Recovery less than lower control limit**
EP075E: Nitroaromatics and Ketones	2948505-001	----	**2-Picoline**	109-06-8	19.0 %	28.4-57%	**Recovery less than lower control limit**
EP079/070: TPH CWG Aliphatic Hydrocarbon Fractions	2959034-005	----	**Aliphatic >C8-C10**	TPHCWG-ALV3	69.4 %	70-130%	**Recovery less than lower control limit**
Matrix Spike (MS) Recoveries							
ED009: Anions	EM1210339-001	Anonymous	**Bromide**	24959-67-9	Not Determined	----	**MS recovery not determined, background level greater than or equal to 4x spike level.**
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA	EM1210291-005	Anonymous	**Sulfate as SO4 - Turbidimetric**	14808-79-8	Not Determined	----	**MS recovery not determined, background level greater than or equal to 4x spike level.**
ED045G: Chloride Discrete analyser	EM1210291-005	Anonymous	**Chloride**	16887-00-6	Not Determined	----	**MS recovery not determined, background level greater than or equal to 4x spike level.**
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Ar	EM1210342-012	Anonymous	**Nitrite + Nitrate as N**	----	Not Determined	----	**MS recovery not determined, background level greater than or equal to 4x spike level.**
EK067G: Total Phosphorus as P by Discrete Analyser	EM1210340-001	Anonymous	**Total Phosphorus as P**	----	Not Determined	----	**MS recovery not determined, background level greater than or equal to 4x spike level.**
EP074A: Monocyclic Aromatic Hydrocarbons	EM1210360-002	Tildilpie Pad 4-9-2012 Sample2	**Benzene**	71-43-2	Not Determined	----	**MS recovery not determined, background level greater than or equal to 4x spike level.**
EP074A: Monocyclic Aromatic Hydrocarbons	EM1210360-002	Tildilpie Pad 4-9-2012 Sample2	**Toluene**	108-88-3	Not Determined	----	**MS recovery not determined, background level greater than or equal to 4x spike level.**
EP074E: Halogenated Aliphatic Compounds	EM1210360-002	Tildilpie Pad 4-9-2012 Sample2	**1,1-Dichloroethene**	75-35-4	Not Determined	----	**Matrix spike recovery not determined due to sample matrix interference.**
EP074E: Halogenated Aliphatic Compounds	EM1210360-002	Tildilpie Pad 4-9-2012 Sample2	**Trichloroethene**	79-01-6	Not Determined	----	**Matrix spike recovery not determined due to sample matrix interference.**
EP074F: Halogenated Aromatic Compounds	EM1210360-002	Tildilpie Pad 4-9-2012 Sample2	**Chlorobenzene**	108-90-7	Not Determined	----	**Matrix spike recovery not determined due to sample matrix interference.**

Matrix: **WATER**

Compound Group Name	Laboratory Sample ID	Client Sample ID	Analyte	CAS Number	Data	Limits	Comment
Matrix Spike (MS) Recoveries - Continued							
EP075A: Phenolic Compounds	EM1210360-002	Tildilpie Pad 4-9-2012 Sample2	**Phenol**	108-95-2	Not Determined	----	**MS recovery not determined, background level greater than or equal to 4x spike level.**
EP075A: Phenolic Compounds	EM1210360-002	Tildilpie Pad 4-9-2012 Sample2	**2-Chlorophenol**	95-57-8	Not Determined	----	**Matrix spike recovery not determined due to sample matrix interference.**
EP075A: Phenolic Compounds	EM1210360-002	Tildilpie Pad 4-9-2012 Sample2	**2-Nitrophenol**	88-75-5	Not Determined	----	**Matrix spike recovery not determined due to sample matrix interference.**
EP075A: Phenolic Compounds	EM1210360-002	Tildilpie Pad 4-9-2012 Sample2	**4-Chloro-3-Methylphenol**	59-50-7	Not Determined	----	**Matrix spike recovery not determined due to sample matrix interference.**
EP075A: Phenolic Compounds	EM1210360-002	Tildilpie Pad 4-9-2012 Sample2	**Pentachlorophenol**	87-86-5	Not Determined	----	**Matrix spike recovery not determined due to sample matrix interference.**
EP075B: Polynuclear Aromatic Hydrocarbons	EM1210360-002	Tildilpie Pad 4-9-2012 Sample2	**Acenaphthene**	83-32-9	Not Determined	----	**Matrix spike recovery not determined due to sample matrix interference.**
EP075B: Polynuclear Aromatic Hydrocarbons	EM1210360-002	Tildilpie Pad 4-9-2012 Sample2	**Pyrene**	129-00-0	Not Determined	----	**Matrix spike recovery not determined due to sample matrix interference.**
EP075D: Nitrosamines	EM1210360-002	Tildilpie Pad 4-9-2012 Sample2	**N-Nitrosodi-n-propylamine**	621-64-7	Not Determined	----	**Matrix spike recovery not determined due to sample matrix interference.**
EP075E: Nitroaromatics and Ketones	EM1210360-002	Tildilpie Pad 4-9-2012 Sample2	**2.4-Dinitrotoluene**	121-14-2	Not Determined	----	**MS recovery not determined, background level greater than or equal to 4x spike level.**
EP075G: Chlorinated Hydrocarbons	EM1210360-002	Tildilpie Pad 4-9-2012 Sample2	**1.4-Dichlorobenzene**	106-46-7	Not Determined	----	**Matrix spike recovery not determined due to sample matrix interference.**
EP075G: Chlorinated Hydrocarbons	EM1210360-002	Tildilpie Pad 4-9-2012 Sample2	**1.2.4-Trichlorobenzene**	120-82-1	Not Determined	----	**Matrix spike recovery not determined due to sample matrix interference.**
EP079/070: TPH CWG Aliphatic Hydrocarbon Fractions	EM1210360-002	Tildilpie Pad 4-9-2012 Sample2	**Aliphatic >C5-C6**	----	Not Determined	----	**MS recovery not determined, background level greater than or equal to 4x spike level.**
EP079/070: TPH CWG Aliphatic Hydrocarbon Fractions	EM1210360-002	Tildilpie Pad 4-9-2012 Sample2	**Aliphatic >C6-C8**	TPHCWG-ALV2	Not Determined	----	**MS recovery not determined, background level greater than or equal to 4x spike level.**
EP079/070: TPH CWG Aliphatic Hydrocarbon Fractions	EM1210360-002	Tildilpie Pad 4-9-2012 Sample2	**Aliphatic >C8-C10**	TPHCWG-ALV3	Not Determined	----	**MS recovery not determined, background level greater than or equal to 4x spike level.**
EP079/070: TPH CWG Aromatic Hydrocarbon Fraction	EM1210360-002	Tildilpie Pad 4-9-2012 Sample2	**Aromatic >C5-C7**	----	Not Determined	----	**MS recovery not determined, background level greater than or equal to 4x spike level.**
EP079/070: TPH CWG Aromatic Hydrocarbon Fraction	EM1210360-002	Tildilpie Pad 4-9-2012 Sample2	**Aromatic >C7-C8**	TPHCWG-ARV2	Not Determined	----	**MS recovery not determined, background level greater than or equal to 4x spike level.**

- **For all matrices, no Method Blank value outliers occur.**

Regular Sample Surrogates

Sub-Matrix: **WATER**

Compound Group Name	Laboratory Sample ID	Client Sample ID	Analyte	CAS Number	Data	Limits	Comment

Sub-Matrix: **WATER**

Compound Group Name	Laboratory Sample ID	Client Sample ID	Analyte	CAS Number	Data	Limits	Comment
Samples Submitted							
EP074S: VOC Surrogates	EM1210360-002	Tildilpie Pad 4-9-2012 Sample2	**1.2-Dichloroethane-D4**	17060-07-0	71.2 %	72-132 %	**Recovery less than lower data quality objective**
EP075S: Acid Extractable Surrogates	EM1210360-002	Tildilpie Pad 4-9-2012 Sample2	**2-Fluorophenol**	367-12-4	Not Determined	----	**Surrogate recovery not determined due to (target or non-target) matrix interferences**
EP075S: Acid Extractable Surrogates	EM1210360-001	Tildilpie Pad 4-9-2012 Sample1	**2-Fluorophenol**	367-12-4	Not Determined	----	**Surrogate recovery not determined due to (target or non-target) matrix interferences**
EP075S: Acid Extractable Surrogates	EM1210360-002	Tildilpie Pad 4-9-2012 Sample2	**Phenol-d6**	13127-88-3	Not Determined	----	**Surrogate recovery not determined due to (target or non-target) matrix interferences**
EP075S: Acid Extractable Surrogates	EM1210360-001	Tildilpie Pad 4-9-2012 Sample1	**Phenol-d6**	13127-88-3	Not Determined	----	**Surrogate recovery not determined due to (target or non-target) matrix interferences**
EP075S: Acid Extractable Surrogates	EM1210360-002	Tildilpie Pad 4-9-2012 Sample2	**2-Chlorophenol-D4**	93951-73-6	Not Determined	----	**Surrogate recovery not determined due to (target or non-target) matrix interferences**
EP075S: Acid Extractable Surrogates	EM1210360-001	Tildilpie Pad 4-9-2012 Sample1	**2-Chlorophenol-D4**	93951-73-6	Not Determined	----	**Surrogate recovery not determined due to (target or non-target) matrix interferences**
EP075S: Acid Extractable Surrogates	EM1210360-002	Tildilpie Pad 4-9-2012 Sample2	**2.4.6-Tribromophenol**	118-79-6	Not Determined	----	**Surrogate recovery not determined due to (target or non-target) matrix interferences**
EP075S: Acid Extractable Surrogates	EM1210360-001	Tildilpie Pad 4-9-2012 Sample1	**2.4.6-Tribromophenol**	118-79-6	Not Determined	----	**Surrogate recovery not determined due to (target or non-target) matrix interferences**
EP075T: Base/Neutral Extractable Surrogates	EM1210360-002	Tildilpie Pad 4-9-2012 Sample2	**Nitrobenzene-D5**	4165-60-0	Not Determined	----	**Surrogate recovery not determined due to (target or non-target) matrix interferences**
EP075T: Base/Neutral Extractable Surrogates	EM1210360-001	Tildilpie Pad 4-9-2012 Sample1	**Nitrobenzene-D5**	4165-60-0	Not Determined	----	**Surrogate recovery not determined due to (target or non-target) matrix interferences**
EP075T: Base/Neutral Extractable Surrogates	EM1210360-002	Tildilpie Pad 4-9-2012 Sample2	**1.2-Dichlorobenzene-D4**	2199-69-1	Not Determined	----	**Surrogate recovery not determined due to (target or non-target) matrix interferences**
EP075T: Base/Neutral Extractable Surrogates	EM1210360-001	Tildilpie Pad 4-9-2012 Sample1	**1.2-Dichlorobenzene-D4**	2199-69-1	Not Determined	----	**Surrogate recovery not determined due to (target or non-target) matrix interferences**
EP075T: Base/Neutral Extractable Surrogates	EM1210360-002	Tildilpie Pad 4-9-2012 Sample2	**2-Fluorobiphenyl**	321-60-8	Not Determined	----	**Surrogate recovery not determined due to (target or non-target) matrix interferences**
EP075T: Base/Neutral Extractable Surrogates	EM1210360-001	Tildilpie Pad 4-9-2012 Sample1	**2-Fluorobiphenyl**	321-60-8	Not Determined	----	**Surrogate recovery not determined due to (target or non-target) matrix interferences**
EP075T: Base/Neutral Extractable Surrogates	EM1210360-002	Tildilpie Pad 4-9-2012 Sample2	**Anthracene-d10**	1719-06-8	Not Determined	----	**Surrogate recovery not determined due to (target or non-target) matrix interferences**
EP075T: Base/Neutral Extractable Surrogates	EM1210360-001	Tildilpie Pad 4-9-2012 Sample1	**Anthracene-d10**	1719-06-8	Not Determined	----	**Surrogate recovery not determined due to (target or non-target) matrix interferences**
EP075T: Base/Neutral Extractable Surrogates	EM1210360-002	Tildilpie Pad 4-9-2012 Sample2	**4-Terphenyl-d14**	1718-51-0	Not Determined	----	**Surrogate recovery not determined due to (target or non-target) matrix interferences**
EP075T: Base/Neutral Extractable Surrogates	EM1210360-001	Tildilpie Pad 4-9-2012 Sample1	**4-Terphenyl-d14**	1718-51-0	Not Determined	----	**Surrogate recovery not determined due to (target or non-target) matrix interferences**

Outliers : Analysis Holding Time Compliance

This report displays Holding Time breaches only. Only the respective Extraction / Preparation and/or Analysis component is/are displayed.

Matrix: **WATER**

Method	*Extraction / Preparation*	*Analysis*

Matrix: **WATER**

Container / Client Sample ID(s)		*Date extracted*	*Due for extraction*	***Days overdue***	*Date analysed*	*Due for analysis*	***Days overdue***
EA005: pH							
Clear Plastic Bottle - Natural							
Tildilpie Pad 4-9-2012 Sample1,	Tildilpie Pad 4-9-2012 Sample2	----	----	----	07-SEP-2012	04-SEP-2012	**3**
EK010-1: Chlorine (Field Test)							
Clear Plastic Bottle - Natural							
Tildilpie Pad 4-9-2012 Sample1,	Tildilpie Pad 4-9-2012 Sample2	----	----	----	07-SEP-2012	04-SEP-2012	**3**

Outliers : Frequency of Quality Control Samples

The following report highlights breaches in the Frequency of Quality Control Samples.

- **No Quality Control Sample Frequency Outliers exist.**

CHAIN OF CUSTODY

ALS Laboratory: please tick →

☐ Sydney: 277 Woodpark Rd, Smithfield NSW 2176 Ph: 02 8784 8555 E:samples.sydney@alsenviro.com
☐ Newcastle: 5 Rosegum Rd, Warabrook NSW 2304 Ph:02 4968 9433 E:samples.newcastle@alsenviro.com
☐ Brisbane: 32 Shand St, Stafford QLD 4053 Ph:07 3243 7222 E:samples.brisbane@alsenviro.com
☐ Townsville: 14-15 Desma Ct, Bohle QLD 4818 Ph:07 4796 0600 E: townsville.environmental@alsenviro.com
☑ Melbourne: 2-4 Westall Rd, Springvale VIC 3171 Ph:03 8549 9600 E: samples.melbourne@alsenviro.com
☐ Adelaide: 2-1 Burma Rd, Pooraka SA 5095 Ph: 08 8359 0890 E:adelaide@alsenviro.com
☐ Perth: 10 Hod Way, Malaga WA 6090 Ph: 08 9209 7655 E: samples.perth@alsenviro.com
☐ Launceston: 27 Wellington St, Launceston TAS 7250 Ph: 03 6331 2158 E: launceston@alsenviro.com

CLIENT:	SANTOS	TURNAROUND REQUIREMENTS : (Standard TAT may be longer for some tests e.g., Ultra Trace Organics)	[redacted] Standard TAT (List due date):
OFFICE:	D&PE, 60 Flinders Street, Adelaide SA		☐ Non Standard or urgent TAT (List due date):
PROJECT:	HFRA Fluids Sampling - Extended Analysis	ALS QUOTE NO.:	EN/039/11
ORDER NUMBER:	879002/538		
PROJECT MANAGER:	Barry Ritchie	CONTACT PH:	
SAMPLER:	Jeff Dzeryk / Andrew Johnston	SAMPLER MOBILE:	NA
COC emailed to ALS? (YES / NO)		EDD FORMAT (or default):	

COC SEQUENCE NUMBER (Circle)
COC: [redacted] 2 3 4 5 6 7
OF: [redacted] 2 3 4 5 6 7

FOR LABORATORY USE ONLY (Circle)
Custody Seal Intact? Yes No N/A
Presence of Ice/Frozen ice bricks present upon receipt? Yes No N/A
Random Sample Temperature on Receipt: 4 °C
Other comments:

Email Reports to (will default to PM if no other addresses are listed): andrew.johnston@santos.com; frac.rig.rep.completions@santos.com; barry.ritchie@santos.com

Email Invoice to (will default to PM if no other addresses are listed): barry.ritchie@santos.com

RELINQUISHED BY:	RECEIVED BY:	RELINQUISHED BY:	RECEIVED BY:
Jeff Dzeryk for CRAIG GOSLETT	Thivanka Dedigama		
DATE/TIME: 4/9/12 4-9-2012 16:30	DATE/TIME: 5-9-2012 06:00	DATE/TIME:	DATE/TIME: 6/9

COMMENTS/SPECIAL HANDLING/STORAGE OR DISPOSAL: Dissolved Metals Required are W-3 + Fe, Se, B, Sr, Al, Mo, Sn, U,

ALS USE ONLY	SAMPLE DETAILS MATRIX: Solid(S) Water(W)			CONTAINER INFORMATION		ANALYSIS REQUIRED including SUITES (NB. Suite Codes must be listed to attract suite price) Where Metals are required, specify Total (unfiltered bottle required) or Dissolved (field filtered bottle required).								Additional Information
LAB ID	SAMPLE ID	DATE / TIME	MATRIX	TYPE & PRESERVATIVE (refer to codes below)	TOTAL BOTTLES	EA005, EA015H, EK011	NT-1B, NT-2A, NT-8A	EG052, EN055-DA, ED009X	EA065, EK025, EK026, EP005	W-3 and EG020F (See Additional Info)	EP117, TRH-CWG	EP074A-H, EP075	EP010, EP050, EP041	Comments (likely contaminant levels, dilutions, or samples requiring specific QC analysis etc)
1	Tindilpie Pad 4-09-2012 Sample 1	4/09/2012 14:00:00	W	1L plastic / green; 60ml plastic green; 125ml plastic purple; 60ml plastic blue; 40ml vial purple; 60ml plastic red; 2 x 40ml vial purple; 3x 100ml glass orange; 2 x 40ml amber glass maroon; 3 x 100ml glass orange; 2 x 500ml amber brown;	18	X	X	X	X	X	X	X	X	Sample taken from Frac Fluid at Tindilpie Pad Welliste prior to treatment. Dissolved Metals Required are W-3 + Fe, Se, B, Sr, Al, Mo, Sn, U, Li
2	Tindilpie Pad 4-09-2012 Sample 2	4/09/2012 14:15:00	W	1L plastic / green; 60ml plastic green; 125ml plastic purple; 60ml plastic blue; 40ml vial purple; 60ml plastic red; 2 x 40ml vial purple; 3x 100ml glass orange; 2 x 40ml amber glass maroon; 3 x 100ml glass orange; 2 x 500ml amber brown;	18	X	X	X	X	X	X	X	X	Sample taken from Frac Fluid at Tindilpie Pad Welliste prior to treatment. Dissolved Metals Required are W-3 + Fe, Se, B, Sr, Al, Mo, Sn, U, Li
				TOTAL	36									

Samples sent to lab for Frac BOD pH Colour Turbidity (RB) Formaldehyde Other
Date 6/9/12.

Environmental Division
Melbourne
JL
Work Order
EM1210360

Telephone : +61-3-8549 9600

Water Container Codes: P = Unpreserved Plastic; N = Nitric Preserved Plastic; ORC = Nitric Preserved ORC; SH = Sodium Hydroxide/Cd Preserved; S = Sodium Hydroxide Preserved Plastic; AG = Amber Glas V = VOA Vial HCl Preserved; VB = VOA Vial Sodium Bisulphate Preserved; VS = VOA Vial Sulfuric Preserved; AV = Airfreight Unpreserved Vial SG = Sulfuric Preserved Amber Glass; H = HCl preserved Plastic; Z = Zinc Acetate Preserved Bottle; E = EDTA Preserved Bottles; ST = Sterile Bottle; ASS = Plastic Bag for Acid Sulphate Soils; B = Unpreserved Bag.

F = Formaldehyde Preserved Glass;

Raymond Thai

From: Sarah Hodgson
Sent: Thursday, 6 September 2012 11:36 AM
To: Samples Melbourne
Subject: RE: SANTOS HFRA Fluids Sampling - Extended Analysis - EM1210360

Hi Ray,

These would not have been field filtered. Please ask the lab to filter.

Thank you,

Regards,
How was your customer experience? Please send us your feedback

Sarah Hodgson

PROJECT MANAGER

ALS | Environmental
Address
4 Westall Road
Springvale VIC 3171
PHONE +61 3 8549 9600
FAX +61 3 8549 9601
www.alsglobal.com
cid:615291706@05102011-231E

-----Original Message-----
From: Samples Melbourne
Sent: Thursday, 6 September 2012 11:34 AM
To: Sarah Hodgson
Subject: SANTOS HFRA Fluids Sampling - Extended Analysis - EM1210360

Hi Sarah,

With regards to the attached COC, the ID's on the bottles have faded and are barely legible. Ranil has sorted the samples as they have been packaged separately, we have done the best we could with checking whether they are the same samples using the sampling times on the bottles which seem to have matched up well. But we have received a unspecified red/green metals bottle for each of the 2 samples that appear to be unfiltered by their physically appearance. Could you please clarify with the client whether they have been field filtered?

Thanks, Ray

CERTIFICATE OF ANALYSIS

Work Order	: **EM1210744**	Page	: 1 of 12
Client	: **SANTOS LTD**	Laboratory	: Environmental Division Melbourne
Contact	: MR BARRY RITCHIE	Contact	: Client Services
Address	: GROUND FLOOR SANTOS CENTRE 60 FLINDERS STREET ADELAIDE SA, AUSTRALIA 5001	Address	: 4 Westall Rd Springvale VIC Australia 3171
E-mail	: barry.ritchie@santos.com	E-mail	: Melbourne.Enviro.Services@alsglobal.com
Telephone	: +61 08 8116 5000	Telephone	: +61-3-8549 9600
Facsimile	: +61 08 8116 5050	Facsimile	: +61-3-8549 9601
Project	: HFRA Fluids Sampling- Extended Analysis	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Order number	: 879002/538		
C-O-C number	: ----	Date Samples Received	: 14-SEP-2012
Sampler	: JM, AJ	Issue Date	: 03-OCT-2012
Site	: ----		
		No. of samples received	: 2
Quote number	: EN/039/12	No. of samples analysed	: 2

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results
- Surrogate Control Limits

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting

- **Bromide, Iodide and alcohols conducted by ALS Sydney, NATA accreditation no. 825, site no 10911.**
- **EP071: Poor duplicate precision for sample EM1210744-001 due to sample heterogeneity.**
- **EP074/079-CWG: Sample EM1210744-001 required dilution due to the presence of high level contaminants. LOR values have been adjusted accordingly.**
- **EP075: EM1210744-001 & 002 Surrogate recoveries not determined for 2-Fluorophenol, Phenol-d6, 2-Chlorophenol-d4 and 2,4,6-Tribromophenol due to matrix interferences.**
- **EP075: EM1210744-001 Particular sample required dilution prior to analysis due to matrix interferences. LOR values have been adjusted accordingly.**
- **EP075: Matrix spike not determined due to matrix interferences.**
- **EP075: 'Sum of PAH' is the sum of the USEPA 16 priority PAHs**
- **Ionic balances were calculated using: major anions - chloride, alkalinity and sulfate; and major cations - calcium, magnesium, potassium and sodium.**
- **MBAS/CTAS conducted by ALS WRG Scoresby, NATA accreditation no. 992, site no. 989.**
- **Samples were filtered through a 0.45um filter prior to the dissolved metals analysis.**

NATA Accredited Laboratory 825

Accredited for compliance with ISO/IEC 17025.

Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Ashesh Patel	Inorganic Chemist	Sydney Inorganics
Danielle White	Committal	WRG Subcontracting
Dilani Fernando	Senior Inorganic Chemist	Melbourne Inorganics
Herman Lin	Laboratory Coordinator	Melbourne Inorganics
Nancy Wang	Senior Semivolatile Instrument Chemist	Melbourne Organics
Nikki Stepniewski	Senior Inorganic Instrument Chemist	Melbourne Inorganics
Pabi Subba	Senior Organic Chemist	Sydney Organics
Sarah Millington	Senior Inorganic Chemist	Sydney Inorganics

Analytical Results

Sub-Matrix: **WATER**

Compound	CAS Number	LOR	Unit	Client sample ID: FR Water	Crosslink Gel	----	----	----
				Client sampling date / time: [13-SEP-2012]	[13-SEP-2012]	----	----	----
				EM1210744-001	EM1210744-002	----	----	----
EA005: pH								
pH Value	----	0.01	pH Unit	**6.10**	----	----	----	----
EA006: Sodium Adsorption Ratio (SAR)								
Sodium Absorption Ratio	----	0.01	-	**4.09**	----	----	----	----
EA015: Total Dissolved Solids								
Total Dissolved Solids @180°C	GIS-210-010	10	mg/L	**1040**	----	----	----	----
EA065: Total Hardness as CaCO3								
Total Hardness as CaCO3	----	1	mg/L	**5**	----	----	----	----
ED009: Anions								
Bromide	24959-67-9	0.010	mg/L	**0.082**	----	----	----	----
Iodide	20461-54-5	0.010	mg/L	<0.010	----	----	----	----
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	----	----	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	----	----	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	**10**	----	----	----	----
Total Alkalinity as CaCO3	----	1	mg/L	**10**	----	----	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	**292**	----	----	----	----
ED045G: Chloride Discrete analyser								
Chloride	16887-00-6	1	mg/L	**370**	----	----	----	----
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	**2**	----	----	----	----
Magnesium	7439-95-4	1	mg/L	<1	----	----	----	----
Sodium	7440-23-5	1	mg/L	**21**	----	----	----	----
Potassium	7440-09-7	1	mg/L	<1	----	----	----	----
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	<0.01	----	----	----	----
Arsenic	7440-38-2	0.001	mg/L	<0.001	----	----	----	----
Barium	7440-39-3	0.001	mg/L	<0.001	----	----	----	----
Beryllium	7440-41-7	0.001	mg/L	<0.001	----	----	----	----
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	----	----	----	----
Cobalt	7440-48-4	0.001	mg/L	<0.001	----	----	----	----
Chromium	7440-47-3	0.001	mg/L	<0.001	----	----	----	----
Copper	7440-50-8	0.001	mg/L	**0.003**	----	----	----	----
Manganese	7439-96-5	0.001	mg/L	**0.002**	----	----	----	----
Nickel	7440-02-0	0.001	mg/L	<0.001	----	----	----	----

Analytical Results

Sub-Matrix: **WATER**

Compound	CAS Number	LOR	Unit	Client sample ID: FR Water Client sampling date / time: [13-SEP-2012] EM1210744-001	Crosslink Gel [13-SEP-2012] EM1210744-002	---- ---- ----	---- ---- ----	---- ---- ----
EG020F: Dissolved Metals by ICP-MS - Continued								
Lead	7439-92-1	0.001	mg/L	<0.001	----	----	----	----
Vanadium	7440-62-2	0.01	mg/L	<0.01	----	----	----	----
Zinc	7440-66-6	0.005	mg/L	**0.006**	----	----	----	----
Lithium	7439-93-2	0.001	mg/L	<0.001	----	----	----	----
Molybdenum	7439-98-7	0.001	mg/L	<0.001	----	----	----	----
Selenium	7782-49-2	0.01	mg/L	<0.01	----	----	----	----
Strontium	7440-24-6	0.001	mg/L	**0.008**	----	----	----	----
Tin	7440-31-5	0.001	mg/L	<0.001	----	----	----	----
Uranium	7440-61-1	0.001	mg/L	<0.001	----	----	----	----
Boron	7440-42-8	0.05	mg/L	<0.05	----	----	----	----
Iron	7439-89-6	0.05	mg/L	<0.05	----	----	----	----
EG035F: Dissolved Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	----	----	----	----
EG052F: Dissolved Silica by ICPAES								
Silica	7631-86-9	0.1	mg/L	<0.1	----	----	----	----
EK010-1: Chlorine (Field Test)								
Free Chlorine	----	0.02	mg/L	**0.26**	----	----	----	----
EK025SF: Free CN by Segmented Flow Analyser								
Free Cyanide	----	0.004	mg/L	<0.004	----	----	----	----
EK026SF: Total CN by Segmented Flow Analyser								
Total Cyanide	57-12-5	0.004	mg/L	<0.004	----	----	----	----
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	<0.1	----	----	----	----
EK055G: Ammonia as N by Discrete Analyser								
Ammonia as N	7664-41-7	0.01	mg/L	**90.5**	----	----	----	----
EK057G: Nitrite as N by Discrete Analyser								
Nitrite as N	----	0.01	mg/L	<0.01	----	----	----	----
EK058G: Nitrate as N by Discrete Analyser								
Nitrate as N	14797-55-8	0.01	mg/L	**0.36**	----	----	----	----
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Nitrite + Nitrate as N	----	0.01	mg/L	**0.36**	----	----	----	----
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser								
Total Kjeldahl Nitrogen as N	----	0.1	mg/L	**185**	----	----	----	----
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser								
^ **Total Nitrogen as N**	----	0.1	mg/L	**185**	----	----	----	----

Analytical Results

Sub-Matrix: **WATER**

Compound	CAS Number	LOR	Unit	Client sample ID	FR Water	Crosslink Gel	----	----	----
				Client sampling date / time	[13-SEP-2012]	[13-SEP-2012]	----	----	----
					EM1210744-001	EM1210744-002	----	----	----
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphorus as P	----	0.01	mg/L		**1.42**	----	----	----	----
EK071G: Reactive Phosphorus as P by discrete analyser									
Reactive Phosphorus as P	----	0.01	mg/L		**0.07**	----	----	----	----
EN055: Ionic Balance									
Total Anions	----	0.01	meq/L		**16.7**	----	----	----	----
Total Cations	----	0.01	meq/L		**15.5**	----	----	----	----
Ionic Balance	----	0.01	%		**3.90**	----	----	----	----
EP005: Total Organic Carbon (TOC)									
Total Organic Carbon	----	1	mg/L		**608**	**23900**	----	----	----
EP010: Formaldehyde									
Formaldehyde	50-00-0	0.1	mg/L		<0.1	----	----	----	----
EP041A: Nonionic Surfactants									
Nonionic Surfactants as CTAS	----	5	mg/L		**105**	----	----	----	----
EP074A: Monocyclic Aromatic Hydrocarbons									
Benzene	71-43-2	1	µg/L		<10	<1	----	----	----
Toluene	108-88-3	2	µg/L		**26**	**13**	----	----	----
Ethylbenzene	100-41-4	2	µg/L		<10	<2	----	----	----
meta- & para-Xylene	108-38-3 106-42-3	2	µg/L		**50**	**17**	----	----	----
Styrene	100-42-5	5	µg/L		<10	<5	----	----	----
ortho-Xylene	95-47-6	2	µg/L		<10	<2	----	----	----
Isopropylbenzene	98-82-8	5	µg/L		<10	<5	----	----	----
n-Propylbenzene	103-65-1	5	µg/L		<10	<5	----	----	----
1.3.5-Trimethylbenzene	108-67-8	5	µg/L		<10	<5	----	----	----
sec-Butylbenzene	135-98-8	5	µg/L		<10	<5	----	----	----
1.2.4-Trimethylbenzene	95-63-6	5	µg/L		<10	<5	----	----	----
tert-Butylbenzene	98-06-6	5	µg/L		<10	<5	----	----	----
p-Isopropyltoluene	99-87-6	5	µg/L		**1450**	**316**	----	----	----
n-Butylbenzene	104-51-8	5	µg/L		<10	<5	----	----	----
EP074B: Oxygenated Compounds									
Vinyl Acetate	108-05-4	50	µg/L		<100	<50	----	----	----
2-Butanone (MEK)	78-93-3	50	µg/L		<100	**50**	----	----	----
4-Methyl-2-pentanone (MIBK)	108-10-1	50	µg/L		<100	<50	----	----	----
2-Hexanone (MBK)	591-78-6	50	µg/L		<100	<50	----	----	----
EP074C: Sulfonated Compounds									
Carbon disulfide	75-15-0	5	µg/L		<10	<5	----	----	----

Analytical Results

Sub-Matrix: **WATER**

Compound	CAS Number	LOR	Unit	Client sample ID: FR Water	Crosslink Gel	----	----	----
				Client sampling date / time: [13-SEP-2012]	[13-SEP-2012]	----	----	----
				EM1210744-001	EM1210744-002	----	----	----
EP074D: Fumigants								
2.2-Dichloropropane	594-20-7	5	µg/L	<10	<5	----	----	----
1.2-Dichloropropane	78-87-5	5	µg/L	<10	<5	----	----	----
cis-1.3-Dichloropropylene	10061-01-5	5	µg/L	<10	<5	----	----	----
trans-1.3-Dichloropropylene	10061-02-6	5	µg/L	<10	<5	----	----	----
1.2-Dibromoethane (EDB)	106-93-4	5	µg/L	<10	<5	----	----	----
EP074E: Halogenated Aliphatic Compounds								
Dichlorodifluoromethane	75-71-8	50	µg/L	<100	<50	----	----	----
Chloromethane	74-87-3	50	µg/L	<100	**60**	----	----	----
Vinyl chloride	75-01-4	50	µg/L	<100	<50	----	----	----
Bromomethane	74-83-9	50	µg/L	<100	<50	----	----	----
Chloroethane	75-00-3	50	µg/L	<100	<50	----	----	----
Trichlorofluoromethane	75-69-4	50	µg/L	<100	<50	----	----	----
1.1-Dichloroethene	75-35-4	5	µg/L	<10	<5	----	----	----
Iodomethane	74-88-4	5	µg/L	<10	**19**	----	----	----
trans-1.2-Dichloroethene	156-60-5	5	µg/L	<10	<5	----	----	----
1.1-Dichloroethane	75-34-3	5	µg/L	<10	<5	----	----	----
cis-1.2-Dichloroethene	156-59-2	5	µg/L	<10	<5	----	----	----
1.1.1-Trichloroethane	71-55-6	5	µg/L	<10	<5	----	----	----
1.1-Dichloropropylene	563-58-6	5	µg/L	<10	<5	----	----	----
Carbon Tetrachloride	56-23-5	5	µg/L	<10	<5	----	----	----
1.2-Dichloroethane	107-06-2	5	µg/L	<10	<5	----	----	----
Trichloroethene	79-01-6	5	µg/L	<10	<5	----	----	----
Dibromomethane	74-95-3	5	µg/L	<10	<5	----	----	----
1.1.2-Trichloroethane	79-00-5	5	µg/L	<10	<5	----	----	----
1.3-Dichloropropane	142-28-9	5	µg/L	<10	<5	----	----	----
Tetrachloroethene	127-18-4	5	µg/L	<10	<5	----	----	----
1.1.1.2-Tetrachloroethane	630-20-6	5	µg/L	<10	<5	----	----	----
trans-1.4-Dichloro-2-butene	110-57-6	5	µg/L	<10	<5	----	----	----
cis-1.4-Dichloro-2-butene	1476-11-5	5	µg/L	<10	<5	----	----	----
1.1.2.2-Tetrachloroethane	79-34-5	5	µg/L	<10	<5	----	----	----
1.2.3-Trichloropropane	96-18-4	5	µg/L	<10	<5	----	----	----
Pentachloroethane	76-01-7	5	µg/L	<10	<5	----	----	----
1.2-Dibromo-3-chloropropane	96-12-8	5	µg/L	<10	<5	----	----	----
EP074F: Halogenated Aromatic Compounds								
Chlorobenzene	108-90-7	5	µg/L	<10	<5	----	----	----
Bromobenzene	108-86-1	5	µg/L	<10	<5	----	----	----

Analytical Results

Sub-Matrix: **WATER**

Compound	CAS Number	LOR	Unit	Client sample ID: FR Water	Crosslink Gel	----	----	----
				Client sampling date / time: [13-SEP-2012]	[13-SEP-2012]	----	----	----
				EM1210744-001	EM1210744-002	----	----	----
EP074F: Halogenated Aromatic Compounds - Continued								
2-Chlorotoluene	95-49-8	5	µg/L	<10	**6**	----	----	----
4-Chlorotoluene	106-43-4	5	µg/L	<10	<5	----	----	----
1.2.3-Trichlorobenzene	87-61-6	5	µg/L	<10	<5	----	----	----
EP074G: Trihalomethanes								
Chloroform	67-66-3	5	µg/L	<10	<5	----	----	----
Bromodichloromethane	75-27-4	5	µg/L	<10	<5	----	----	----
Dibromochloromethane	124-48-1	5	µg/L	<10	<5	----	----	----
Bromoform	75-25-2	5	µg/L	<10	<5	----	----	----
EP075A: Phenolic Compounds								
Phenol	108-95-2	2	µg/L	<10	<2	----	----	----
2-Chlorophenol	95-57-8	2	µg/L	<10	<2	----	----	----
2-Methylphenol	95-48-7	2	µg/L	<10	<2	----	----	----
3- & 4-Methylphenol	1319-77-3	4	µg/L	<20	<4	----	----	----
2-Nitrophenol	88-75-5	2	µg/L	<10	<2	----	----	----
2.4-Dimethylphenol	105-67-9	2	µg/L	<10	<2	----	----	----
2.4-Dichlorophenol	120-83-2	2	µg/L	<10	<2	----	----	----
2.6-Dichlorophenol	87-65-0	2	µg/L	<10	<2	----	----	----
4-Chloro-3-Methylphenol	59-50-7	2	µg/L	<10	<2	----	----	----
2.4.6-Trichlorophenol	88-06-2	2	µg/L	<10	<2	----	----	----
2.4.5-Trichlorophenol	95-95-4	2	µg/L	<10	<2	----	----	----
Pentachlorophenol	87-86-5	4	µg/L	<20	<4	----	----	----
EP075B: Polynuclear Aromatic Hydrocarbons								
Naphthalene	91-20-3	2	µg/L	<10	<2	----	----	----
2-Methylnaphthalene	91-57-6	2	µg/L	<10	<2	----	----	----
2-Chloronaphthalene	91-58-7	2	µg/L	<10	<2	----	----	----
Acenaphthylene	208-96-8	2	µg/L	<10	<2	----	----	----
Acenaphthene	83-32-9	2	µg/L	<10	<2	----	----	----
Fluorene	86-73-7	2	µg/L	<10	<2	----	----	----
Phenanthrene	85-01-8	2	µg/L	<10	<2	----	----	----
Anthracene	120-12-7	2	µg/L	<10	<2	----	----	----
Fluoranthene	206-44-0	2	µg/L	<10	<2	----	----	----
Pyrene	129-00-0	2	µg/L	<10	<2	----	----	----
N-2-Fluorenyl Acetamide	53-96-3	2	µg/L	<10	<2	----	----	----
Benz(a)anthracene	56-55-3	2	µg/L	<10	<2	----	----	----
Chrysene	218-01-9	2	µg/L	<10	<2	----	----	----

Analytical Results

Sub-Matrix: **WATER**

Compound	CAS Number	LOR	Unit	Client sample ID: FR Water	Crosslink Gel	----	----	----
				Client sampling date / time: [13-SEP-2012]	[13-SEP-2012]	----	----	----
				EM1210744-001	EM1210744-002	----	----	----
EP075B: Polynuclear Aromatic Hydrocarbons - Continued								
Benzo(b) & Benzo(k)fluoranthene	205-99-2 207-08-9	4	µg/L	<20	<4	----	----	----
7.12-Dimethylbenz(a)anthracene	57-97-6	2	µg/L	<10	<2	----	----	----
Benzo(a)pyrene	50-32-8	2	µg/L	<10	<2	----	----	----
3-Methylcholanthrene	56-49-5	2	µg/L	<10	<2	----	----	----
Indeno(1.2.3.cd)pyrene	193-39-5	2	µg/L	<10	<2	----	----	----
Dibenz(a.h)anthracene	53-70-3	2	µg/L	<10	<2	----	----	----
Benzo(g.h.i)perylene	191-24-2	2	µg/L	<10	<2	----	----	----
^ **Sum of PAHs**	----	2	µg/L	<10	<2	----	----	----
^ **Benzo(a)pyrene TEQ (WHO)**	----	2	µg/L	<10	<2	----	----	----
EP075C: Phthalate Esters								
Dimethyl phthalate	131-11-3	2	µg/L	<10	<2	----	----	----
Diethyl phthalate	84-66-2	2	µg/L	<10	<2	----	----	----
Di-n-butyl phthalate	84-74-2	2	µg/L	<10	<2	----	----	----
Butyl benzyl phthalate	85-68-7	2	µg/L	<10	<2	----	----	----
bis(2-ethylhexyl) phthalate	117-81-7	10	µg/L	<50	<10	----	----	----
Di-n-octylphthalate	117-84-0	2	µg/L	<10	<2	----	----	----
EP075D: Nitrosamines								
N-Nitrosomethylethylamine	10595-95-6	2	µg/L	<10	<2	----	----	----
N-Nitrosodiethylamine	55-18-5	2	µg/L	<10	<2	----	----	----
N-Nitrosopyrrolidine	930-55-2	4	µg/L	<20	<4	----	----	----
N-Nitrosomorpholine	59-89-2	2	µg/L	<10	<2	----	----	----
N-Nitrosodi-n-propylamine	621-64-7	2	µg/L	<10	<2	----	----	----
N-Nitrosopiperidine	100-75-4	2	µg/L	<10	<2	----	----	----
N-Nitrosodibutylamine	924-16-3	2	µg/L	<10	<2	----	----	----
N-Nitrosodiphenyl & Diphenylamine	86-30-6 122-39-4	4	µg/L	<20	<4	----	----	----
Methapyrilene	91-80-5	2	µg/L	<10	<2	----	----	----
EP075E: Nitroaromatics and Ketones								
2-Picoline	109-06-8	2	µg/L	<10	<2	----	----	----
Acetophenone	98-86-2	2	µg/L	<10	<2	----	----	----
Nitrobenzene	98-95-3	2	µg/L	<10	<2	----	----	----
Isophorone	78-59-1	2	µg/L	<10	<2	----	----	----
2.6-Dinitrotoluene	606-20-2	4	µg/L	<20	<4	----	----	----
2.4-Dinitrotoluene	121-14-2	4	µg/L	<20	<4	----	----	----
1-Naphthylamine	134-32-7	2	µg/L	<10	<2	----	----	----

Analytical Results

Sub-Matrix: **WATER**

Compound	CAS Number	LOR	Unit	Client sample ID: FR Water	Crosslink Gel	----	----	----
				Client sampling date / time: [13-SEP-2012]	[13-SEP-2012]	----	----	----
				EM1210744-001	EM1210744-002	----	----	----
EP075E: Nitroaromatics and Ketones - Continued								
4-Nitroquinoline-N-oxide	56-57-5	2	µg/L	<10	<2	----	----	----
5-Nitro-o-toluidine	99-55-8	2	µg/L	<10	<2	----	----	----
Azobenzene	103-33-3	2	µg/L	<10	<2	----	----	----
1.3.5-Trinitrobenzene	99-35-4	2	µg/L	<10	<2	----	----	----
Phenacetin	62-44-2	2	µg/L	<10	<2	----	----	----
4-Aminobiphenyl	92-67-1	2	µg/L	<10	<2	----	----	----
Pentachloronitrobenzene	82-68-8	2	µg/L	<10	<2	----	----	----
Pronamide	23950-58-5	2	µg/L	<10	<2	----	----	----
Dimethylaminoazobenzene	60-11-7	2	µg/L	<10	<2	----	----	----
Chlorobenzilate	510-15-6	2	µg/L	<10	<2	----	----	----
EP075F: Haloethers								
Bis(2-chloroethyl) ether	111-44-4	2	µg/L	<10	<2	----	----	----
Bis(2-chloroethoxy) methane	111-91-1	2	µg/L	<10	<2	----	----	----
4-Chlorophenyl phenyl ether	7005-72-3	2	µg/L	<10	<2	----	----	----
4-Bromophenyl phenyl ether	101-55-3	2	µg/L	<10	<2	----	----	----
EP075G: Chlorinated Hydrocarbons								
1.3-Dichlorobenzene	541-73-1	2	µg/L	<10	<2	----	----	----
1.4-Dichlorobenzene	106-46-7	2	µg/L	<10	<2	----	----	----
1.2-Dichlorobenzene	95-50-1	2	µg/L	<10	<2	----	----	----
Hexachloroethane	67-72-1	2	µg/L	<10	<2	----	----	----
1.2.4-Trichlorobenzene	120-82-1	2	µg/L	<10	<2	----	----	----
Hexachloropropylene	1888-71-7	2	µg/L	<10	<2	----	----	----
Hexachlorobutadiene	87-68-3	2	µg/L	<10	<2	----	----	----
Hexachlorocyclopentadiene	77-47-4	10	µg/L	<50	<10	----	----	----
Pentachlorobenzene	608-93-5	2	µg/L	<10	<2	----	----	----
Hexachlorobenzene (HCB)	118-74-1	4	µg/L	<20	<4	----	----	----
EP075H: Anilines and Benzidines								
Aniline	62-53-3	2	µg/L	<10	<2	----	----	----
4-Chloroaniline	106-47-8	2	µg/L	<10	<2	----	----	----
2-Nitroaniline	88-74-4	4	µg/L	<20	<4	----	----	----
3-Nitroaniline	99-09-2	4	µg/L	<20	<4	----	----	----
Dibenzofuran	132-64-9	2	µg/L	<10	<2	----	----	----
4-Nitroaniline	100-01-6	2	µg/L	<10	<2	----	----	----
Carbazole	86-74-8	2	µg/L	<10	<2	----	----	----
3.3`-Dichlorobenzidine	91-94-1	2	µg/L	<10	<2	----	----	----
EP075I: Organochlorine Pesticides								

Analytical Results

Sub-Matrix: **WATER**

Compound	CAS Number	LOR	Unit	Client sample ID: FR Water	Crosslink Gel	----	----	----
				Client sampling date / time: [13-SEP-2012]	[13-SEP-2012]	----	----	----
				EM1210744-001	EM1210744-002	----	----	----
EP075I: Organochlorine Pesticides - Continued								
alpha-BHC	319-84-6	2	µg/L	<10	<2	----	----	----
beta-BHC	319-85-7	2	µg/L	<10	<2	----	----	----
gamma-BHC	58-89-9	2	µg/L	<10	<2	----	----	----
delta-BHC	319-86-8	2	µg/L	<10	<2	----	----	----
Heptachlor	76-44-8	2	µg/L	<10	<2	----	----	----
Aldrin	309-00-2	2	µg/L	<10	<2	----	----	----
Heptachlor epoxide	1024-57-3	2	µg/L	<10	<2	----	----	----
alpha-Endosulfan	959-98-8	2	µg/L	<10	<2	----	----	----
4.4`-DDE	72-55-9	2	µg/L	<10	<2	----	----	----
Dieldrin	60-57-1	2	µg/L	<10	<2	----	----	----
Endrin	72-20-8	2	µg/L	<10	<2	----	----	----
beta-Endosulfan	33213-65-9	2	µg/L	<10	<2	----	----	----
4.4`-DDD	72-54-8	2	µg/L	<10	<2	----	----	----
Endosulfan sulfate	1031-07-8	2	µg/L	<10	<2	----	----	----
4.4`-DDT	50-29-3	4	µg/L	<20	<4	----	----	----
^ **Sum of Aldrin + Dieldrin**	309-00-2/60-57-1	4	µg/L	<20	<4	----	----	----
^ **Sum of DDD + DDE + DDT**	----	4	µg/L	<20	<4	----	----	----
EP075J: Organophosphorus Pesticides								
Dichlorvos	62-73-7	2	µg/L	<10	<2	----	----	----
Dimethoate	60-51-5	2	µg/L	<10	<2	----	----	----
Diazinon	333-41-5	2	µg/L	<10	<2	----	----	----
Chlorpyrifos-methyl	5598-13-0	2	µg/L	<10	<2	----	----	----
Malathion	121-75-5	2	µg/L	<10	<2	----	----	----
Fenthion	55-38-9	2	µg/L	<10	<2	----	----	----
Chlorpyrifos	2921-88-2	2	µg/L	<10	<2	----	----	----
Pirimphos-ethyl	23505-41-1	2	µg/L	<10	<2	----	----	----
Chlorfenvinphos	470-90-6	2	µg/L	<10	<2	----	----	----
Prothiofos	34643-46-4	2	µg/L	<10	<2	----	----	----
Ethion	563-12-2	2	µg/L	<10	<2	----	----	----
EP117: Alcohols								
Ethanol	64-17-5	50	µg/L	**138**	**163**	----	----	----
Isopropanol	67-63-0	50	µg/L	**4270**	**4150**	----	----	----
n-Propanol	71-23-8	50	µg/L	<125	<125	----	----	----
Isobutanol	78-83-1	50	µg/L	<125	<125	----	----	----
n-Butanol	71-36-3	50	µg/L	<125	<125	----	----	----
RIVM Aliphatic Hydrocarbon Fractions								

Analytical Results

Sub-Matrix: **WATER**

Compound	CAS Number	LOR	Unit	Client sample ID	FR Water	Crosslink Gel	----	----	----
				Client sampling date / time	[13-SEP-2012]	[13-SEP-2012]	----	----	----
					EM1210744-001	EM1210744-002	----	----	----
RIVM Aliphatic Hydrocarbon Fractions - Continued									
Aliphatic >C5-C6	----	20	µg/L		<200	**38**	----	----	----
Aliphatic >C6-C8	TPHCWG-ALV2	20	µg/L		**216**	<20	----	----	----
Aliphatic >C8-C10	TPHCWG-ALV3	20	µg/L		**19200**	**155**	----	----	----
Aliphatic >C10-C12	TPHCWG-ALE1	50	µg/L		**1980**	**850**	----	----	----
Aliphatic >C12-C16	TPHCWG-ALE2	50	µg/L		<50	<50	----	----	----
Aliphatic >C16-C21	----	50	µg/L		<50	<50	----	----	----
Aliphatic >C21-C35	----	50	µg/L		<50	<50	----	----	----
RIVM Aromatic Hydrocarbon Fractions									
Aromatic >C5-C7	----	5	µg/L		<10	<5	----	----	----
Aromatic >C7-C8	TPHCWG-ARV2	5	µg/L		**23**	**12**	----	----	----
Aromatic >C8-C10	TPHCWG-ARV3	5	µg/L		**47**	**18**	----	----	----
Aromatic >C10-C12	TPHCWG-ARE1	50	µg/L		**5200**	**1640**	----	----	----
Aromatic >C12-C16	TPHCWG-ARE2	50	µg/L		**410**	<50	----	----	----
Aromatic >C16-C21	TPHCWG-ARE3	50	µg/L		**410**	<50	----	----	----
Aromatic >C21-C35	TPHCWG-ARE4	50	µg/L		**205**	**56**	----	----	----
Subcontracted Analysis: MBAS									
Anionic Surfactants as MBAS	----	0.1	mg/L		<0.1	----	----	----	----
EP074S: VOC Surrogates									
1.2-Dichloroethane-D4	17060-07-0	0.1	%		**106**	**75.0**	----	----	----
Toluene-D8	2037-26-5	0.1	%		**108**	**94.7**	----	----	----
4-Bromofluorobenzene	460-00-4	0.1	%		**117**	**87.9**	----	----	----
EP075S: Acid Extractable Surrogates									
2-Fluorophenol	367-12-4	0.1	%		**Not Determined**	**Not Determined**	----	----	----
Phenol-d6	13127-88-3	0.1	%		**Not Determined**	**Not Determined**	----	----	----
2-Chlorophenol-D4	93951-73-6	0.1	%		**Not Determined**	**Not Determined**	----	----	----
2.4.6-Tribromophenol	118-79-6	0.1	%		**Not Determined**	**Not Determined**	----	----	----
EP075T: Base/Neutral Extractable Surrogates									
Nitrobenzene-D5	4165-60-0	0.1	%		**70.0**	**97.8**	----	----	----
1.2-Dichlorobenzene-D4	2199-69-1	0.1	%		**47.0**	**91.1**	----	----	----
2-Fluorobiphenyl	321-60-8	0.1	%		**58.8**	**73.7**	----	----	----
Anthracene-d10	1719-06-8	0.1	%		**82.9**	**49.3**	----	----	----
4-Terphenyl-d14	1718-51-0	0.1	%		**85.3**	**97.5**	----	----	----
EP079/EP070S:TPH Surrogates - semivolatile speciation									
2-Fluorobiphenyl	321-60-8	0.1	%		**97.2**	**101**	----	----	----
2-Bromonaphthalene	580-13-2	0.1	%		**97.7**	**96.1**	----	----	----

Surrogate Control Limits

Sub-Matrix: **WATER**		Recovery Limits (%)	
Compound	*CAS Number*	*Low*	*High*
EP074S: VOC Surrogates			
1.2-Dichloroethane-D4	17060-07-0	72	132
Toluene-D8	2037-26-5	74	128
4-Bromofluorobenzene	460-00-4	70	132
EP075S: Acid Extractable Surrogates			
2-Fluorophenol	367-12-4	10	83
Phenol-d6	13127-88-3	10	49
2-Chlorophenol-D4	93951-73-6	20.3	101
2.4.6-Tribromophenol	118-79-6	19.5	134
EP075T: Base/Neutral Extractable Surrogates			
Nitrobenzene-D5	4165-60-0	18.2	114
1.2-Dichlorobenzene-D4	2199-69-1	18.8	100
2-Fluorobiphenyl	321-60-8	25.3	122
Anthracene-d10	1719-06-8	35	137
4-Terphenyl-d14	1718-51-0	32	136
EP079/EP070S:TPH Surrogates - semivolatile speciation			
2-Fluorobiphenyl	321-60-8	77	127
2-Bromonaphthalene	580-13-2	67	123

QUALITY CONTROL REPORT

Work Order	: **EM1210744**	Page	: 1 of 23
Client	: **SANTOS LTD**	Laboratory	: Environmental Division Melbourne
Contact	: MR BARRY RITCHIE	Contact	: Client Services
Address	: GROUND FLOOR SANTOS CENTRE 60 FLINDERS STREET ADELAIDE SA, AUSTRALIA 5001	Address	: 4 Westall Rd Springvale VIC Australia 3171
E-mail	: barry.ritchie@santos.com	E-mail	: Melbourne.Enviro.Services@alsglobal.com
Telephone	: +61 08 8116 5000	Telephone	: +61-3-8549 9600
Facsimile	: +61 08 8116 5050	Facsimile	: +61-3-8549 9601
Project	: HFRA Fluids Sampling- Extended Analysis	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Site	: ----		
C-O-C number	: ----	Date Samples Received	: 14-SEP-2012
Sampler	: JM, AJ	Issue Date	: 03-OCT-2012
Order number	: 879002/538		
		No. of samples received	: 2
Quote number	: EN/039/12	No. of samples analysed	: 2

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Method Blank (MB) and Laboratory Control Spike (LCS) Report; Recovery and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits

NATA Accredited Laboratory 825

Accredited for compliance with ISO/IEC 17025.

Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Ashesh Patel	Inorganic Chemist	Sydney Inorganics
Danielle White	Committal	WRG Subcontracting
Dilani Fernando	Senior Inorganic Chemist	Melbourne Inorganics
Herman Lin	Laboratory Coordinator	Melbourne Inorganics
Nancy Wang	Senior Semivolatile Instrument Chemist	Melbourne Organics
Nikki Stepniewski	Senior Inorganic Instrument Chemist	Melbourne Inorganics
Pabi Subba	Senior Organic Chemist	Sydney Organics
Sarah Millington	Senior Inorganic Chemist	Sydney Inorganics

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

Key : Anonymous = Refers to samples which are not specifically part of this work order but formed part of the QC process lot
CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
RPD = Relative Percentage Difference
# = Indicates failed QC

Laboratory Duplicate (DUP) Report

The quality control term Laboratory Duplicate refers to a randomly selected intralaboratory split. Laboratory duplicates provide information regarding method precision and sample heterogeneity. The permitted ranges for the Relative Percent Deviation (RPD) of Laboratory Duplicates are specified in ALS Method QWI-EN/38 and are dependent on the magnitude of results in comparison to the level of reporting: Result < 10 times LOR:- No Limit; Result between 10 and 20 times LOR:- 0% - 50%; Result > 20 times LOR:- 0% - 20%.

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
EA005: pH (QC Lot: 2505886)									
EM1210744-001	FR Water	EA005: pH Value	----	0.01	pH Unit	6.10	6.08	0.3	0% - 20%
EM1210840-002	Anonymous	EA005: pH Value	----	0.01	pH Unit	6.59	6.59	0.0	0% - 20%
EA015: Total Dissolved Solids (QC Lot: 2505277)									
EM1210744-001	FR Water	EA015H: Total Dissolved Solids @180°C	GIS-210-010	10	mg/L	1040	1010	3.1	0% - 20%
EM1210843-004	Anonymous	EA015H: Total Dissolved Solids @180°C	GIS-210-010	10	mg/L	1080	1060	1.9	0% - 20%
ED009: Anions (QC Lot: 2507802)									
EM1210846-001	Anonymous	ED009-X: Bromide	24959-67-9	0.010	mg/L	<0.010	<0.010	0.0	No Limit
		ED009-X: Iodide	20461-54-5	0.010	mg/L	<0.010	<0.010	0.0	No Limit
EM1210854-006	Anonymous	ED009-X: Bromide	24959-67-9	0.010	mg/L	<0.010	<0.010	0.0	No Limit
		ED009-X: Iodide	20461-54-5	0.010	mg/L	<0.010	<0.010	0.0	No Limit
ED037P: Alkalinity by PC Titrator (QC Lot: 2501656)									
EM1210742-007	Anonymous	ED037-P: Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	<1	<1	0.0	No Limit
EM1210755-001	Anonymous	ED037-P: Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	13	11	21.1	0% - 50%
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	13	11	21.1	0% - 50%
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA (QC Lot: 2501638)									
EM1210737-005	Anonymous	ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	2490	2480	0.4	0% - 20%
EM1210744-001	FR Water	ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	292	298	1.9	0% - 20%
ED045G: Chloride Discrete analyser (QC Lot: 2501641)									
EM1210737-005	Anonymous	ED045G: Chloride	16887-00-6	1	mg/L	12300	12000	2.1	0% - 20%
EM1210744-001	FR Water	ED045G: Chloride	16887-00-6	1	mg/L	370	364	1.7	0% - 20%
ED093F: Dissolved Major Cations (QC Lot: 2501640)									
EM1210737-005	Anonymous	ED093F: Calcium	7440-70-2	1	mg/L	578	607	4.9	0% - 20%
		ED093F: Magnesium	7439-95-4	1	mg/L	777	808	3.9	0% - 20%
		ED093F: Sodium	7440-23-5	1	mg/L	7230	7430	2.8	0% - 20%
		ED093F: Potassium	7440-09-7	1	mg/L	190	194	2.2	0% - 20%
EM1210744-001	FR Water	ED093F: Calcium	7440-70-2	1	mg/L	2	<1	0.0	No Limit
		ED093F: Magnesium	7439-95-4	1	mg/L	<1	<1	0.0	No Limit
		ED093F: Sodium	7440-23-5	1	mg/L	21	20	0.0	0% - 20%
		ED093F: Potassium	7440-09-7	1	mg/L	<1	<1	0.0	No Limit

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
EG020F: Dissolved Metals by ICP-MS (QC Lot: 2506756)									
EM1210728-001	Anonymous	EG020A-F: Cadmium	7440-43-9	0.0001	mg/L	0.0834	0.0854	2.5	0% - 20%
		EG020A-F: Arsenic	7440-38-2	0.001	mg/L	0.021	0.022	5.0	0% - 20%
		EG020A-F: Beryllium	7440-41-7	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-F: Barium	7440-39-3	0.001	mg/L	0.043	0.045	4.6	0% - 20%
		EG020A-F: Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-F: Cobalt	7440-48-4	0.001	mg/L	0.011	0.012	0.0	0% - 50%
		EG020A-F: Copper	7440-50-8	0.001	mg/L	0.020	0.019	0.0	0% - 50%
		EG020A-F: Lead	7439-92-1	0.001	mg/L	0.019	0.018	0.0	0% - 50%
		EG020A-F: Lithium	7439-93-2	0.001	mg/L	0.174	0.164	6.0	0% - 20%
		EG020A-F: Manganese	7439-96-5	0.001	mg/L	18.1	18.1	0.06	0% - 20%
		EG020A-F: Molybdenum	7439-98-7	0.001	mg/L	0.005	0.005	0.0	No Limit
		EG020A-F: Nickel	7440-02-0	0.001	mg/L	0.012	0.015	23.7	0% - 50%
		EG020A-F: Tin	7440-31-5	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-F: Zinc	7440-66-6	0.005	mg/L	14.0	14.4	2.9	0% - 20%
		EG020A-F: Aluminium	7429-90-5	0.01	mg/L	<0.01	<0.01	0.0	No Limit
		EG020A-F: Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	0.0	No Limit
		EG020A-F: Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	0.0	No Limit
		EG020A-F: Boron	7440-42-8	0.05	mg/L	0.70	0.73	4.4	0% - 50%
		EG020A-F: Iron	7439-89-6	0.05	mg/L	0.58	0.60	3.1	0% - 50%
EM1210728-011	Anonymous	EG020A-F: Cadmium	7440-43-9	0.0001	mg/L	0.0002	0.0001	0.0	No Limit
		EG020A-F: Arsenic	7440-38-2	0.001	mg/L	0.040	0.039	0.0	0% - 20%
		EG020A-F: Beryllium	7440-41-7	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-F: Barium	7440-39-3	0.001	mg/L	0.032	0.033	0.0	0% - 20%
		EG020A-F: Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-F: Cobalt	7440-48-4	0.001	mg/L	0.004	0.004	0.0	No Limit
		EG020A-F: Copper	7440-50-8	0.001	mg/L	0.006	0.005	0.0	No Limit
		EG020A-F: Lead	7439-92-1	0.001	mg/L	0.002	0.001	0.0	No Limit
		EG020A-F: Lithium	7439-93-2	0.001	mg/L	0.152	0.154	1.5	0% - 20%
		EG020A-F: Manganese	7439-96-5	0.001	mg/L	0.326	0.328	0.5	0% - 20%
		EG020A-F: Molybdenum	7439-98-7	0.001	mg/L	0.252	0.252	0.0	0% - 20%
		EG020A-F: Nickel	7440-02-0	0.001	mg/L	0.007	0.005	23.1	No Limit
		EG020A-F: Tin	7440-31-5	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-F: Zinc	7440-66-6	0.005	mg/L	0.012	0.010	15.1	No Limit
		EG020A-F: Aluminium	7429-90-5	0.01	mg/L	<0.01	<0.01	0.0	No Limit
		EG020A-F: Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	0.0	No Limit
		EG020A-F: Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	0.0	No Limit
		EG020A-F: Boron	7440-42-8	0.05	mg/L	4.90	4.88	0.3	0% - 20%
		EG020A-F: Iron	7439-89-6	0.05	mg/L	1.14	1.03	10.4	0% - 20%
EG020F: Dissolved Metals by ICP-MS (QC Lot: 2506757)									

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
EG020F: Dissolved Metals by ICP-MS (QC Lot: 2506757) - continued									
EM1210728-001	Anonymous	EG020B-F: Strontium	7440-24-6	0.001	mg/L	3.86	3.94	2.2	0% - 20%
		EG020B-F: Uranium	7440-61-1	0.001	mg/L	0.002	0.002	0.0	No Limit
EM1210728-011	Anonymous	EG020B-F: Strontium	7440-24-6	0.001	mg/L	8.78	8.77	0.1	0% - 20%
		EG020B-F: Uranium	7440-61-1	0.001	mg/L	0.010	0.009	0.0	No Limit
EG035F: Dissolved Mercury by FIMS (QC Lot: 2506755)									
EM1210728-001	Anonymous	EG035F: Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	0.0	No Limit
EM1210728-011	Anonymous	EG035F: Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	0.0	No Limit
EK025SF: Free CN by Segmented Flow Analyser (QC Lot: 2501301)									
EM1210670-001	Anonymous	EK025SF: Free Cyanide	----	0.004	mg/L	<0.004	<0.004	0.0	No Limit
EM1210741-005	Anonymous	EK025SF: Free Cyanide	----	0.004	mg/L	<0.004	<0.004	0.0	No Limit
EK026SF: Total CN by Segmented Flow Analyser (QC Lot: 2501302)									
EM1210670-001	Anonymous	EK026SF: Total Cyanide	57-12-5	0.004	mg/L	<0.004	<0.004	0.0	No Limit
EM1210741-003	Anonymous	EK026SF: Total Cyanide	57-12-5	0.004	mg/L	<0.004	<0.004	0.0	No Limit
EK040P: Fluoride by PC Titrator (QC Lot: 2501652)									
EM1210670-001	Anonymous	EK040P: Fluoride	16984-48-8	0.1	mg/L	0.8	0.8	0.0	No Limit
EM1210729-006	Anonymous	EK040P: Fluoride	16984-48-8	0.1	mg/L	2.9	2.7	7.6	0% - 20%
EK055G: Ammonia as N by Discrete Analyser (QC Lot: 2503677)									
EM1210744-001	FR Water	EK055G: Ammonia as N	7664-41-7	0.01	mg/L	90.5	87.2	3.7	0% - 20%
EK057G: Nitrite as N by Discrete Analyser (QC Lot: 2501639)									
EM1210737-005	Anonymous	EK057G: Nitrite as N	----	0.01	mg/L	<0.01	<0.01	0.0	No Limit
EM1210744-001	FR Water	EK057G: Nitrite as N	----	0.01	mg/L	<0.01	<0.01	0.0	No Limit
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser (QC Lot: 2503676)									
EM1210701-002	Anonymous	EK059G: Nitrite + Nitrate as N	----	0.01	mg/L	0.07	0.07	0.0	No Limit
EM1210736-013	Anonymous	EK059G: Nitrite + Nitrate as N	----	0.01	mg/L	0.02	0.02	0.0	No Limit
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser (QC Lot: 2503250)									
EM1210719-001	Anonymous	EK061G: Total Kjeldahl Nitrogen as N	----	0.1	mg/L	53.0	63.2	17.6	0% - 20%
EM1210744-001	FR Water	EK061G: Total Kjeldahl Nitrogen as N	----	0.1	mg/L	185	199	7.3	0% - 20%
EK067G: Total Phosphorus as P by Discrete Analyser (QC Lot: 2503251)									
EM1210719-001	Anonymous	EK067G: Total Phosphorus as P	----	0.01	mg/L	23.8	28.1	16.6	0% - 20%
EM1210744-001	FR Water	EK067G: Total Phosphorus as P	----	0.01	mg/L	1.42	1.67	16.2	0% - 20%
EK071G: Reactive Phosphorus as P by discrete analyser (QC Lot: 2501642)									
EM1210744-001	FR Water	EK071G: Reactive Phosphorus as P	----	0.01	mg/L	0.07	0.07	0.0	No Limit
EP005: Total Organic Carbon (TOC) (QC Lot: 2519209)									
EM1210744-001	FR Water	EP005: Total Organic Carbon	----	1	mg/L	608	620	2.0	0% - 20%
EM1211004-003	Anonymous	EP005: Total Organic Carbon	----	1	mg/L	2	2	0.0	No Limit
EP010: Formaldehyde (QC Lot: 2501649)									
EM1210744-001	FR Water	EP010: Formaldehyde	50-00-0	0.1	mg/L	<0.1	<0.1	0.0	No Limit
EP041A: Nonionic Surfactants (QC Lot: 2504783)									

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
EP041A: Nonionic Surfactants (QC Lot: 2504783) - continued									
EP1207681-009	Anonymous	EP041A: Nonionic Surfactants as CTAS	----	5	mg/L	<5	<5	0.0	No Limit
EP074A: Monocyclic Aromatic Hydrocarbons (QC Lot: 2518778)									
ER1200156-001	Anonymous	EP074: Benzene	71-43-2	1	µg/L	<1	<1	0.0	No Limit
		EP074: Toluene	108-88-3	2	µg/L	<2	<2	0.0	No Limit
		EP074: Ethylbenzene	100-41-4	2	µg/L	<2	<2	0.0	No Limit
		EP074: meta- & para-Xylene	108-38-3 106-42-3	2	µg/L	<2	<2	0.0	No Limit
		EP074: ortho-Xylene	95-47-6	2	µg/L	<2	<2	0.0	No Limit
		EP074: Styrene	100-42-5	5	µg/L	<5	<5	0.0	No Limit
		EP074: Isopropylbenzene	98-82-8	5	µg/L	<5	<5	0.0	No Limit
		EP074: n-Propylbenzene	103-65-1	5	µg/L	<5	<5	0.0	No Limit
		EP074: 1.3.5-Trimethylbenzene	108-67-8	5	µg/L	<5	<5	0.0	No Limit
		EP074: sec-Butylbenzene	135-98-8	5	µg/L	<5	<5	0.0	No Limit
		EP074: 1.2.4-Trimethylbenzene	95-63-6	5	µg/L	<5	<5	0.0	No Limit
		EP074: tert-Butylbenzene	98-06-6	5	µg/L	<5	<5	0.0	No Limit
		EP074: p-Isopropyltoluene	99-87-6	5	µg/L	<5	<5	0.0	No Limit
		EP074: n-Butylbenzene	104-51-8	5	µg/L	<5	<5	0.0	No Limit
EP074B: Oxygenated Compounds (QC Lot: 2518778)									
ER1200156-001	Anonymous	EP074: Vinyl Acetate	108-05-4	50	µg/L	<50	<50	0.0	No Limit
		EP074: 2-Butanone (MEK)	78-93-3	50	µg/L	<50	<50	0.0	No Limit
		EP074: 4-Methyl-2-pentanone (MIBK)	108-10-1	50	µg/L	<50	<50	0.0	No Limit
		EP074: 2-Hexanone (MBK)	591-78-6	50	µg/L	<50	<50	0.0	No Limit
EP074C: Sulfonated Compounds (QC Lot: 2518778)									
ER1200156-001	Anonymous	EP074: Carbon disulfide	75-15-0	5	µg/L	<5	<5	0.0	No Limit
EP074D: Fumigants (QC Lot: 2518778)									
ER1200156-001	Anonymous	EP074: 2.2-Dichloropropane	594-20-7	5	µg/L	<5	<5	0.0	No Limit
		EP074: 1.2-Dichloropropane	78-87-5	5	µg/L	<5	<5	0.0	No Limit
		EP074: cis-1.3-Dichloropropylene	10061-01-5	5	µg/L	<5	<5	0.0	No Limit
		EP074: trans-1.3-Dichloropropylene	10061-02-6	5	µg/L	<5	<5	0.0	No Limit
		EP074: 1.2-Dibromoethane (EDB)	106-93-4	5	µg/L	<5	<5	0.0	No Limit
EP074E: Halogenated Aliphatic Compounds (QC Lot: 2518778)									
ER1200156-001	Anonymous	EP074: 1.1-Dichloroethene	75-35-4	5	µg/L	<5	<5	0.0	No Limit
		EP074: Iodomethane	74-88-4	5	µg/L	<5	<5	0.0	No Limit
		EP074: trans-1.2-Dichloroethene	156-60-5	5	µg/L	<5	<5	0.0	No Limit
		EP074: 1.1-Dichloroethane	75-34-3	5	µg/L	<5	<5	0.0	No Limit
		EP074: cis-1.2-Dichloroethene	156-59-2	5	µg/L	<5	<5	0.0	No Limit
		EP074: 1.1.1-Trichloroethane	71-55-6	5	µg/L	<5	<5	0.0	No Limit
		EP074: 1.1-Dichloropropylene	563-58-6	5	µg/L	<5	<5	0.0	No Limit
		EP074: Carbon Tetrachloride	56-23-5	5	µg/L	<5	<5	0.0	No Limit

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
EP074E: Halogenated Aliphatic Compounds (QC Lot: 2518778) - continued									
ER1200156-001	Anonymous	EP074: 1.2-Dichloroethane	107-06-2	5	µg/L	<5	<5	0.0	No Limit
		EP074: Trichloroethene	79-01-6	5	µg/L	<5	<5	0.0	No Limit
		EP074: Dibromomethane	74-95-3	5	µg/L	<5	<5	0.0	No Limit
		EP074: 1.1.2-Trichloroethane	79-00-5	5	µg/L	<5	<5	0.0	No Limit
		EP074: 1.3-Dichloropropane	142-28-9	5	µg/L	<5	<5	0.0	No Limit
		EP074: Tetrachloroethene	127-18-4	5	µg/L	<5	<5	0.0	No Limit
		EP074: 1.1.1.2-Tetrachloroethane	630-20-6	5	µg/L	<5	<5	0.0	No Limit
		EP074: trans-1.4-Dichloro-2-butene	110-57-6	5	µg/L	<5	<5	0.0	No Limit
		EP074: cis-1.4-Dichloro-2-butene	1476-11-5	5	µg/L	<5	<5	0.0	No Limit
		EP074: 1.1.2.2-Tetrachloroethane	79-34-5	5	µg/L	<5	<5	0.0	No Limit
		EP074: 1.2.3-Trichloropropane	96-18-4	5	µg/L	<5	<5	0.0	No Limit
		EP074: Pentachloroethane	76-01-7	5	µg/L	<5	<5	0.0	No Limit
		EP074: 1.2-Dibromo-3-chloropropane	96-12-8	5	µg/L	<5	<5	0.0	No Limit
		EP074: Dichlorodifluoromethane	75-71-8	50	µg/L	<50	<50	0.0	No Limit
		EP074: Chloromethane	74-87-3	50	µg/L	<50	<50	0.0	No Limit
		EP074: Vinyl chloride	75-01-4	50	µg/L	<50	<50	0.0	No Limit
		EP074: Bromomethane	74-83-9	50	µg/L	<50	<50	0.0	No Limit
		EP074: Chloroethane	75-00-3	50	µg/L	<50	<50	0.0	No Limit
		EP074: Trichlorofluoromethane	75-69-4	50	µg/L	<50	<50	0.0	No Limit
EP074F: Halogenated Aromatic Compounds (QC Lot: 2518778)									
ER1200156-001	Anonymous	EP074: Chlorobenzene	108-90-7	5	µg/L	<5	<5	0.0	No Limit
		EP074: Bromobenzene	108-86-1	5	µg/L	<5	<5	0.0	No Limit
		EP074: 2-Chlorotoluene	95-49-8	5	µg/L	<5	<5	0.0	No Limit
		EP074: 4-Chlorotoluene	106-43-4	5	µg/L	<5	<5	0.0	No Limit
		EP074: 1.2.3-Trichlorobenzene	87-61-6	5	µg/L	<5	<5	0.0	No Limit
EP074G: Trihalomethanes (QC Lot: 2518778)									
ER1200156-001	Anonymous	EP074: Chloroform	67-66-3	5	µg/L	<5	<5	0.0	No Limit
		EP074: Bromodichloromethane	75-27-4	5	µg/L	<5	<5	0.0	No Limit
		EP074: Dibromochloromethane	124-48-1	5	µg/L	<5	<5	0.0	No Limit
		EP074: Bromoform	75-25-2	5	µg/L	<5	<5	0.0	No Limit
EP075A: Phenolic Compounds (QC Lot: 2501530)									
EM1210744-001	FR Water	EP075: Phenol	108-95-2	2	µg/L	<10	<10	0.0	No Limit
		EP075: 2-Chlorophenol	95-57-8	2	µg/L	<10	<10	0.0	No Limit
		EP075: 2-Methylphenol	95-48-7	2	µg/L	<10	<10	0.0	No Limit
		EP075: 2-Nitrophenol	88-75-5	2	µg/L	<10	<10	0.0	No Limit
		EP075: 2.4-Dimethylphenol	105-67-9	2	µg/L	<10	<10	0.0	No Limit
		EP075: 2.4-Dichlorophenol	120-83-2	2	µg/L	<10	<10	0.0	No Limit
		EP075: 2.6-Dichlorophenol	87-65-0	2	µg/L	<10	<10	0.0	No Limit
		EP075: 4-Chloro-3-Methylphenol	59-50-7	2	µg/L	<10	<10	0.0	No Limit

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
EP075A: Phenolic Compounds (QC Lot: 2501530) - continued									
EM1210744-001	FR Water	EP075: 2.4.6-Trichlorophenol	88-06-2	2	µg/L	<10	<10	0.0	No Limit
		EP075: 2.4.5-Trichlorophenol	95-95-4	2	µg/L	<10	<10	0.0	No Limit
		EP075: 3- & 4-Methylphenol	1319-77-3	4	µg/L	<20	<20	0.0	No Limit
		EP075: Pentachlorophenol	87-86-5	4	µg/L	<20	<20	0.0	No Limit
EP075B: Polynuclear Aromatic Hydrocarbons (QC Lot: 2501530)									
EM1210744-001	FR Water	EP075: Naphthalene	91-20-3	2	µg/L	<10	<10	0.0	No Limit
		EP075: 2-Methylnaphthalene	91-57-6	2	µg/L	<10	<10	0.0	No Limit
		EP075: 2-Chloronaphthalene	91-58-7	2	µg/L	<10	<10	0.0	No Limit
		EP075: Acenaphthylene	208-96-8	2	µg/L	<10	<10	0.0	No Limit
		EP075: Acenaphthene	83-32-9	2	µg/L	<10	<10	0.0	No Limit
		EP075: Fluorene	86-73-7	2	µg/L	<10	<10	0.0	No Limit
		EP075: Phenanthrene	85-01-8	2	µg/L	<10	<10	0.0	No Limit
		EP075: Anthracene	120-12-7	2	µg/L	<10	<10	0.0	No Limit
		EP075: Fluoranthene	206-44-0	2	µg/L	<10	<10	0.0	No Limit
		EP075: Pyrene	129-00-0	2	µg/L	<10	<10	0.0	No Limit
		EP075: N-2-Fluorenyl Acetamide	53-96-3	2	µg/L	<10	<10	0.0	No Limit
		EP075: Benz(a)anthracene	56-55-3	2	µg/L	<10	<10	0.0	No Limit
		EP075: Chrysene	218-01-9	2	µg/L	<10	<10	0.0	No Limit
		EP075: 7.12-Dimethylbenz(a)anthracene	57-97-6	2	µg/L	<10	<10	0.0	No Limit
		EP075: Benzo(a)pyrene	50-32-8	2	µg/L	<10	<10	0.0	No Limit
		EP075: 3-Methylcholanthrene	56-49-5	2	µg/L	<10	<10	0.0	No Limit
		EP075: Indeno(1.2.3.cd)pyrene	193-39-5	2	µg/L	<10	<10	0.0	No Limit
		EP075: Dibenz(a.h)anthracene	53-70-3	2	µg/L	<10	<10	0.0	No Limit
		EP075: Benzo(g.h.i)perylene	191-24-2	2	µg/L	<10	<10	0.0	No Limit
		EP075: Sum of PAHs	----	2	µg/L	<10	<10	0.0	No Limit
		EP075: Benzo(a)pyrene TEQ (WHO)	----	2	µg/L	<10	<10	0.0	No Limit
		EP075: Benzo(b) & Benzo(k)fluoranthene	205-99-2 207-08-9	4	µg/L	<20	<20	0.0	No Limit
EP075C: Phthalate Esters (QC Lot: 2501530)									
EM1210744-001	FR Water	EP075: bis(2-ethylhexyl) phthalate	117-81-7	10	µg/L	<50	<50	0.0	No Limit
		EP075: Dimethyl phthalate	131-11-3	2	µg/L	<10	<10	0.0	No Limit
		EP075: Diethyl phthalate	84-66-2	2	µg/L	<10	<10	0.0	No Limit
		EP075: Di-n-butyl phthalate	84-74-2	2	µg/L	<10	<10	0.0	No Limit
		EP075: Butyl benzyl phthalate	85-68-7	2	µg/L	<10	<10	0.0	No Limit
		EP075: Di-n-octylphthalate	117-84-0	2	µg/L	<10	<10	0.0	No Limit
EP075D: Nitrosamines (QC Lot: 2501530)									
EM1210744-001	FR Water	EP075: N-Nitrosomethylethylamine	10595-95-6	2	µg/L	<10	<10	0.0	No Limit
		EP075: N-Nitrosodiethylamine	55-18-5	2	µg/L	<10	<10	0.0	No Limit
		EP075: N-Nitrosomorpholine	59-89-2	2	µg/L	<10	<10	0.0	No Limit

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
EP075D: Nitrosamines (QC Lot: 2501530) - continued									
EM1210744-001	FR Water	EP075: N-Nitrosodi-n-propylamine	621-64-7	2	µg/L	<10	<10	0.0	No Limit
		EP075: N-Nitrosopiperidine	100-75-4	2	µg/L	<10	<10	0.0	No Limit
		EP075: N-Nitrosodibutylamine	924-16-3	2	µg/L	<10	<10	0.0	No Limit
		EP075: Methapyrilene	91-80-5	2	µg/L	<10	<10	0.0	No Limit
		EP075: N-Nitrosopyrrolidine	930-55-2	4	µg/L	<20	<20	0.0	No Limit
		EP075: N-Nitrosodiphenyl & Diphenylamine	86-30-6 122-39-4	4	µg/L	<20	<20	0.0	No Limit
EP075E: Nitroaromatics and Ketones (QC Lot: 2501530)									
EM1210744-001	FR Water	EP075: 2-Picoline	109-06-8	2	µg/L	<10	<10	0.0	No Limit
		EP075: Acetophenone	98-86-2	2	µg/L	<10	<10	0.0	No Limit
		EP075: Nitrobenzene	98-95-3	2	µg/L	<10	<10	0.0	No Limit
		EP075: Isophorone	78-59-1	2	µg/L	<10	<10	0.0	No Limit
		EP075: 1-Naphthylamine	134-32-7	2	µg/L	<10	<10	0.0	No Limit
		EP075: 4-Nitroquinoline-N-oxide	56-57-5	2	µg/L	<10	<10	0.0	No Limit
		EP075: 5-Nitro-o-toluidine	99-55-8	2	µg/L	<10	<10	0.0	No Limit
		EP075: Azobenzene	103-33-3	2	µg/L	<10	<10	0.0	No Limit
		EP075: 1.3.5-Trinitrobenzene	99-35-4	2	µg/L	<10	<10	0.0	No Limit
		EP075: Phenacetin	62-44-2	2	µg/L	<10	<10	0.0	No Limit
		EP075: 4-Aminobiphenyl	92-67-1	2	µg/L	<10	<10	0.0	No Limit
		EP075: Pentachloronitrobenzene	82-68-8	2	µg/L	<10	<10	0.0	No Limit
		EP075: Pronamide	23950-58-5	2	µg/L	<10	<10	0.0	No Limit
		EP075: Dimethylaminoazobenzene	60-11-7	2	µg/L	<10	<10	0.0	No Limit
		EP075: Chlorobenzilate	510-15-6	2	µg/L	<10	<10	0.0	No Limit
		EP075: 2.6-Dinitrotoluene	606-20-2	4	µg/L	<20	<20	0.0	No Limit
		EP075: 2.4-Dinitrotoluene	121-14-2	4	µg/L	<20	<20	0.0	No Limit
EP075F: Haloethers (QC Lot: 2501530)									
EM1210744-001	FR Water	EP075: Bis(2-chloroethyl) ether	111-44-4	2	µg/L	<10	<10	0.0	No Limit
		EP075: Bis(2-chloroethoxy) methane	111-91-1	2	µg/L	<10	<10	0.0	No Limit
		EP075: 4-Chlorophenyl phenyl ether	7005-72-3	2	µg/L	<10	<10	0.0	No Limit
		EP075: 4-Bromophenyl phenyl ether	101-55-3	2	µg/L	<10	<10	0.0	No Limit
EP075G: Chlorinated Hydrocarbons (QC Lot: 2501530)									
EM1210744-001	FR Water	EP075: Hexachlorocyclopentadiene	77-47-4	10	µg/L	<50	<50	0.0	No Limit
		EP075: 1.4-Dichlorobenzene	106-46-7	2	µg/L	<10	<10	0.0	No Limit
		EP075: 1.3-Dichlorobenzene	541-73-1	2	µg/L	<10	<10	0.0	No Limit
		EP075: 1.2-Dichlorobenzene	95-50-1	2	µg/L	<10	<10	0.0	No Limit
		EP075: Hexachloroethane	67-72-1	2	µg/L	<10	<10	0.0	No Limit
		EP075: 1.2.4-Trichlorobenzene	120-82-1	2	µg/L	<10	<10	0.0	No Limit
		EP075: Hexachloropropylene	1888-71-7	2	µg/L	<10	<10	0.0	No Limit
		EP075: Hexachlorobutadiene	87-68-3	2	µg/L	<10	<10	0.0	No Limit

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
EP075G: Chlorinated Hydrocarbons (QC Lot: 2501530) - continued									
EM1210744-001	FR Water	EP075: Pentachlorobenzene	608-93-5	2	µg/L	<10	<10	0.0	No Limit
		EP075: Hexachlorobenzene (HCB)	118-74-1	4	µg/L	<20	<20	0.0	No Limit
EP075H: Anilines and Benzidines (QC Lot: 2501530)									
EM1210744-001	FR Water	EP075: Aniline	62-53-3	2	µg/L	<10	<10	0.0	No Limit
		EP075: 4-Chloroaniline	106-47-8	2	µg/L	<10	<10	0.0	No Limit
		EP075: Dibenzofuran	132-64-9	2	µg/L	<10	<10	0.0	No Limit
		EP075: 4-Nitroaniline	100-01-6	2	µg/L	<10	<10	0.0	No Limit
		EP075: Carbazole	86-74-8	2	µg/L	<10	<10	0.0	No Limit
		EP075: 3.3`-Dichlorobenzidine	91-94-1	2	µg/L	<10	<10	0.0	No Limit
		EP075: 2-Nitroaniline	88-74-4	4	µg/L	<20	<20	0.0	No Limit
		EP075: 3-Nitroaniline	99-09-2	4	µg/L	<20	<20	0.0	No Limit
EP075I: Organochlorine Pesticides (QC Lot: 2501530)									
EM1210744-001	FR Water	EP075: alpha-BHC	319-84-6	2	µg/L	<10	<10	0.0	No Limit
		EP075: beta-BHC	319-85-7	2	µg/L	<10	<10	0.0	No Limit
		EP075: gamma-BHC	58-89-9	2	µg/L	<10	<10	0.0	No Limit
		EP075: delta-BHC	319-86-8	2	µg/L	<10	<10	0.0	No Limit
		EP075: Heptachlor	76-44-8	2	µg/L	<10	<10	0.0	No Limit
		EP075: Aldrin	309-00-2	2	µg/L	<10	<10	0.0	No Limit
		EP075: Heptachlor epoxide	1024-57-3	2	µg/L	<10	<10	0.0	No Limit
		EP075: alpha-Endosulfan	959-98-8	2	µg/L	<10	<10	0.0	No Limit
		EP075: 4.4`-DDE	72-55-9	2	µg/L	<10	<10	0.0	No Limit
		EP075: Dieldrin	60-57-1	2	µg/L	<10	<10	0.0	No Limit
		EP075: Endrin	72-20-8	2	µg/L	<10	<10	0.0	No Limit
		EP075: beta-Endosulfan	33213-65-9	2	µg/L	<10	<10	0.0	No Limit
		EP075: 4.4`-DDD	72-54-8	2	µg/L	<10	<10	0.0	No Limit
		EP075: Endosulfan sulfate	1031-07-8	2	µg/L	<10	<10	0.0	No Limit
		EP075: 4.4`-DDT	50-29-3	4	µg/L	<20	<20	0.0	No Limit
EP075J: Organophosphorus Pesticides (QC Lot: 2501530)									
EM1210744-001	FR Water	EP075: Dichlorvos	62-73-7	2	µg/L	<10	<10	0.0	No Limit
		EP075: Dimethoate	60-51-5	2	µg/L	<10	<10	0.0	No Limit
		EP075: Diazinon	333-41-5	2	µg/L	<10	<10	0.0	No Limit
		EP075: Chlorpyrifos-methyl	5598-13-0	2	µg/L	<10	<10	0.0	No Limit
		EP075: Malathion	121-75-5	2	µg/L	<10	<10	0.0	No Limit
		EP075: Fenthion	55-38-9	2	µg/L	<10	<10	0.0	No Limit
		EP075: Chlorpyrifos	2921-88-2	2	µg/L	<10	<10	0.0	No Limit
		EP075: Pirimphos-ethyl	23505-41-1	2	µg/L	<10	<10	0.0	No Limit
		EP075: Chlorfenvinphos	470-90-6	2	µg/L	<10	<10	0.0	No Limit
		EP075: Prothiofos	34643-46-4	2	µg/L	<10	<10	0.0	No Limit
		EP075: Ethion	563-12-2	2	µg/L	<10	<10	0.0	No Limit

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
EP079/070: TPH CWG Aliphatic Hydrocarbon Fractions (QC Lot: 2501533)									
EM1210744-001	FR Water	EP070-CWG: Aliphatic >C10-C12	TPHCWG-ALE1	50	µg/L	1980	1260	# 44.6	0% - 20%
		EP070-CWG: Aliphatic >C12-C16	TPHCWG-ALE2	50	µg/L	<50	<50	0.0	No Limit
		EP070-CWG: Aliphatic >C16-C21	----	50	µg/L	<50	<50	0.0	No Limit
		EP070-CWG: Aliphatic >C21-C35	----	50	µg/L	<50	<50	0.0	No Limit
EP079/070: TPH CWG Aliphatic Hydrocarbon Fractions (QC Lot: 2518779)									
ER1200156-001	Anonymous	EP079-CWG: Aliphatic >C5-C6	----	20	µg/L	<20	<20	0.0	No Limit
		EP079-CWG: Aliphatic >C6-C8	TPHCWG-ALV2	20	µg/L	<20	<20	0.0	No Limit
		EP079-CWG: Aliphatic >C8-C10	TPHCWG-ALV3	20	µg/L	<20	<20	0.0	No Limit
EP079/070: TPH CWG Aromatic Hydrocarbon Fractions (QC Lot: 2501533)									
EM1210744-001	FR Water	EP070-CWG: Aromatic >C10-C12	TPHCWG-ARE1	50	µg/L	5200	4340	17.9	0% - 20%
		EP070-CWG: Aromatic >C12-C16	TPHCWG-ARE2	50	µg/L	410	265	43.0	No Limit
		EP070-CWG: Aromatic >C16-C21	TPHCWG-ARE3	50	µg/L	410	298	31.6	No Limit
		EP070-CWG: Aromatic >C21-C35	TPHCWG-ARE4	50	µg/L	205	132	43.0	No Limit
EP079/070: TPH CWG Aromatic Hydrocarbon Fractions (QC Lot: 2518779)									
ER1200156-001	Anonymous	EP079-CWG: Aromatic >C5-C7	----	5	µg/L	<5	<5	0.0	No Limit
		EP079-CWG: Aromatic >C7-C8	TPHCWG-ARV 2	5	µg/L	<5	<5	0.0	No Limit
		EP079-CWG: Aromatic >C8-C10	TPHCWG-ARV 3	5	µg/L	<5	<5	0.0	No Limit
EP117: Alcohols (QC Lot: 2509203)									
EB1224362-001	Anonymous	EP117: Ethanol	64-17-5	50	µg/L	165	180	8.7	No Limit
		EP117: Isopropanol	67-63-0	50	µg/L	<50	<50	0.0	No Limit
		EP117: n-Propanol	71-23-8	50	µg/L	<50	<50	0.0	No Limit
		EP117: Isobutanol	78-83-1	50	µg/L	<50	<50	0.0	No Limit
		EP117: n-Butanol	71-36-3	50	µg/L	<50	<50	0.0	No Limit
EB1224362-002	Anonymous	EP117: Ethanol	64-17-5	50	µg/L	299	296	1.1	No Limit
		EP117: Isopropanol	67-63-0	50	µg/L	<50	<50	0.0	No Limit
		EP117: n-Propanol	71-23-8	50	µg/L	<50	<50	0.0	No Limit
		EP117: Isobutanol	78-83-1	50	µg/L	<50	<50	0.0	No Limit
		EP117: n-Butanol	71-36-3	50	µg/L	<50	<50	0.0	No Limit

Method Blank (MB) and Laboratory Control Spike (LCS) Report

The quality control term Method / Laboratory Blank refers to an analyte free matrix to which all reagents are added in the same volumes or proportions as used in standard sample preparation. The purpose of this QC parameter is to monitor potential laboratory contamination. The quality control term Laboratory Control Sample (LCS) refers to a certified reference material, or a known interference free matrix spiked with target analytes. The purpose of this QC parameter is to monitor method precision and accuracy independent of sample matrix. Dynamic Recovery Limits are based on statistical evaluation of processed LCS.

Sub-Matrix: **WATER**

				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Recovery Limits (%)	
Method: Compound	CAS Number	LOR	Unit	Result	Concentration	LCS	Low	High
EA015: Total Dissolved Solids (QCLot: 2505277)								
EA015H: Total Dissolved Solids @180°C	GIS-210-010	10	mg/L	<10	2000 mg/L	101	98	104
ED009: Anions (QCLot: 2507802)								
ED009-X: Bromide	24959-67-9	0.01	mg/L	<0.010	2 mg/L	101	90	110
ED009-X: Iodide	20461-54-5	0.01	mg/L	<0.010	0.5 mg/L	83.8	73	125
ED037P: Alkalinity by PC Titrator (QCLot: 2501656)								
ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	----	200 mg/L	96.4	77	127
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA (QCLot: 2501638)								
ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	<1	12.5 mg/L	105	81	125
ED045G: Chloride Discrete analyser (QCLot: 2501641)								
ED045G: Chloride	16887-00-6	1	mg/L	<1	1000 mg/L	96.7	89	117
ED093F: Dissolved Major Cations (QCLot: 2501640)								
ED093F: Calcium	7440-70-2	1	mg/L	<1	5 mg/L	101	83	129
ED093F: Magnesium	7439-95-4	1	mg/L	<1	5 mg/L	99.9	80	124
ED093F: Sodium	7440-23-5	1	mg/L	<1	50 mg/L	94.1	77	125
ED093F: Potassium	7440-09-7	1	mg/L	<1	50 mg/L	96.1	77	123
EG020F: Dissolved Metals by ICP-MS (QCLot: 2506756)								
EG020A-F: Aluminium	7429-90-5	0.01	mg/L	<0.01	0.5 mg/L	100	80	120
EG020A-F: Arsenic	7440-38-2	0.001	mg/L	<0.001	0.1 mg/L	99.1	87	109
EG020A-F: Beryllium	7440-41-7	0.001	mg/L	<0.001	0.1 mg/L	104	70	124
EG020A-F: Barium	7440-39-3	0.001	mg/L	<0.001	0.1 mg/L	102	88	110
EG020A-F: Cadmium	7440-43-9	0.0001	mg/L	<0.0001	0.1 mg/L	101	88	110
EG020A-F: Chromium	7440-47-3	0.001	mg/L	<0.001	0.1 mg/L	95.0	86	112
EG020A-F: Cobalt	7440-48-4	0.001	mg/L	<0.001	0.1 mg/L	99.1	87	111
EG020A-F: Copper	7440-50-8	0.001	mg/L	<0.001	0.1 mg/L	100	86	108
EG020A-F: Lead	7439-92-1	0.001	mg/L	<0.001	0.1 mg/L	103	90	110
EG020A-F: Lithium	7439-93-2	0.001	mg/L	<0.001	0.1 mg/L	105	60	130
EG020A-F: Manganese	7439-96-5	0.001	mg/L	<0.001	0.1 mg/L	93.0	87	111
EG020A-F: Molybdenum	7439-98-7	0.001	mg/L	<0.001	0.1 mg/L	103	84	108
EG020A-F: Nickel	7440-02-0	0.001	mg/L	<0.001	0.1 mg/L	102	86	112
EG020A-F: Selenium	7782-49-2	0.01	mg/L	<0.01	0.1 mg/L	103	83	111
EG020A-F: Tin	7440-31-5	0.001	mg/L	<0.001	0.1 mg/L	100	83	111
EG020A-F: Vanadium	7440-62-2	0.01	mg/L	<0.01	0.1 mg/L	98.8	85	113
EG020A-F: Zinc	7440-66-6	0.005	mg/L	<0.005	0.1 mg/L	102	86	120
EG020A-F: Boron	7440-42-8	0.05	mg/L	<0.05	0.1 mg/L	98.9	61	133

Sub-Matrix: **WATER**

Method: Compound	CAS Number	LOR	Unit	Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Recovery Limits (%)	
				Result	Concentration	LCS	Low	High
EG020F: Dissolved Metals by ICP-MS (QCLot: 2506756) - continued								
EG020A-F: Iron	7439-89-6	0.05	mg/L	<0.05	0.5 mg/L	95.5	79	119
EG020F: Dissolved Metals by ICP-MS (QCLot: 2506757)								
EG020B-F: Strontium	7440-24-6	0.001	mg/L	<0.001	0.1 mg/L	99.1	88	108
EG020B-F: Uranium	7440-61-1	0.001	mg/L	<0.001	----	----	----	----
EG035F: Dissolved Mercury by FIMS (QCLot: 2506755)								
EG035F: Mercury	7439-97-6	0.0001	mg/L	<0.0001	0.0100 mg/L	99.5	71	125
EK025SF: Free CN by Segmented Flow Analyser (QCLot: 2501301)								
EK025SF: Free Cyanide	----	0.004	mg/L	<0.004	0.2 mg/L	96.1	73	111
EK026SF: Total CN by Segmented Flow Analyser (QCLot: 2501302)								
EK026SF: Total Cyanide	57-12-5	0.004	mg/L	<0.004	0.2 mg/L	88.2	85	125
EK040P: Fluoride by PC Titrator (QCLot: 2501652)								
EK040P: Fluoride	16984-48-8	0.1	mg/L	<0.1	5 mg/L	103	78	120
EK055G: Ammonia as N by Discrete Analyser (QCLot: 2503677)								
EK055G: Ammonia as N	7664-41-7	0.01	mg/L	<0.01	0.5 mg/L	105	76	122
EK057G: Nitrite as N by Discrete Analyser (QCLot: 2501639)								
EK057G: Nitrite as N	----	0.01	mg/L	<0.01	0.5 mg/L	94.0	84	112
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser (QCLot: 2503676)								
EK059G: Nitrite + Nitrate as N	----	0.01	mg/L	<0.01	0.5 mg/L	103	73	127
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser (QCLot: 2503250)								
EK061G: Total Kjeldahl Nitrogen as N	----	0.1	mg/L	<0.1	10 mg/L	92.3	63	117
EK067G: Total Phosphorus as P by Discrete Analyser (QCLot: 2503251)								
EK067G: Total Phosphorus as P	----	0.01	mg/L	<0.01	4.42 mg/L	102	73	117
EK071G: Reactive Phosphorus as P by discrete analyser (QCLot: 2501642)								
EK071G: Reactive Phosphorus as P	----	0.01	mg/L	<0.01	0.5 mg/L	87.8	84	108
EP005: Total Organic Carbon (TOC) (QCLot: 2519209)								
EP005: Total Organic Carbon	----	1	mg/L	<1	100 mg/L	101	81	111
EP010: Formaldehyde (QCLot: 2501649)								
EP010: Formaldehyde	50-00-0	0.1	mg/L	<0.1	5.0 mg/L	102	91	117
EP041A: Nonionic Surfactants (QCLot: 2504783)								
EP041A: Nonionic Surfactants as CTAS	----	5	mg/L	<5	10 mg/L	102	70	128
EP074A: Monocyclic Aromatic Hydrocarbons (QCLot: 2518778)								
EP074: Benzene	71-43-2	1	µg/L	<1	20 µg/L	101	79	121
EP074: Toluene	108-88-3	2	µg/L	<2	20 µg/L	102	80	124
EP074: Ethylbenzene	100-41-4	2	µg/L	<2	20 µg/L	101	79	121
EP074: meta- & para-Xylene	108-38-3 106-42-3	2	µg/L	<2	40 µg/L	103	80	122

Sub-Matrix: **WATER**

Method: Compound	CAS Number	LOR	Unit	Method Blank (MB) Report	Laboratory Control Spike (LCS) Report		
					Spike	Spike Recovery (%)	Recovery Limits (%)
				Result	Concentration	LCS	Low	High
EP074A: Monocyclic Aromatic Hydrocarbons (QCLot: 2518778) - continued								
EP074: Styrene	100-42-5	5	µg/L	<5	20 µg/L	103	74	122
EP074: ortho-Xylene	95-47-6	2	µg/L	<2	20 µg/L	106	81	123
EP074: Isopropylbenzene	98-82-8	5	µg/L	<5	20 µg/L	105	80	120
EP074: n-Propylbenzene	103-65-1	5	µg/L	<5	20 µg/L	95.7	70	120
EP074: 1.3.5-Trimethylbenzene	108-67-8	5	µg/L	<5	20 µg/L	96.2	71	119
EP074: sec-Butylbenzene	135-98-8	5	µg/L	<5	20 µg/L	93.5	72	120
EP074: 1.2.4-Trimethylbenzene	95-63-6	5	µg/L	<5	20 µg/L	97.5	73	119
EP074: tert-Butylbenzene	98-06-6	5	µg/L	<5	20 µg/L	94.6	73	119
EP074: p-Isopropyltoluene	99-87-6	5	µg/L	<5	20 µg/L	97.4	71	121
EP074: n-Butylbenzene	104-51-8	5	µg/L	<5	20 µg/L	96.9	65	121
EP074B: Oxygenated Compounds (QCLot: 2518778)								
EP074: Vinyl Acetate	108-05-4	50	µg/L	<50	200 µg/L	87.0	57	131
EP074: 2-Butanone (MEK)	78-93-3	50	µg/L	<50	200 µg/L	92.8	69	135
EP074: 4-Methyl-2-pentanone (MIBK)	108-10-1	50	µg/L	<50	200 µg/L	93.7	68	136
EP074: 2-Hexanone (MBK)	591-78-6	50	µg/L	<50	200 µg/L	97.0	68	138
EP074C: Sulfonated Compounds (QCLot: 2518778)								
EP074: Carbon disulfide	75-15-0	5	µg/L	<5	20 µg/L	85.8	67	127
EP074D: Fumigants (QCLot: 2518778)								
EP074: 2.2-Dichloropropane	594-20-7	5	µg/L	<5	20 µg/L	77.5	59	128
EP074: 1.2-Dichloropropane	78-87-5	5	µg/L	<5	20 µg/L	97.2	77	121
EP074: cis-1.3-Dichloropropylene	10061-01-5	5	µg/L	<5	20 µg/L	76.9	70	118
EP074: trans-1.3-Dichloropropylene	10061-02-6	5	µg/L	<5	20 µg/L	69.6	66	120
EP074: 1.2-Dibromoethane (EDB)	106-93-4	5	µg/L	<5	20 µg/L	97.0	78	124
EP074E: Halogenated Aliphatic Compounds (QCLot: 2518778)								
EP074: Dichlorodifluoromethane	75-71-8	50	µg/L	<50	200 µg/L	101	58	148
EP074: Chloromethane	74-87-3	50	µg/L	<50	200 µg/L	119	62	142
EP074: Vinyl chloride	75-01-4	50	µg/L	<50	200 µg/L	110	61	141
EP074: Bromomethane	74-83-9	50	µg/L	<50	200 µg/L	103	57	131
EP074: Chloroethane	75-00-3	50	µg/L	<50	200 µg/L	97.1	64	138
EP074: Trichlorofluoromethane	75-69-4	50	µg/L	<50	200 µg/L	98.5	67	131
EP074: 1.1-Dichloroethene	75-35-4	5	µg/L	<5	20 µg/L	89.8	71	125
EP074: Iodomethane	74-88-4	5	µg/L	<5	20 µg/L	109	61	135
EP074: trans-1.2-Dichloroethene	156-60-5	5	µg/L	<5	20 µg/L	95.0	75	121
EP074: 1.1-Dichloroethane	75-34-3	5	µg/L	<5	20 µg/L	95.3	77	121
EP074: cis-1.2-Dichloroethene	156-59-2	5	µg/L	<5	20 µg/L	102	78	122
EP074: 1.1.1-Trichloroethane	71-55-6	5	µg/L	<5	20 µg/L	85.3	70	120
EP074: 1.1-Dichloropropylene	563-58-6	5	µg/L	<5	20 µg/L	95.7	74	122
EP074: Carbon Tetrachloride	56-23-5	5	µg/L	<5	20 µg/L	78.6	57	123

Sub-Matrix: **WATER**

Method: Compound	CAS Number	LOR	Unit	Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Recovery Limits (%)	
				Result	Concentration	LCS	Low	High
EP074E: Halogenated Aliphatic Compounds (QCLot: 2518778) - continued								
EP074: 1.2-Dichloroethane	107-06-2	5	µg/L	<5	20 µg/L	99.8	75	125
EP074: Trichloroethene	79-01-6	5	µg/L	<5	20 µg/L	97.4	77	121
EP074: Dibromomethane	74-95-3	5	µg/L	<5	20 µg/L	93.7	76	122
EP074: 1.1.2-Trichloroethane	79-00-5	5	µg/L	<5	20 µg/L	103	78	126
EP074: 1.3-Dichloropropane	142-28-9	5	µg/L	<5	20 µg/L	102	79	125
EP074: Tetrachloroethene	127-18-4	5	µg/L	<5	20 µg/L	98.8	76	122
EP074: 1.1.1.2-Tetrachloroethane	630-20-6	5	µg/L	<5	20 µg/L	84.8	65	119
EP074: trans-1.4-Dichloro-2-butene	110-57-6	5	µg/L	<5	20 µg/L	83.9	46	126
EP074: cis-1.4-Dichloro-2-butene	1476-11-5	5	µg/L	<5	20 µg/L	62.8	54	132
EP074: 1.1.2.2-Tetrachloroethane	79-34-5	5	µg/L	<5	20 µg/L	98.6	75	131
EP074: 1.2.3-Trichloropropane	96-18-4	5	µg/L	<5	20 µg/L	100	75	133
EP074: Pentachloroethane	76-01-7	5	µg/L	<5	20 µg/L	75.4	46	118
EP074: 1.2-Dibromo-3-chloropropane	96-12-8	5	µg/L	<5	20 µg/L	71.2	54	124
EP074F: Halogenated Aromatic Compounds (QCLot: 2518778)								
EP074: Chlorobenzene	108-90-7	5	µg/L	<5	20 µg/L	103	81	121
EP074: Bromobenzene	108-86-1	5	µg/L	<5	20 µg/L	86.8	75	119
EP074: 2-Chlorotoluene	95-49-8	5	µg/L	<5	20 µg/L	98.4	73	121
EP074: 4-Chlorotoluene	106-43-4	5	µg/L	<5	20 µg/L	100	72	120
EP074: 1.2.3-Trichlorobenzene	87-61-6	5	µg/L	<5	20 µg/L	106	69	123
EP074G: Trihalomethanes (QCLot: 2518778)								
EP074: Chloroform	67-66-3	5	µg/L	<5	20 µg/L	98.0	77	121
EP074: Bromodichloromethane	75-27-4	5	µg/L	<5	20 µg/L	83.2	69	117
EP074: Dibromochloromethane	124-48-1	5	µg/L	<5	20 µg/L	80.9	59	119
EP074: Bromoform	75-25-2	5	µg/L	<5	20 µg/L	75.4	49	121
EP075A: Phenolic Compounds (QCLot: 2501530)								
EP075: Phenol	108-95-2	2	µg/L	<2	10 µg/L	45.7	10	65
EP075: 2-Chlorophenol	95-57-8	2	µg/L	<2	10 µg/L	86.0	29.8	108
EP075: 2-Methylphenol	95-48-7	2	µg/L	<2	10 µg/L	80.6	21.9	110
EP075: 3- & 4-Methylphenol	1319-77-3	2	µg/L	----	20 µg/L	43.6	10	108
		4	µg/L	<4	----	----	----	----
EP075: 2-Nitrophenol	88-75-5	2	µg/L	<2	10 µg/L	97.1	31.2	123
EP075: 2.4-Dimethylphenol	105-67-9	2	µg/L	<2	10 µg/L	94.4	36	124
EP075: 2.4-Dichlorophenol	120-83-2	2	µg/L	<2	10 µg/L	88.4	31.2	125
EP075: 2.6-Dichlorophenol	87-65-0	2	µg/L	<2	10 µg/L	90.4	33	123
EP075: 4-Chloro-3-Methylphenol	59-50-7	2	µg/L	<2	10 µg/L	95.8	39	125
EP075: 2.4.6-Trichlorophenol	88-06-2	2	µg/L	<2	10 µg/L	85.0	23.9	134
EP075: 2.4.5-Trichlorophenol	95-95-4	2	µg/L	<2	10 µg/L	79.7	31.6	136
EP075: Pentachlorophenol	87-86-5	2	µg/L	----	10 µg/L	# 24.5	47	153
		4	µg/L	<4	----	----	----	----

Sub-Matrix: **WATER**

Method: Compound	CAS Number	LOR	Unit	Method Blank (MB) Report	Laboratory Control Spike (LCS) Report		
					Spike	Spike Recovery (%)	Recovery Limits (%)
				Result	Concentration	LCS	Low	High
EP075B: Polynuclear Aromatic Hydrocarbons (QCLot: 2501530)								
EP075: Naphthalene	91-20-3	2	µg/L	<2	10 µg/L	97.9	33	117
EP075: 2-Methylnaphthalene	91-57-6	2	µg/L	<2	10 µg/L	98.4	33	123
EP075: 2-Chloronaphthalene	91-58-7	2	µg/L	<2	10 µg/L	95.1	22.6	133
EP075: Acenaphthylene	208-96-8	2	µg/L	<2	10 µg/L	99.4	35	131
EP075: Acenaphthene	83-32-9	2	µg/L	<2	10 µg/L	90.0	37	127
EP075: Fluorene	86-73-7	2	µg/L	<2	10 µg/L	89.9	39	133
EP075: Phenanthrene	85-01-8	2	µg/L	<2	10 µg/L	108	42	134
EP075: Anthracene	120-12-7	2	µg/L	<2	10 µg/L	108	41	135
EP075: Fluoranthene	206-44-0	2	µg/L	<2	10 µg/L	111	40	146
EP075: Pyrene	129-00-0	2	µg/L	<2	10 µg/L	110	42	142
EP075: N-2-Fluorenyl Acetamide	53-96-3	2	µg/L	<2	10 µg/L	119	40	146
EP075: Benz(a)anthracene	56-55-3	2	µg/L	<2	10 µg/L	104	41	143
EP075: Chrysene	218-01-9	2	µg/L	<2	10 µg/L	116	40	146
EP075: Benzo(b) & Benzo(k)fluoranthene	205-99-2 207-08-9	4	µg/L	<4	20 µg/L	116	21	151
EP075: 7.12-Dimethylbenz(a)anthracene	57-97-6	2	µg/L	<2	10 µg/L	119	39	151
EP075: Benzo(a)pyrene	50-32-8	2	µg/L	<2	10 µg/L	119	39	141
EP075: 3-Methylcholanthrene	56-49-5	2	µg/L	<2	10 µg/L	104	33	139
EP075: Indeno(1.2.3.cd)pyrene	193-39-5	2	µg/L	<2	10 µg/L	116	31.5	139
EP075: Dibenz(a.h)anthracene	53-70-3	2	µg/L	<2	10 µg/L	116	30.1	140
EP075: Benzo(g.h.i)perylene	191-24-2	2	µg/L	<2	10 µg/L	113	29.5	138
EP075C: Phthalate Esters (QCLot: 2501530)								
EP075: Dimethyl phthalate	131-11-3	2	µg/L	<2	10 µg/L	103	41	141
EP075: Diethyl phthalate	84-66-2	2	µg/L	<2	10 µg/L	94.9	45	139
EP075: Di-n-butyl phthalate	84-74-2	2	µg/L	<2	10 µg/L	126	42	150
EP075: Butyl benzyl phthalate	85-68-7	2	µg/L	<2	10 µg/L	113	36	152
EP075: bis(2-ethylhexyl) phthalate	117-81-7	10	µg/L	<10	----	----	----	----
		20	µg/L	----	10 µg/L	110	42	158
EP075: Di-n-octylphthalate	117-84-0	2	µg/L	<2	10 µg/L	110	43	141
EP075D: Nitrosamines (QCLot: 2501530)								
EP075: N-Nitrosomethylethylamine	10595-95-6	2	µg/L	<2	10 µg/L	107	10	109
EP075: N-Nitrosodiethylamine	55-18-5	2	µg/L	<2	10 µg/L	98.0	23.5	124
EP075: N-Nitrosopyrrolidine	930-55-2	4	µg/L	<4	10 µg/L	75.6	18.8	97
EP075: N-Nitrosomorpholine	59-89-2	2	µg/L	<2	10 µg/L	70.6	18.3	94
EP075: N-Nitrosodi-n-propylamine	621-64-7	2	µg/L	<2	10 µg/L	104	30.6	129
EP075: N-Nitrosopiperidine	100-75-4	2	µg/L	<2	10 µg/L	99.4	32	126
EP075: N-Nitrosodibutylamine	924-16-3	2	µg/L	<2	10 µg/L	104	29.1	135
EP075: N-Nitrosodiphenyl & Diphenylamine	86-30-6 122-39-4	4	µg/L	<4	10 µg/L	92.6	39	139

Sub-Matrix: **WATER**

Method: Compound	CAS Number	LOR	Unit	Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Recovery Limits (%)	
				Result	Concentration	LCS	Low	High
EP075D: Nitrosamines (QCLot: 2501530) - continued								
EP075: Methapyrilene	91-80-5	2	µg/L	<2	10 µg/L	41.9	28.1	70
EP075E: Nitroaromatics and Ketones (QCLot: 2501530)								
EP075: 2-Picoline	109-06-8	2	µg/L	<2	10 µg/L	# 10.2	28.4	57
EP075: Acetophenone	98-86-2	2	µg/L	<2	10 µg/L	98.9	34	126
EP075: Nitrobenzene	98-95-3	2	µg/L	<2	10 µg/L	96.3	36	120
EP075: Isophorone	78-59-1	2	µg/L	<2	10 µg/L	95.3	38	124
EP075: 2.6-Dinitrotoluene	606-20-2	4	µg/L	<4	10 µg/L	103	38	142
EP075: 2.4-Dinitrotoluene	121-14-2	4	µg/L	<4	10 µg/L	89.7	44	138
EP075: 1-Naphthylamine	134-32-7	2	µg/L	<2	10 µg/L	114	29.8	152
EP075: 4-Nitroquinoline-N-oxide	56-57-5	2	µg/L	<2	10 µg/L	138	25.9	168
EP075: 5-Nitro-o-toluidine	99-55-8	2	µg/L	<2	10 µg/L	102	26.2	138
EP075: Azobenzene	103-33-3	2	µg/L	<2	10 µg/L	90.0	43	135
EP075: 1.3.5-Trinitrobenzene	99-35-4	2	µg/L	<2	10 µg/L	92.4	10	158
EP075: Phenacetin	62-44-2	2	µg/L	<2	10 µg/L	80.7	37	131
EP075: 4-Aminobiphenyl	92-67-1	2	µg/L	<2	10 µg/L	144	10	150
EP075: Pentachloronitrobenzene	82-68-8	2	µg/L	<2	10 µg/L	89.0	38	146
EP075: Pronamide	23950-58-5	2	µg/L	<2	10 µg/L	107	45	139
EP075: Dimethylaminoazobenzene	60-11-7	2	µg/L	<2	10 µg/L	109	37	147
EP075: Chlorobenzilate	510-15-6	2	µg/L	<2	10 µg/L	109	42	148
EP075F: Haloethers (QCLot: 2501530)								
EP075: Bis(2-chloroethyl) ether	111-44-4	2	µg/L	<2	10 µg/L	116	10	142
EP075: Bis(2-chloroethoxy) methane	111-91-1	2	µg/L	<2	10 µg/L	98.7	34	126
EP075: 4-Chlorophenyl phenyl ether	7005-72-3	2	µg/L	<2	10 µg/L	88.8	39	133
EP075: 4-Bromophenyl phenyl ether	101-55-3	2	µg/L	<2	10 µg/L	90.5	39	137
EP075G: Chlorinated Hydrocarbons (QCLot: 2501530)								
EP075: 1.4-Dichlorobenzene	106-46-7	2	µg/L	<2	10 µg/L	92.3	23	109
EP075: 1.3-Dichlorobenzene	541-73-1	2	µg/L	<2	10 µg/L	89.7	19.8	112
EP075: 1.2-Dichlorobenzene	95-50-1	2	µg/L	<2	10 µg/L	92.8	25.2	109
EP075: Hexachloroethane	67-72-1	2	µg/L	<2	10 µg/L	87.4	17.4	115
EP075: 1.2.4-Trichlorobenzene	120-82-1	2	µg/L	<2	10 µg/L	93.2	25.7	112
EP075: Hexachloropropylene	1888-71-7	2	µg/L	<2	10 µg/L	91.5	19.1	115
EP075: Hexachlorobutadiene	87-68-3	2	µg/L	<2	10 µg/L	92.6	21.1	117
EP075: Hexachlorocyclopentadiene	77-47-4	10	µg/L	<10	10 µg/L	76.4	10	120
EP075: Pentachlorobenzene	608-93-5	2	µg/L	<2	10 µg/L	88.1	36	130
EP075: Hexachlorobenzene (HCB)	118-74-1	4	µg/L	<4	20 µg/L	88.7	11.1	135
EP075H: Anilines and Benzidines (QCLot: 2501530)								
EP075: Aniline	62-53-3	2	µg/L	<2	10 µg/L	78.6	19.8	96
EP075: 4-Chloroaniline	106-47-8	2	µg/L	<2	10 µg/L	99.2	16.4	130

Sub-Matrix: **WATER**

Method: Compound	CAS Number	LOR	Unit	Method Blank (MB) Report	Laboratory Control Spike (LCS) Report		
					Spike	Spike Recovery (%)	Recovery Limits (%)
				Result	Concentration	LCS	Low	High
EP075H: Anilines and Benzidines (QCLot: 2501530) - continued								
EP075: 2-Nitroaniline	88-74-4	4	µg/L	<4	10 µg/L	104	38	138
EP075: 3-Nitroaniline	99-09-2	4	µg/L	<4	10 µg/L	100	10	135
EP075: Dibenzofuran	132-64-9	2	µg/L	<2	10 µg/L	91.6	39	129
EP075: 4-Nitroaniline	100-01-6	2	µg/L	<2	10 µg/L	83.8	22.8	133
EP075: Carbazole	86-74-8	2	µg/L	<2	10 µg/L	110	44	138
EP075: 3.3`-Dichlorobenzidine	91-94-1	2	µg/L	<2	10 µg/L	# 124	14.6	107
EP075I: Organochlorine Pesticides (QCLot: 2501530)								
EP075: alpha-BHC	319-84-6	2	µg/L	<2	10 µg/L	90.0	41	143
EP075: beta-BHC	319-85-7	2	µg/L	<2	10 µg/L	91.7	39	145
EP075: gamma-BHC	58-89-9	2	µg/L	<2	10 µg/L	89.4	39	143
EP075: delta-BHC	319-86-8	2	µg/L	<2	10 µg/L	108	42	142
EP075: Heptachlor	76-44-8	2	µg/L	<2	10 µg/L	108	39	139
EP075: Aldrin	309-00-2	2	µg/L	<2	10 µg/L	106	40	142
EP075: Heptachlor epoxide	1024-57-3	2	µg/L	<2	10 µg/L	110	37	147
EP075: alpha-Endosulfan	959-98-8	2	µg/L	<2	10 µg/L	85.3	42	146
EP075: 4.4`-DDE	72-55-9	2	µg/L	<2	10 µg/L	105	41	141
EP075: Dieldrin	60-57-1	2	µg/L	<2	10 µg/L	108	42	144
EP075: Endrin	72-20-8	2	µg/L	<2	10 µg/L	113	41	145
EP075: beta-Endosulfan	33213-65-9	2	µg/L	<2	10 µg/L	108	42	146
EP075: 4.4`-DDD	72-54-8	2	µg/L	<2	10 µg/L	109	40	148
EP075: Endosulfan sulfate	1031-07-8	2	µg/L	<2	10 µg/L	119	38	152
EP075: 4.4`-DDT	50-29-3	4	µg/L	<4	10 µg/L	120	33	145
EP075J: Organophosphorus Pesticides (QCLot: 2501530)								
EP075: Dichlorvos	62-73-7	2	µg/L	<2	10 µg/L	102	38	132
EP075: Dimethoate	60-51-5	2	µg/L	<2	10 µg/L	88.7	36	138
EP075: Diazinon	333-41-5	2	µg/L	<2	10 µg/L	110	43	141
EP075: Chlorpyrifos-methyl	5598-13-0	2	µg/L	<2	10 µg/L	107	43	141
EP075: Malathion	121-75-5	2	µg/L	<2	10 µg/L	117	44	148
EP075: Fenthion	55-38-9	2	µg/L	<2	10 µg/L	111	42	144
EP075: Chlorpyrifos	2921-88-2	2	µg/L	<2	10 µg/L	109	42	142
EP075: Pirimphos-ethyl	23505-41-1	2	µg/L	<2	10 µg/L	108	44	142
EP075: Chlorfenvinphos	470-90-6	2	µg/L	<2	10 µg/L	114	44	146
EP075: Prothiofos	34643-46-4	2	µg/L	<2	10 µg/L	111	40	142
EP075: Ethion	563-12-2	2	µg/L	<2	10 µg/L	108	42	146
EP079/070: TPH CWG Aliphatic Hydrocarbon Fractions (QCLot: 2501533)								
EP070-CWG: Aliphatic >C10-C12	TPHCWG-AL E1	50	µg/L	<50	2505 µg/L	77.9	70	130
EP070-CWG: Aliphatic >C12-C16	TPHCWG-AL E2	50	µg/L	<50	10590 µg/L	84.9	70	130

Sub-Matrix: **WATER**

Method: Compound	CAS Number	LOR	Unit	Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Recovery Limits (%)	
				Result	Concentration	LCS	Low	High
EP079/070: TPH CWG Aliphatic Hydrocarbon Fractions (QCLot: 2501533) - continued								
EP070-CWG: Aliphatic >C16-C21	----	50	µg/L	<50	9345 µg/L	99.6	70	130
EP070-CWG: Aliphatic >C21-C35	----	50	µg/L	<50	2253 µg/L	96.8	70	130
EP079/070: TPH CWG Aliphatic Hydrocarbon Fractions (QCLot: 2518779)								
EP079-CWG: Aliphatic >C5-C6	----	20	µg/L	<20	50 µg/L	100	70	130
EP079-CWG: Aliphatic >C6-C8	TPHCWG-AL V2	20	µg/L	<20	100 µg/L	102	70	130
EP079-CWG: Aliphatic >C8-C10	TPHCWG-AL V3	20	µg/L	<20	100 µg/L	106	70	130
EP079/070: TPH CWG Aromatic Hydrocarbon Fractions (QCLot: 2501533)								
EP070-CWG: Aromatic >C10-C12	TPHCWG-AR E1	50	µg/L	<50	750 µg/L	78.2	70	130
EP070-CWG: Aromatic >C12-C16	TPHCWG-AR E2	50	µg/L	<50	3174 µg/L	91.1	70	130
EP070-CWG: Aromatic >C16-C21	TPHCWG-AR E3	50	µg/L	<50	2607 µg/L	85.3	70	130
EP070-CWG: Aromatic >C21-C35	TPHCWG-AR E4	50	µg/L	<50	606 µg/L	83.1	70	130
EP079/070: TPH CWG Aromatic Hydrocarbon Fractions (QCLot: 2518779)								
EP079-CWG: Aromatic >C5-C7	----	1	µg/L	<1	20 µg/L	97.0	70	130
EP079-CWG: Aromatic >C7-C8	TPHCWG-AR V2	2	µg/L	<2	20 µg/L	98.6	70	130
EP079-CWG: Aromatic >C8-C10	TPHCWG-AR V3	2	µg/L	<2	160 µg/L	97.2	70	130
EP117: Alcohols (QCLot: 2509203)								
EP117: Ethanol	64-17-5	50	µg/L	<50	100 µg/L	86.4	73	121
EP117: Isopropanol	67-63-0	50	µg/L	<50	100 µg/L	92.2	73	113
EP117: n-Propanol	71-23-8	50	µg/L	<50	100 µg/L	93.3	68	116
EP117: Isobutanol	78-83-1	50	µg/L	<50	100 µg/L	90.9	67	117
EP117: n-Butanol	71-36-3	50	µg/L	<50	100 µg/L	87.3	65	119

Matrix Spike (MS) Report

The quality control term Matrix Spike (MS) refers to an intralaboratory split sample spiked with a representative set of target analytes. The purpose of this QC parameter is to monitor potential matrix effects on analyte recoveries. Static Recovery Limits as per laboratory Data Quality Objectives (DQOs). Ideal recovery ranges stated may be waived in the event of sample matrix interference.

Sub-Matrix: **WATER**

				Matrix Spike (MS) Report			
				Spike	Spike Recovery (%)	Recovery Limits (%)	
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Concentration	MS	Low	High
ED009: Anions (QCLot: 2507802)							
EM1210846-001	Anonymous	ED009-X: Bromide	24959-67-9	0.2 mg/L	112	70	130
		ED009-X: Iodide	20461-54-5	0.2 mg/L	122	70	130
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA (QCLot: 2501638)							
EM1210737-006	Anonymous	ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	10 mg/L	# Not Determined	70	130
ED045G: Chloride Discrete analyser (QCLot: 2501641)							
EM1210737-006	Anonymous	ED045G: Chloride	16887-00-6	400 mg/L	# Not Determined	70	130
EG020F: Dissolved Metals by ICP-MS (QCLot: 2506756)							
EM1210728-001	Anonymous	EG020A-F: Arsenic	7440-38-2	0.2 mg/L	116	89	139
		EG020A-F: Beryllium	7440-41-7	0.2 mg/L	112	64	138
		EG020A-F: Barium	7440-39-3	0.2 mg/L	102	80	122
		EG020A-F: Cadmium	7440-43-9	0.05 mg/L	114	75	131
		EG020A-F: Chromium	7440-47-3	0.2 mg/L	97.9	70	130
		EG020A-F: Cobalt	7440-48-4	0.2 mg/L	108	77	129
		EG020A-F: Copper	7440-50-8	0.2 mg/L	104	71	127
		EG020A-F: Lead	7439-92-1	0.2 mg/L	99.3	71	123
		EG020A-F: Manganese	7439-96-5	0.2 mg/L	# Not Determined	66	132
		EG020A-F: Nickel	7440-02-0	0.2 mg/L	101	73	129
		EG020A-F: Vanadium	7440-62-2	0.2 mg/L	98.4	70	130
		EG020A-F: Zinc	7440-66-6	0.2 mg/L	# Not Determined	68	136
EG035F: Dissolved Mercury by FIMS (QCLot: 2506755)							
EM1210728-002	Anonymous	EG035F: Mercury	7439-97-6	0.0100 mg/L	# 58.9	70	130
EK025SF: Free CN by Segmented Flow Analyser (QCLot: 2501301)							
EM1210670-002	Anonymous	EK025SF: Free Cyanide	----	0.2 mg/L	82.3	70	130
EK026SF: Total CN by Segmented Flow Analyser (QCLot: 2501302)							
EM1210670-002	Anonymous	EK026SF: Total Cyanide	57-12-5	0.2 mg/L	88.0	70	130
EK040P: Fluoride by PC Titrator (QCLot: 2501652)							
EM1210670-002	Anonymous	EK040P: Fluoride	16984-48-8	5.0 mg/L	93.2	70	130
EK055G: Ammonia as N by Discrete Analyser (QCLot: 2503677)							
EM1210744-002	Crosslink Gel	EK055G: Ammonia as N	7664-41-7	0.5 mg/L	96.8	70	130
EK057G: Nitrite as N by Discrete Analyser (QCLot: 2501639)							
EM1210737-006	Anonymous	EK057G: Nitrite as N	----	0.5 mg/L	91.7	70	130
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser (QCLot: 2503676)							
EM1210719-001	Anonymous	EK059G: Nitrite + Nitrate as N	----	0.5 mg/L	# Not Determined	70	130

Sub-Matrix: **WATER**

Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Matrix Spike (MS) Report: Spike Concentration	Spike Recovery (%): MS	Recovery Limits (%): Low	Recovery Limits (%): High
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser (QCLot: 2503250)							
EM1210719-001	Anonymous	EK061G: Total Kjeldahl Nitrogen as N	----	5 mg/L	# Not Determined	70	130
EK067G: Total Phosphorus as P by Discrete Analyser (QCLot: 2503251)							
EM1210719-001	Anonymous	EK067G: Total Phosphorus as P	----	1 mg/L	# Not Determined	70	130
EK071G: Reactive Phosphorus as P by discrete analyser (QCLot: 2501642)							
EM1210743-002	Anonymous	EK071G: Reactive Phosphorus as P	----	0.5 mg/L	112	70	130
EP005: Total Organic Carbon (TOC) (QCLot: 2519209)							
EM1210744-002	Crosslink Gel	EP005: Total Organic Carbon	----	1000 mg/L	# Not Determined	70	130
EP041A: Nonionic Surfactants (QCLot: 2504783)							
EP1207681-009	Anonymous	EP041A: Nonionic Surfactants as CTAS	----	5 mg/L	106	70	130
EP074A: Monocyclic Aromatic Hydrocarbons (QCLot: 2518778)							
ER1200156-004	Anonymous	EP074: Benzene	71-43-2	20 µg/L	96.2	64	121
		EP074: Toluene	108-88-3	20 µg/L	99.3	63	125
EP074E: Halogenated Aliphatic Compounds (QCLot: 2518778)							
ER1200156-004	Anonymous	EP074: 1.1-Dichloroethene	75-35-4	20 µg/L	90.4	52	104
		EP074: Trichloroethene	79-01-6	20 µg/L	92.8	59	120
EP074F: Halogenated Aromatic Compounds (QCLot: 2518778)							
ER1200156-004	Anonymous	EP074: Chlorobenzene	108-90-7	20 µg/L	102	63	132
EP075A: Phenolic Compounds (QCLot: 2501530)							
EM1210744-002	Crosslink Gel	EP075: Phenol	108-95-2	10 µg/L	# Not Determined	10	51
		EP075: 2-Chlorophenol	95-57-8	10 µg/L	# Not Determined	26.1	104
		EP075: 2-Nitrophenol	88-75-5	10 µg/L	# Not Determined	34	118
		EP075: 4-Chloro-3-Methylphenol	59-50-7	10 µg/L	# Not Determined	24.9	135
		EP075: Pentachlorophenol	87-86-5	10 µg/L	# Not Determined	29.9	194
EP075B: Polynuclear Aromatic Hydrocarbons (QCLot: 2501530)							
EM1210744-002	Crosslink Gel	EP075: Acenaphthene	83-32-9	10 µg/L	# Not Determined	27	133
		EP075: Pyrene	129-00-0	10 µg/L	# Not Determined	28.1	146
EP075D: Nitrosamines (QCLot: 2501530)							
EM1210744-002	Crosslink Gel	EP075: N-Nitrosodi-n-propylamine	621-64-7	10 µg/L	# Not Determined	22.8	125
EP075E: Nitroaromatics and Ketones (QCLot: 2501530)							
EM1210744-002	Crosslink Gel	EP075: 2.4-Dinitrotoluene	121-14-2	10 µg/L	# Not Determined	27.9	138
EP075G: Chlorinated Hydrocarbons (QCLot: 2501530)							
EM1210744-002	Crosslink Gel	EP075: 1.4-Dichlorobenzene	106-46-7	10 µg/L	# Not Determined	22.1	112
		EP075: 1.2.4-Trichlorobenzene	120-82-1	10 µg/L	# Not Determined	15.3	117
EP079/070: TPH CWG Aliphatic Hydrocarbon Fractions (QCLot: 2501533)							
EM1210744-002	Crosslink Gel						

Sub-Matrix: **WATER**

				Matrix Spike (MS) Report			
				Spike	Spike Recovery (%)	Recovery Limits (%)	
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Concentration	MS	Low	High
EP079/070: TPH CWG Aliphatic Hydrocarbon Fractions (QCLot: 2501533) - continued							
EM1210744-002	Crosslink Gel	EP070-CWG: Aliphatic >C10-C12	TPHCWG-ALE1	2505 µg/L	72.2	70	130
		EP070-CWG: Aliphatic >C12-C16	TPHCWG-ALE2	10590 µg/L	76.7	70	130
		EP070-CWG: Aliphatic >C16-C21	----	9345 µg/L	91.6	70	130
		EP070-CWG: Aliphatic >C21-C35	----	2253 µg/L	89.5	70	130
EP079/070: TPH CWG Aliphatic Hydrocarbon Fractions (QCLot: 2518779)							
ER1200156-004	Anonymous	EP079-CWG: Aliphatic >C5-C6	----	70 µg/L	87.9	70	130
		EP079-CWG: Aliphatic >C6-C8	TPHCWG-ALV2	140 µg/L	86.6	70	130
		EP079-CWG: Aliphatic >C8-C10	TPHCWG-ALV3	120 µg/L	99.2	70	130
EP079/070: TPH CWG Aromatic Hydrocarbon Fractions (QCLot: 2501533)							
EM1210744-002	Crosslink Gel	EP070-CWG: Aromatic >C10-C12	TPHCWG-ARE1	750 µg/L	94.7	70	130
		EP070-CWG: Aromatic >C12-C16	TPHCWG-ARE2	3174 µg/L	93.6	70	130
		EP070-CWG: Aromatic >C16-C21	TPHCWG-ARE3	2607 µg/L	88.5	70	130
		EP070-CWG: Aromatic >C21-C35	TPHCWG-ARE4	606 µg/L	85.1	70	130
EP079/070: TPH CWG Aromatic Hydrocarbon Fractions (QCLot: 2518779)							
ER1200156-004	Anonymous	EP079-CWG: Aromatic >C5-C7	----	20 µg/L	95.4	70	130
		EP079-CWG: Aromatic >C7-C8	TPHCWG-ARV2	20 µg/L	99.7	70	130
EP117: Alcohols (QCLot: 2509203)							
EB1224362-001	Anonymous	EP117: Ethanol	64-17-5	100 µg/L	101	70	130
		EP117: Isopropanol	67-63-0	100 µg/L	104	70	130
		EP117: n-Propanol	71-23-8	100 µg/L	94.1	70	130
		EP117: Isobutanol	78-83-1	100 µg/L	102	70	130
		EP117: n-Butanol	71-36-3	100 µg/L	89.2	70	130

INTERPRETIVE QUALITY CONTROL REPORT

Work Order	: **EM1210744**	Page	: 1 of 14
Client	: SANTOS LTD	Laboratory	: Environmental Division Melbourne
Contact	: MR BARRY RITCHIE	Contact	: Client Services
Address	: GROUND FLOOR SANTOS CENTRE 60 FLINDERS STREET ADELAIDE SA, AUSTRALIA 5001	Address	: 4 Westall Rd Springvale VIC Australia 3171
E-mail	: barry.ritchie@santos.com	E-mail	: Melbourne.Enviro.Services@alsglobal.com
Telephone	: +61 08 8116 5000	Telephone	: +61-3-8549 9600
Facsimile	: +61 08 8116 5050	Facsimile	: +61-3-8549 9601
Project	: HFRA Fluids Sampling- Extended Analysis	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Site	: ----		
C-O-C number	: ----	Date Samples Received	: 14-SEP-2012
Sampler	: JM, AJ	Issue Date	: 03-OCT-2012
Order number	: 879002/538		
		No. of samples received	: 2
Quote number	: EN/039/12	No. of samples analysed	: 2

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Interpretive Quality Control Report contains the following information:

- Analysis Holding Time Compliance
- Quality Control Parameter Frequency Compliance
- Brief Method Summaries
- Summary of Outliers

Analysis Holding Time Compliance

The following report summarises extraction / preparation and analysis times and compares with recommended holding times. Dates reported represent first date of extraction or analysis and precludes subsequent dilutions and reruns. Information is also provided re the sample container (preservative) from which the analysis aliquot was taken. Elapsed period to analysis represents number of days from sampling where no extraction / digestion is involved or period from extraction / digestion where this is present. For composite samples, sampling date is assumed to be that of the oldest sample contributing to the composite. Sample date for laboratory produced leachates is assumed as the completion date of the leaching process. Outliers for holding time are based on USEPA SW 846, APHA, AS and NEPM (1999). A listing of breaches is provided in the Summary of Outliers.

Holding times for leachate methods (excluding elutriates) vary according to the analytes being determined on the resulting solution. For non-volatile analytes, the holding time compliance assessment compares the leach date with the shortest analyte holding time for the equivalent soil method. These soil holding times are: Organics (14 days); Mercury (28 days) & other metals (180 days). A recorded breach therefore does not guarantee a breach for all non-volatile parameters.

Matrix: **WATER**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method / Container / Client Sample ID(s)	Sample Date	Extraction / Preparation			Analysis		
		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EA005: pH							
Clear Plastic Bottle - Natural							
FR Water	**13-SEP-2012**	**----**	----	----	**19-SEP-2012**	13-SEP-2012	×
EA006: Sodium Adsorption Ratio (SAR)							
Clear Plastic Bottle - Natural							
FR Water	**13-SEP-2012**	**---**	20-SEP-2012	----	**18-SEP-2012**	20-SEP-2012	✓
EA015: Total Dissolved Solids							
Clear Plastic Bottle - Natural							
FR Water	**13-SEP-2012**	**---**	20-SEP-2012	----	**19-SEP-2012**	20-SEP-2012	✓
ED009: Anions							
Clear Plastic Bottle - Natural							
FR Water	**13-SEP-2012**	**----**	----	----	**20-SEP-2012**	11-OCT-2012	✓
ED037P: Alkalinity by PC Titrator							
Clear Plastic Bottle - Natural							
FR Water	**13-SEP-2012**	**---**	27-SEP-2012	----	**17-SEP-2012**	27-SEP-2012	✓
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA							
Clear Plastic Bottle - Natural							
FR Water	**13-SEP-2012**	**---**	11-OCT-2012	----	**18-SEP-2012**	11-OCT-2012	✓
ED045G: Chloride Discrete analyser							
Clear Plastic Bottle - Natural							
FR Water	**13-SEP-2012**	**---**	11-OCT-2012	----	**18-SEP-2012**	11-OCT-2012	✓
ED093F: Dissolved Major Cations							
Clear Plastic Bottle - Natural							
FR Water	**13-SEP-2012**	**---**	20-SEP-2012	----	**18-SEP-2012**	20-SEP-2012	✓
EG020F: Dissolved Metals by ICP-MS							
Clear Plastic Bottle - Natural							
FR Water	**13-SEP-2012**	**---**	12-MAR-2013	----	**21-SEP-2012**	12-MAR-2013	✓
EG035F: Dissolved Mercury by FIMS							
Clear Plastic Bottle - Natural							
FR Water	**13-SEP-2012**	**---**	11-OCT-2012	----	**20-SEP-2012**	11-OCT-2012	✓
EK010-1: Chlorine (Field Test)							
Clear Plastic Bottle - Natural							
FR Water	**13-SEP-2012**	**----**	----	----	**14-SEP-2012**	13-SEP-2012	×

Matrix: **WATER**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method / Container / Client Sample ID(s)	Sample Date	Extraction / Preparation			Analysis		
		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EK025SF: Free CN by Segmented Flow Analyser							
White Plastic Bottle-NaOH							
FR Water	**13-SEP-2012**	---	27-SEP-2012	----	**17-SEP-2012**	27-SEP-2012	✓
EK026SF: Total CN by Segmented Flow Analyser							
White Plastic Bottle-NaOH							
FR Water	**13-SEP-2012**	---	27-SEP-2012	----	**17-SEP-2012**	27-SEP-2012	✓
EK040P: Fluoride by PC Titrator							
Clear Plastic Bottle - Natural							
FR Water	**13-SEP-2012**	---	11-OCT-2012	----	**17-SEP-2012**	11-OCT-2012	✓
EK055G: Ammonia as N by Discrete Analyser							
Clear Plastic Bottle - Sulfuric Acid							
FR Water, Crosslink Gel	**13-SEP-2012**	---	11-OCT-2012	----	**19-SEP-2012**	11-OCT-2012	✓
EK057G: Nitrite as N by Discrete Analyser							
Clear Plastic Bottle - Natural							
FR Water	**13-SEP-2012**	---	15-SEP-2012	----	**14-SEP-2012**	15-SEP-2012	✓
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser							
Clear Plastic Bottle - Sulfuric Acid							
FR Water	**13-SEP-2012**	---	11-OCT-2012	----	**19-SEP-2012**	11-OCT-2012	✓
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser							
Clear Plastic Bottle - Sulfuric Acid							
FR Water	**13-SEP-2012**	**19-SEP-2012**	11-OCT-2012	✓	**19-SEP-2012**	11-OCT-2012	✓
EK067G: Total Phosphorus as P by Discrete Analyser							
Clear Plastic Bottle - Sulfuric Acid							
FR Water	**13-SEP-2012**	**19-SEP-2012**	11-OCT-2012	✓	**19-SEP-2012**	11-OCT-2012	✓
EK071G: Reactive Phosphorus as P by discrete analyser							
Clear Plastic Bottle - Natural							
FR Water	**13-SEP-2012**	---	15-SEP-2012	----	**14-SEP-2012**	15-SEP-2012	✓
EP005: Total Organic Carbon (TOC)							
Amber TOC Vial - Sulfuric Acid							
FR Water, Crosslink Gel	**13-SEP-2012**	**----**	----	----	**26-SEP-2012**	11-OCT-2012	✓
EP010: Formaldehyde							
Clear Plastic Bottle - Natural							
FR Water	**13-SEP-2012**	**----**	----	----	**14-SEP-2012**	15-SEP-2012	✓
EP041A: Nonionic Surfactants							
Pres. with Formaldehyde on receipt							
FR Water	**13-SEP-2012**	**----**	----	----	**20-SEP-2012**	11-OCT-2012	✓
EP074A: Monocyclic Aromatic Hydrocarbons							
Amber VOC Vial - Sulfuric Acid							
FR Water, Crosslink Gel	**13-SEP-2012**	**27-SEP-2012**	27-SEP-2012	✓	**27-SEP-2012**	27-SEP-2012	✓
EP074B: Oxygenated Compounds							
Amber VOC Vial - Sulfuric Acid							
FR Water, Crosslink Gel	**13-SEP-2012**	**27-SEP-2012**	27-SEP-2012	✓	**27-SEP-2012**	27-SEP-2012	✓

Matrix: **WATER**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method / Container / Client Sample ID(s)	Sample Date	Extraction / Preparation			Analysis		
		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EP074C: Sulfonated Compounds							
Amber VOC Vial - Sulfuric Acid							
FR Water, Crosslink Gel	**13-SEP-2012**	**27-SEP-2012**	27-SEP-2012	✓	**27-SEP-2012**	27-SEP-2012	✓
EP074D: Fumigants							
Amber VOC Vial - Sulfuric Acid							
FR Water, Crosslink Gel	**13-SEP-2012**	**27-SEP-2012**	27-SEP-2012	✓	**27-SEP-2012**	27-SEP-2012	✓
EP074E: Halogenated Aliphatic Compounds							
Amber VOC Vial - Sulfuric Acid							
FR Water, Crosslink Gel	**13-SEP-2012**	**27-SEP-2012**	27-SEP-2012	✓	**27-SEP-2012**	27-SEP-2012	✓
EP074F: Halogenated Aromatic Compounds							
Amber VOC Vial - Sulfuric Acid							
FR Water, Crosslink Gel	**13-SEP-2012**	**27-SEP-2012**	27-SEP-2012	✓	**27-SEP-2012**	27-SEP-2012	✓
EP074G: Trihalomethanes							
Amber VOC Vial - Sulfuric Acid							
FR Water, Crosslink Gel	**13-SEP-2012**	**27-SEP-2012**	27-SEP-2012	✓	**27-SEP-2012**	27-SEP-2012	✓
EP075A: Phenolic Compounds							
Amber Glass Bottle - Unpreserved							
FR Water, Crosslink Gel	**13-SEP-2012**	**17-SEP-2012**	20-SEP-2012	✓	**19-SEP-2012**	27-OCT-2012	✓
EP075B: Polynuclear Aromatic Hydrocarbons							
Amber Glass Bottle - Unpreserved							
FR Water, Crosslink Gel	**13-SEP-2012**	**17-SEP-2012**	20-SEP-2012	✓	**19-SEP-2012**	27-OCT-2012	✓
EP075C: Phthalate Esters							
Amber Glass Bottle - Unpreserved							
FR Water, Crosslink Gel	**13-SEP-2012**	**17-SEP-2012**	20-SEP-2012	✓	**19-SEP-2012**	27-OCT-2012	✓
EP075D: Nitrosamines							
Amber Glass Bottle - Unpreserved							
FR Water, Crosslink Gel	**13-SEP-2012**	**17-SEP-2012**	20-SEP-2012	✓	**19-SEP-2012**	27-OCT-2012	✓
EP075E: Nitroaromatics and Ketones							
Amber Glass Bottle - Unpreserved							
FR Water, Crosslink Gel	**13-SEP-2012**	**17-SEP-2012**	20-SEP-2012	✓	**19-SEP-2012**	27-OCT-2012	✓
EP075F: Haloethers							
Amber Glass Bottle - Unpreserved							
FR Water, Crosslink Gel	**13-SEP-2012**	**17-SEP-2012**	20-SEP-2012	✓	**19-SEP-2012**	27-OCT-2012	✓
EP075G: Chlorinated Hydrocarbons							
Amber Glass Bottle - Unpreserved							
FR Water, Crosslink Gel	**13-SEP-2012**	**17-SEP-2012**	20-SEP-2012	✓	**19-SEP-2012**	27-OCT-2012	✓
EP075H: Anilines and Benzidines							
Amber Glass Bottle - Unpreserved							
FR Water, Crosslink Gel	**13-SEP-2012**	**17-SEP-2012**	20-SEP-2012	✓	**19-SEP-2012**	27-OCT-2012	✓
EP075I: Organochlorine Pesticides							
Amber Glass Bottle - Unpreserved							
FR Water, Crosslink Gel	**13-SEP-2012**	**17-SEP-2012**	20-SEP-2012	✓	**19-SEP-2012**	27-OCT-2012	✓

Matrix: **WATER**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method / Container / Client Sample ID(s)	Sample Date	Extraction / Preparation			Analysis		
		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EP075J: Organophosphorus Pesticides							
Amber Glass Bottle - Unpreserved							
FR Water, Crosslink Gel	**13-SEP-2012**	**17-SEP-2012**	20-SEP-2012	✓	**19-SEP-2012**	27-OCT-2012	✓
EP117: Alcohols							
Amber VOC Vial - Sulfuric Acid							
FR Water, Crosslink Gel	**13-SEP-2012**	**----**	----	----	**20-SEP-2012**	27-SEP-2012	✓
RIVM Aliphatic Hydrocarbon Fractions							
Amber Glass Bottle - Unpreserved							
FR Water, Crosslink Gel	**13-SEP-2012**	**17-SEP-2012**	20-SEP-2012	✓	**19-SEP-2012**	27-OCT-2012	✓
Amber VOC Vial - Sulfuric Acid							
FR Water, Crosslink Gel	**13-SEP-2012**	**27-SEP-2012**	27-SEP-2012	✓	**27-SEP-2012**	27-SEP-2012	✓
RIVM Aromatic Hydrocarbon Fractions							
Amber Glass Bottle - Unpreserved							
FR Water, Crosslink Gel	**13-SEP-2012**	**17-SEP-2012**	20-SEP-2012	✓	**19-SEP-2012**	27-OCT-2012	✓
Amber VOC Vial - Sulfuric Acid							
FR Water, Crosslink Gel	**13-SEP-2012**	**27-SEP-2012**	27-SEP-2012	✓	**27-SEP-2012**	27-SEP-2012	✓

Quality Control Parameter Frequency Compliance

The following report summarises the frequency of laboratory QC samples analysed within the analytical lot(s) in which the submitted sample(s) was(where) processed. Actual rate should be greater than or equal to the expected rate. A listing of breaches is provided in the Summary of Outliers.

Matrix: **WATER**

Evaluation: × = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	*Method*	*QC*	*Regular*	***Actual***	***Expected***	*Evaluation*	
Laboratory Duplicates (DUP)							
Alcohols by HS-GC-MS	EP117	2	13	**15.4**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Alkalinity by PC Titrator	ED037-P	2	16	**12.5**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Ammonia as N by Discrete analyser	EK055G	1	3	**33.3**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Chloride by Discrete Analyser	ED045G	2	9	**22.2**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Dissolved Mercury by FIMS	EG035F	2	19	**10.5**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Dissolved Metals by ICP-MS - Suite A	EG020A-F	2	19	**10.5**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Dissolved Metals by ICP-MS - Suite B	EG020B-F	2	19	**10.5**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Fluoride by PC Titrator	EK040P	2	12	**16.7**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Formaldehyde	EP010	1	1	**100.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Free CN by Segmented Flow Analyser	EK025SF	2	17	**11.8**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Major Cations - Dissolved	ED093F	2	9	**22.2**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	2	11	**18.2**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Nitrite as N by Discrete Analyser	EK057G	2	12	**16.7**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Nonionic Surfactants as CTAS	EP041A	1	2	**50.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
pH	EA005	2	19	**10.5**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Reactive Phosphorus as P-By Discrete Analyser	EK071G	1	3	**33.3**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Semivolatile Organic Compounds	EP075	1	3	**33.3**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Standard Anions -by IC (Extended Method)	ED009-X	2	17	**11.8**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	2	18	**11.1**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Cyanide by Segmented Flow Analyser	EK026SF	2	18	**11.1**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Dissolved Solids (High Level)	EA015H	2	14	**14.3**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Kjeldahl Nitrogen as N By Discrete Analyser	EK061G	2	13	**15.4**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Organic Carbon	EP005	2	20	**10.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Phosphorus as P By Discrete Analyser	EK067G	2	10	**20.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
TPH Speciation (TPH CWG RIVM fractions)	EP070-CWG	1	2	**50.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Volatile Hydrocarbon Speciation (TPH CWG fractions)	EP079-CWG	1	4	**25.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Volatile Organic Compounds	EP074	1	4	**25.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Laboratory Control Samples (LCS)							
Alcohols by HS-GC-MS	EP117	1	13	**7.7**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Alkalinity by PC Titrator	ED037-P	1	16	**6.3**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Ammonia as N by Discrete analyser	EK055G	1	3	**33.3**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Chloride by Discrete Analyser	ED045G	2	9	**22.2**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Dissolved Mercury by FIMS	EG035F	1	19	**5.3**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Dissolved Metals by ICP-MS - Suite A	EG020A-F	1	19	**5.3**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Dissolved Metals by ICP-MS - Suite B	EG020B-F	1	19	**5.3**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Fluoride by PC Titrator	EK040P	1	12	**8.3**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Formaldehyde	EP010	1	1	**100.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Free CN by Segmented Flow Analyser	EK025SF	1	17	**5.9**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Major Cations - Dissolved	ED093F	1	9	**11.1**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement

Matrix: **WATER**

Evaluation: × = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	*Method*	*QC*	*Regular*	***Actual***	***Expected***	*Evaluation*	
Laboratory Control Samples (LCS) - Continued							
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	1	11	**9.1**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Nitrite as N by Discrete Analyser	EK057G	1	12	**8.3**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Nonionic Surfactants as CTAS	EP041A	1	2	**50.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Reactive Phosphorus as P-By Discrete Analyser	EK071G	1	3	**33.3**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Semivolatile Organic Compounds	EP075	1	3	**33.3**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Standard Anions -by IC (Extended Method)	ED009-X	1	17	**5.9**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	1	18	**5.6**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Cyanide by Segmented Flow Analyser	EK026SF	1	18	**5.6**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Dissolved Solids (High Level)	EA015H	1	14	**7.1**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Kjeldahl Nitrogen as N By Discrete Analyser	EK061G	1	13	**7.7**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Organic Carbon	EP005	1	20	**5.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Phosphorus as P By Discrete Analyser	EK067G	1	10	**10.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
TPH Speciation (TPH CWG RIVM fractions)	EP070-CWG	1	2	**50.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Volatile Hydrocarbon Speciation (TPH CWG fractions)	EP079-CWG	1	4	**25.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Volatile Organic Compounds	EP074	1	4	**25.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Method Blanks (MB)							
Alcohols by HS-GC-MS	EP117	1	13	**7.7**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Ammonia as N by Discrete analyser	EK055G	1	3	**33.3**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Chloride by Discrete Analyser	ED045G	1	9	**11.1**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Dissolved Mercury by FIMS	EG035F	1	19	**5.3**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Dissolved Metals by ICP-MS - Suite A	EG020A-F	1	19	**5.3**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Dissolved Metals by ICP-MS - Suite B	EG020B-F	1	19	**5.3**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Fluoride by PC Titrator	EK040P	1	12	**8.3**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Formaldehyde	EP010	1	1	**100.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Free CN by Segmented Flow Analyser	EK025SF	1	17	**5.9**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Major Cations - Dissolved	ED093F	1	9	**11.1**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	1	11	**9.1**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Nitrite as N by Discrete Analyser	EK057G	1	12	**8.3**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Nonionic Surfactants as CTAS	EP041A	1	2	**50.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Reactive Phosphorus as P-By Discrete Analyser	EK071G	1	3	**33.3**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Semivolatile Organic Compounds	EP075	1	3	**33.3**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Standard Anions -by IC (Extended Method)	ED009-X	1	17	**5.9**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	1	18	**5.6**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Cyanide by Segmented Flow Analyser	EK026SF	1	18	**5.6**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Dissolved Solids (High Level)	EA015H	1	14	**7.1**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Kjeldahl Nitrogen as N By Discrete Analyser	EK061G	1	13	**7.7**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Organic Carbon	EP005	1	20	**5.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Phosphorus as P By Discrete Analyser	EK067G	1	10	**10.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
TPH Speciation (TPH CWG RIVM fractions)	EP070-CWG	1	2	**50.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Volatile Hydrocarbon Speciation (TPH CWG fractions)	EP079-CWG	1	4	**25.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Volatile Organic Compounds	EP074	1	4	**25.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Matrix Spikes (MS)							
Alcohols by HS-GC-MS	EP117	1	13	**7.7**	**5.0**	✓	ALS QCS3 requirement

Matrix: **WATER**

Evaluation: × = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	*Method*	*QC*	*Regular*	***Actual***	***Expected***	*Evaluation*	
Matrix Spikes (MS) - Continued							
Ammonia as N by Discrete analyser	EK055G	1	3	**33.3**	**5.0**	✓	ALS QCS3 requirement
Chloride by Discrete Analyser	ED045G	1	9	**11.1**	**5.0**	✓	ALS QCS3 requirement
Dissolved Mercury by FIMS	EG035F	1	19	**5.3**	**5.0**	✓	ALS QCS3 requirement
Dissolved Metals by ICP-MS - Suite A	EG020A-F	1	19	**5.3**	**5.0**	✓	ALS QCS3 requirement
Fluoride by PC Titrator	EK040P	1	12	**8.3**	**5.0**	✓	ALS QCS3 requirement
Free CN by Segmented Flow Analyser	EK025SF	1	17	**5.9**	**5.0**	✓	ALS QCS3 requirement
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	1	11	**9.1**	**5.0**	✓	ALS QCS3 requirement
Nitrite as N by Discrete Analyser	EK057G	1	12	**8.3**	**5.0**	✓	ALS QCS3 requirement
Nonionic Surfactants as CTAS	EP041A	1	2	**50.0**	**5.0**	✓	ALS QCS3 requirement
Reactive Phosphorus as P-By Discrete Analyser	EK071G	1	3	**33.3**	**5.0**	✓	ALS QCS3 requirement
Semivolatile Organic Compounds	EP075	1	3	**33.3**	**5.0**	✓	ALS QCS3 requirement
Standard Anions -by IC (Extended Method)	ED009-X	1	17	**5.9**	**5.0**	✓	ALS QCS3 requirement
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	1	18	**5.6**	**5.0**	✓	ALS QCS3 requirement
Total Cyanide by Segmented Flow Analyser	EK026SF	1	18	**5.6**	**5.0**	✓	ALS QCS3 requirement
Total Kjeldahl Nitrogen as N By Discrete Analyser	EK061G	1	13	**7.7**	**5.0**	✓	ALS QCS3 requirement
Total Organic Carbon	EP005	1	20	**5.0**	**5.0**	✓	ALS QCS3 requirement
Total Phosphorus as P By Discrete Analyser	EK067G	1	10	**10.0**	**5.0**	✓	ALS QCS3 requirement
TPH Speciation (TPH CWG RIVM fractions)	EP070-CWG	1	2	**50.0**	**5.0**	✓	ALS QCS3 requirement
Volatile Hydrocarbon Speciation (TPH CWG fractions)	EP079-CWG	1	4	**25.0**	**5.0**	✓	ALS QCS3 requirement
Volatile Organic Compounds	EP074	1	4	**25.0**	**5.0**	✓	ALS QCS3 requirement

Brief Method Summaries

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the US EPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request. The following report provides brief descriptions of the analytical procedures employed for results reported in the Certificate of Analysis. Sources from which ALS methods have been developed are provided within the Method Descriptions.

Analytical Methods	Method	Matrix	Method Descriptions
pH	EA005	WATER	APHA 21st ed. 4500 H+ B. pH of water samples is determined by ISE either manually or by automated pH meter. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Total Dissolved Solids (High Level)	EA015H	WATER	In-House, APHA 21st ed., 2540C A gravimetric procedure that determines the amount of `filterable` residue in an aqueous sample. A well-mixed sample is filtered through a glass fibre filter (1.2um). The filtrate is evaporated to dryness and dried to constant weight at 180+/-5C. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Hardness as CaCO3	EA065	WATER	APHA 21st ed., 2340 B. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Standard Anions -by IC (Extended Method)	* ED009-X	WATER	APHA 21st ed., 4110. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Alkalinity by PC Titrator	ED037-P	WATER	APHA 21st ed., 2320 B This procedure determines alkalinity by automated measurement (e.g. PC Titrate) using pH 4.5 for indicating the total alkalinity end-point. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Major Anions - Dissolved	ED040F	WATER	APHA 21st ed., 3120. The 0.45um filtered samples are determined by ICP/AES for Sulfur and/or Silcon content and reported as Sulfate and/or Silica after conversion by gravimetric factor.
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	WATER	APHA 21st ed., 4500-SO4 Dissolved sulfate is determined in a 0.45um filtered sample. Sulfate ions are converted to a barium sulfate suspension in an acetic acid medium with barium chloride. Light absorbance of the BaSO4 suspension is measured by a photometer and the SO4-2 concentration is determined by comparison of the reading with a standard curve. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Chloride by Discrete Analyser	ED045G	WATER	APHA 21st ed., 4500 Cl - G.The thiocyanate ion is liberated from mercuric thiocyanate through sequestration of mercury by the chloride ion to form non-ionised mercuric chloride.in the presence of ferric ions the librated thiocynate forms highly-coloured ferric thiocynate which is measured at 480 nm APHA 21st edition seal method 2 017-1-L april 2003
Major Cations - Dissolved	ED093F	WATER	Major Cations is determined based on APHA 21st ed., 3120; USEPA SW 846 - 6010 The ICPAES technique ionises the 0.45um filtered sample atoms emitting a characteristic spectrum. This spectrum is then compared against matrix matched standards for quantification. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2) Sodium Absorption Ratio is calculated from Ca, Mg and Na which determined by ALS in house method QWI-EN/ED093F. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2) Hardness parameters are calculated based on APHA 21st ed., 2340 B. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Dissolved Metals by ICP-MS - Suite A	EG020A-F	WATER	(APHA 21st ed., 3125; USEPA SW846 - 6020, ALS QWI-EN/EG020): Samples are 0.45 um filtered prior to analysis. The ICPMS technique utilizes a highly efficient argon plasma to ionize selected elements. Ions are then passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to their measurement by a discrete dynode ion detector.
Dissolved Metals by ICP-MS - Suite B	EG020B-F	WATER	(APHA 21st ed., 3125; USEPA SW846 - 6020, ALS QWI-EN/EG020): Samples are 0.45 um filtered prior to analysis. The ICPMS technique utilizes a highly efficient argon plasma to ionize selected elements. Ions are then passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to their measurement by a discrete dynode ion detector.

Analytical Methods	Method	Matrix	Method Descriptions
Dissolved Mercury by FIMS	EG035F	WATER	AS 3550, APHA 21st ed. 3112 Hg - B (Flow-injection (SnCl2)(Cold Vapour generation) AAS) Samples are 0.45 um filtered prior to analysis. FIM-AAS is an automated flameless atomic absorption technique. A bromate/bromide reagent is used to oxidise any organic mercury compounds in the filtered sample. The ionic mercury is reduced online to atomic mercury vapour by SnCl2 which is then purged into a heated quartz cell. Quantification is by comparing absorbance against a calibration curve. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Silica (Total Dissolved) by ICPAES	EG052F	WATER	APHA 21st ed., 4500-SiO2. Silica (Total) determined by calculation from Silicon by ICPAES.
Residual Chlorine by DPD Colourimetry	EK010-1 (Field)	WATER	Adapted from APHA 21st edition, 4500-Cl G, using Palintest Chlorometer 1000
Free CN by Segmented Flow Analyser	EK025SF	WATER	ASTM D7237: Using an automated segmented flow analyser, a sample at high pH (sodium hydroxide preserved) is buffered to pH 6.0. The hydrogen cyanide present passes across a gas dialysis membrane into an acceptor stream consisting of 0.01 M sodium hydroxide. The acceptor stream mixes with a buffer at pH 5.2 and reacts with chloramine-T to form cyanogen chloride. Cyanogen chloride reacts with 4-pyridine carboxylic acid and 1,3-dimethylbarbituric acid to give a red colour, measured at 600nm. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Total Cyanide by Segmented Flow Analyser	EK026SF	WATER	APHA 4500-CN-O. Sodium hydroxide preserved samples are introduced into an automated segmented flow analyser. Complex bound cyanide is decomposed in a continuously flowing stream, at a pH of 3.8, by the effect of UV light. A UV-B lamp (312 nm) and a decomposition spiral of borosilicate glass are used to filter out UV light with a wavelength of less than 290 nm thus preventing the conversion of thiocyanate into cyanide. The hydrogen cyanide present at a pH of 3.8 is separated by gas dialysis. The hydrogen cyanide is then determined photometrically, based on the reaction of cyanide with chloramine-T to form cyanogen chloride. This then reacts with 4-pyridine carboxylic acid and 1,3-dimethylbarbituric acid to give a red colour which is measured at 600 nm. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Fluoride by PC Titrator	EK040P	WATER	APHA 21st ed., 4500 F--C CDTA is added to the sample to provide a uniform ionic strength background, adjust pH, and break up complexes. Fluoride concentration is determined by either manual or automatic ISE measurement. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Ammonia as N by Discrete analyser	EK055G	WATER	APHA 21st ed., 4500-NH3 G Ammonia is determined by direct colorimetry by Discrete Analyser. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Nitrite as N by Discrete Analyser	EK057G	WATER	APHA 21st ed., 4500-NO2- B. Nitrite is determined by direct colourimetry by Discrete Analyser. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Nitrate as N by Discrete Analyser	EK058G	WATER	APHA 21st ed., 4500-NO3- F. Nitrate is reduced to nitrite by way of a chemical reduction followed by quantification by Discrete Analyser. Nitrite is determined seperately by direct colourimetry and result for Nitrate calculated as the difference between the two results. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	WATER	APHA 21st ed., 4500-NO3- F. Combined oxidised Nitrogen (NO2+NO3) is determined by Chemical Reduction and direct colourimetry by Discrete Analyser. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Total Kjeldahl Nitrogen as N By Discrete Analyser	EK061G	WATER	APHA 21st ed., 4500-Norg D. 25mL water samples are digested using a traditional Kjeldahl digestion followed by determination by Discrete Analyser. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Total Nitrogen as N (TKN + Nox) By Discrete Analyser	EK062G	WATER	APHA 21st ed., 4500-Norg / 4500-NO3-. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Total Phosphorus as P By Discrete Analyser	EK067G	WATER	APHA 21st ed., 4500-P B&F This procedure involves sulphuric acid digestion of a 100mL sample to break phosphorus down to orthophosphate. The orthophosphate reacts with ammonium molybdate and antimony potassium tartrate to form a complex which is then reduced and its concentration measured at 880nm using Discrete Analyser. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)

Analytical Methods	Method	Matrix	Method Descriptions
Reactive Phosphorus as P-By Discrete Analyser	EK071G	WATER	APHA 21st ed., 4500-P F Ammonium molybdate and potassium antimonyl tartrate reacts in acid medium with othophosphate to form a heteropoly acid -phosphomolybdic acid - which is reduced to intensely coloured molybdenum blue by ascorbic acid. Quantification is by Discrete Analyser. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Ionic Balance by PCT DA and Turbi SO4 DA	EN055 - PG	WATER	APHA 21st Ed. 1030F. The Ionic Balance is calculated based on the major Anions and Cations. The major anions include Alkalinity, Chloride and Sulfate which determined by PCT and DA. The Cations are determined by Turbi SO4 by DA. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Total Organic Carbon	EP005	WATER	APHA 21st ed., 5310 B, The automated TOC analyzer determines Total and Inorganic Carbon by IR cell. TOC is calculated as the difference. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Formaldehyde	EP010	WATER	In-house (ASTM D 6303-98) Determined by colourimetry using NASH reagent. The Hantszch reaction method is based on the reaction of acetylacetone with formaldehyde in the presence of excess ammonium acetate to form a coloured compound.
Nonionic Surfactants as CTAS	EP041A	WATER	APHA 21st ed., 5540 B & D This method estimates the non-ionic surfactant content of waters. Sublation transfers all surfactants into a solvent matrix. Cationic and Anionic surfactants are removed by an ion exchange resin column. The remaining surfactant is coloured up with Cobalt Thiocyanate solution and quantified by UV-vis against LAS standards. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
TPH Speciation (TPH CWG RIVM fractions)	EP070-CWG	WATER	In-house: Determination of TPH following fractionation by GC-FID. Fractions correspond to those outlined in TPHCWG, 1998,Analysis of Petroleum Hydrocarbons in Environmental Media, TPH Criteria Working Group, Toxicity Technical Action Group, vol I and RIVM report 601501021/2004, Environmental Risk Limits for Mineral Oil (Total Petroleum Hydrocarbons). Aliphatic >C21 - C35 is defined by RIVM only.
Volatile Organic Compounds	EP074	WATER	USEPA SW 846 - 8260B Water samples are directly purged prior to analysis by Capillary GC/MS and quantification is by comparison against an established 5 point calibration curve. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Semivolatile Organic Compounds	EP075	WATER	USEPA SW 846 - 8270D Sample extracts are analysed by Capillary GC/MS and quantification is by comparison against an established 5 point calibration curve. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Volatile Hydrocarbon Speciation (TPH CWG fractions)	EP079-CWG	WATER	In-house. Conventional TPH and MAH data are determined by Purge and Trap GCMS analysis. TIC data (as fractions) and target aromatics (or groups of aromatics) are used to compute aliphatic and aromotic hydrocarbon fractions by addition or difference. Fractions conform to those outlined in TPHCWG, 1998,Analysis of Petroleum Hydrocarbons in Environmental Media, TPH Criteria Working Group, Toxicity Technical Action Group, vol I and RIVM report 601501021/2004, Environmental Risk Limits for Mineral Oil (Total Petroleum Hydrocarbons)
Alcohols by HS-GC-MS	* EP117	WATER	In House. A 10 mL aliquot of sample is mixed with 4 g of sodium chloride, equilibrated at 80 degrees C for 10 minutes and the headspace analysed by GCMS in the selected ion monitoring mode.
Anionic Surfactants as MBAS	W-MBAS	WATER	APHA 5540 C. Analysis subcontracted to ALS Scoresby (NATA Accredited Laboratory No. 992).

Preparation Methods	Method	Matrix	Method Descriptions
Separatory Funnel Extraction of Liquids	ORG14	WATER	USEPA SW 846 - 3510B 500 mL to 1L of sample is transferred to a separatory funnel and serially extracted three times using 60mL DCM for each extract. The resultant extracts are combined, dehydrated and concentrated for analysis. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2). ALS default excludes sediment which may be resident in the container.
Separatory Funnel Extraction of Liquids	ORG14-HX	WATER	Variation of USEPA SW 846 - 3510B: 500 mL to 0.5L of sample is transferred to a separatory funnel and serially extracted three times using 30mL DCM for each extract. The resultant extracts are combined, dehydrated, and exchanged into 5 mL of hexane for analysis. ALS default excludes sediment which may be resident in the container.

Summary of Outliers

Outliers : Quality Control Samples

The following report highlights outliers flagged in the Quality Control (QC) Report. Surrogate recovery limits are static and based on USEPA SW846 or ALS-QWI/EN/38 (in the absence of specific USEPA limits). This report displays QC Outliers (breaches) only.

Duplicates, Method Blanks, Laboratory Control Samples and Matrix Spikes

Matrix: **WATER**

Compound Group Name	Laboratory Sample ID	Client Sample ID	Analyte	CAS Number	Data	Limits	Comment
Duplicate (DUP) RPDs							
EP079/070: TPH CWG Aliphatic Hydrocarbon Fractions	EM1210744-001	FR Water	**Aliphatic >C10-C12**	TPHCWG-ALE1	44.6 %	0-20%	**RPD exceeds LOR based limits**
Laboratory Control Spike (LCS) Recoveries							
EP075A: Phenolic Compounds	2965492-022	----	**Pentachlorophenol**	87-86-5	24.5 %	47-153%	**Recovery less than lower control limit**
EP075E: Nitroaromatics and Ketones	2965492-022	----	**2-Picoline**	109-06-8	10.2 %	28.4-57%	**Recovery less than lower control limit**
EP075H: Anilines and Benzidines	2965492-022	----	**3.3`-Dichlorobenzidine**	91-94-1	124 %	14.6-107%	**Recovery greater than upper control limit**
Matrix Spike (MS) Recoveries							
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA	EM1210737-006	Anonymous	**Sulfate as SO4 - Turbidimetric**	14808-79-8	Not Determined	----	**MS recovery not determined, background level greater than or equal to 4x spike level.**
ED045G: Chloride Discrete analyser	EM1210737-006	Anonymous	**Chloride**	16887-00-6	Not Determined	----	**MS recovery not determined, background level greater than or equal to 4x spike level.**
EG020F: Dissolved Metals by ICP-MS	EM1210728-001	Anonymous	**Manganese**	7439-96-5	Not Determined	----	**MS recovery not determined, background level greater than or equal to 4x spike level.**
EG020F: Dissolved Metals by ICP-MS	EM1210728-001	Anonymous	**Zinc**	7440-66-6	Not Determined	----	**MS recovery not determined, background level greater than or equal to 4x spike level.**
EG035F: Dissolved Mercury by FIMS	EM1210728-002	Anonymous	**Mercury**	7439-97-6	58.9 %	70-130%	**Recovery less than lower data quality objective**
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Ar	EM1210719-001	Anonymous	**Nitrite + Nitrate as N**	----	Not Determined	----	**MS recovery not determined, background level greater than or equal to 4x spike level.**
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser	EM1210719-001	Anonymous	**Total Kjeldahl Nitrogen as N**	----	Not Determined	----	**MS recovery not determined, background level greater than or equal to 4x spike level.**
EK067G: Total Phosphorus as P by Discrete Analyser	EM1210719-001	Anonymous	**Total Phosphorus as P**	----	Not Determined	----	**MS recovery not determined, background level greater than or equal to 4x spike level.**
EP005: Total Organic Carbon (TOC)	EM1210744-002	Crosslink Gel	**Total Organic Carbon**	----	Not Determined	----	**MS recovery not determined, background level greater than or equal to 4x spike level.**
EP075A: Phenolic Compounds	EM1210744-002	Crosslink Gel	**Phenol**	108-95-2	Not Determined	----	**Matrix spike recovery not determined due to sample matrix interference.**
EP075A: Phenolic Compounds	EM1210744-002	Crosslink Gel	**2-Chlorophenol**	95-57-8	Not Determined	----	**Matrix spike recovery not determined due to sample matrix interference.**

Matrix: **WATER**

Compound Group Name	Laboratory Sample ID	Client Sample ID	Analyte	CAS Number	Data	Limits	Comment
Matrix Spike (MS) Recoveries - Continued							
EP075A: Phenolic Compounds	EM1210744-002	Crosslink Gel	**2-Nitrophenol**	88-75-5	Not Determined	----	**Matrix spike recovery not determined due to sample matrix interference.**
EP075A: Phenolic Compounds	EM1210744-002	Crosslink Gel	**4-Chloro-3-Methylphenol**	59-50-7	Not Determined	----	**Matrix spike recovery not determined due to sample matrix interference.**
EP075A: Phenolic Compounds	EM1210744-002	Crosslink Gel	**Pentachlorophenol**	87-86-5	Not Determined	----	**Matrix spike recovery not determined due to sample matrix interference.**
EP075B: Polynuclear Aromatic Hydrocarbons	EM1210744-002	Crosslink Gel	**Acenaphthene**	83-32-9	Not Determined	----	**Matrix spike recovery not determined due to sample matrix interference.**
EP075B: Polynuclear Aromatic Hydrocarbons	EM1210744-002	Crosslink Gel	**Pyrene**	129-00-0	Not Determined	----	**Matrix spike recovery not determined due to sample matrix interference.**
EP075D: Nitrosamines	EM1210744-002	Crosslink Gel	**N-Nitrosodi-n-propylamine**	621-64-7	Not Determined	----	**Matrix spike recovery not determined due to sample matrix interference.**
EP075E: Nitroaromatics and Ketones	EM1210744-002	Crosslink Gel	**2.4-Dinitrotoluene**	121-14-2	Not Determined	----	**Matrix spike recovery not determined due to sample matrix interference.**
EP075G: Chlorinated Hydrocarbons	EM1210744-002	Crosslink Gel	**1.4-Dichlorobenzene**	106-46-7	Not Determined	----	**Matrix spike recovery not determined due to sample matrix interference.**
EP075G: Chlorinated Hydrocarbons	EM1210744-002	Crosslink Gel	**1.2.4-Trichlorobenzene**	120-82-1	Not Determined	----	**Matrix spike recovery not determined due to sample matrix interference.**

- **For all matrices, no Method Blank value outliers occur.**

Regular Sample Surrogates

Sub-Matrix: **WATER**

Compound Group Name	Laboratory Sample ID	Client Sample ID	Analyte	CAS Number	Data	Limits	Comment
Samples Submitted							
EP075S: Acid Extractable Surrogates	EM1210744-002	Crosslink Gel	**2-Fluorophenol**	367-12-4	Not Determined	----	**Surrogate recovery not determined due to (target or non-target) matrix interferences**
EP075S: Acid Extractable Surrogates	EM1210744-001	FR Water	**2-Fluorophenol**	367-12-4	Not Determined	----	**Surrogate recovery not determined due to (target or non-target) matrix interferences**
EP075S: Acid Extractable Surrogates	EM1210744-002	Crosslink Gel	**Phenol-d6**	13127-88-3	Not Determined	----	**Surrogate recovery not determined due to (target or non-target) matrix interferences**
EP075S: Acid Extractable Surrogates	EM1210744-001	FR Water	**Phenol-d6**	13127-88-3	Not Determined	----	**Surrogate recovery not determined due to (target or non-target) matrix interferences**
EP075S: Acid Extractable Surrogates	EM1210744-002	Crosslink Gel	**2-Chlorophenol-D4**	93951-73-6	Not Determined	----	**Surrogate recovery not determined due to (target or non-target) matrix interferences**
EP075S: Acid Extractable Surrogates	EM1210744-001	FR Water	**2-Chlorophenol-D4**	93951-73-6	Not Determined	----	**Surrogate recovery not determined due to (target or non-target) matrix interferences**
EP075S: Acid Extractable Surrogates	EM1210744-002	Crosslink Gel	**2.4.6-Tribromophenol**	118-79-6	Not Determined	----	**Surrogate recovery not determined due to (target or non-target) matrix interferences**
EP075S: Acid Extractable Surrogates	EM1210744-001	FR Water	**2.4.6-Tribromophenol**	118-79-6	Not Determined	----	**Surrogate recovery not determined due to (target or non-target) matrix interferences**

Outliers : Analysis Holding Time Compliance

This report displays Holding Time breaches only. Only the respective Extraction / Preparation and/or Analysis component is/are displayed.

Matrix: **WATER**

Method / Container / Client Sample ID(s)	Extraction / Preparation			Analysis		
	Date extracted	Due for extraction	Days overdue	Date analysed	Due for analysis	Days overdue
EA005: pH						
Clear Plastic Bottle - Natural						
FR Water	----	----	----	19-SEP-2012	13-SEP-2012	**6**
EK010-1: Chlorine (Field Test)						
Clear Plastic Bottle - Natural						
FR Water	----	----	----	14-SEP-2012	13-SEP-2012	**1**

Outliers : Frequency of Quality Control Samples

The following report highlights breaches in the Frequency of Quality Control Samples.

- **No Quality Control Sample Frequency Outliers exist.**

CHAIN OF CUSTODY

ALS Laboratory: please tick →

CLIENT:	SANTOS	TURNAROUND REQUIREMENTS : (Standard TAT may be longer for some tests e.g. Ultra Trace Organics)	☐ Standard TAT (List due date): ☒ Non Standard or urgent TAT (List due date): 19/09/2012
OFFICE:	Eastern Australia D&C, 60 Flinders Street, Adelaide SA	ALS QUOTE NO.:	EN/039/11
PROJECT:	HFRA Fluids Sampling - Extended Analysis	COC SEQUENCE NUMBER (Circle)	COC: 1 2 3 4 5 6 7 / OF: 1 2 3 4 5 6 7
ORDER NUMBER:	879002/538		
PROJECT MANAGER:	Barry Ritchie	CONTACT PH: 8116	
SAMPLER:	Jim McGowen / Andrew Johnston	SAMPLER MOBILE:	
COC emailed to ALS? (YES / NO)		EDD FORMAT (or default):	

Email Reports to (will default to PM if no other addresses are listed): andrew.johnston@santos.com; frac.rig.rep.completions@santos.com; barry.ritchie@santos.com; thomas.delaney@santos.com

Email Invoice to (will default to PM if no other addresses are listed): barry.ritchie@santos.com

RELINQUISHED BY:	RECEIVED BY:	RELINQUISHED BY:	RECEIVED BY:
Richard Durant			[signature]
DATE/TIME: 13/9/12 14:30	DATE/TIME:	DATE/TIME:	DATE/TIME: 14/9, 11:05

FOR LABORATORY USE ONLY (Circle)
- Custody Seal Intact? Yes No N/A
- Free ice / frozen ice bricks present upon receipt? Yes No N/A
- Random Sample Temperature on Receipt: °C
- Other comment: 8 °C

COMMENTS/SPECIAL HANDLING/STORAGE OR DISPDSAL: Dissolved Metals Required are W-3 + Fe, Se, B, Sr, Al, Mo, Sn, U, I

ANALYSIS REQUIRED including SUITES (NB. Suite Codes must be listed to attract suite price) — Where Metals are required, specify Total (unfiltered bottle required) or Dissolved (field filtered bottle required).

LAB ID (ALS USE ONLY)	SAMPLE ID	DATE / TIME	MATRIX	TYPE & PRESERVATIVE (refer to codes below)	TOTAL BOTTLES	EA005, EA015H, EK011 (pH TDS Chloride)	NT-1B, NT-2A, NT-8A	EG052, ENO55-DA, ED009X (Reactive Silica Bromide/Iodide)	EA065, EK025, EK026, EP005 (Hardness CN TOC)	W-3 and EG020F (See Additional Info)	EP117, TRH-CWG	EP074A-H, EP075	EP010, EP050, EP041	Additional Information
														Comments on likely contaminant levels, dilutions, or samples requiring specific QC analysis etc.
1 FR Water	Complete with Sample Name that is written on all sample bottles	Complete with date	W	1L plastic / green; 60ml plastic green; 125ml plastic purple; 60ml plastic blue; 40ml vial purple; 60ml plastic red; 2 x 40ml vial purple; 3x 100ml glass orange; 2 x 40ml amber glass maroon; 3 x 100ml glass orange; 2 x 500ml amber brown;	18	X	X	X	X	X	X	X	X	Describe sample type etc. HyborH etc and use of distilled water as applicable
2 Crosslink Gel	Complete with Sample Name that is written on all sample bottles	Complete with date	W	1L plastic / green; 60ml plastic green; 125ml plastic purple; 60ml plastic blue; 40ml vial purple; 60ml plastic red; 2 x 40ml vial purple; 3x 100ml glass orange; 2 x 40ml amber glass maroon; 3 x 100ml glass orange; 2 x 500ml amber brown;	18	X	X	X	X	X	X	X	X	
				TOTAL	36									

Water Container Codes: P = Unpreserved Plastic; N = Nitric Preserved Plastic; ORC = Nitric Preserved ORC; SH = Sodium Hydroxide/Cd Preserved; S = Sodium Hydroxide Preserved Plastic; AG = Amber Glass Unpreserved; AP - Airfreight Unpreserved Plastic
V = VOA Vial HCl Preserved; VB = VOA Vial Sodium Bisulphate Preserved; VS = VOA Vial Sulfuric Preserved; AV = Airfreight Unpreserved Vial SG = Sulfuric Preserved Amber Glass; H = HCl preserved Plastic; HS = HCl preserved Speciation bottle; SP = Sulfuric Preserved Plastic; F = Formaldehyde Preserved Glass;
Z = Zinc Acetate Preserved Bottle; E = EDTA Preserved Bottles; ST = Sterile Bottle; ASS = Plastic Bag for Acid Sulphate Soils; B = Unpreserved Bag.

Environmental Division
Melbourne
Work Order
14/9 EM1210744
Telephone : + 61-3-8549 9600

Ranil Weerakkody

From: on behalf of Samples Melbourne
To: Sarah Hodgson
Subject: EM1210744
Attachments: img-914132707-0001.pdf

Hi Sarah,

For this work order we received unspecified red metal bottles for sample 1 and 2 . please clarify.
Cheers,
RU

-----Original Message-----
From: DocuCentre-IV C2260 [mailto:ALSEMLP011@als.com.au]
Sent: Friday, 14 September 2012 1:27 PM
To: Samples Melbourne
Subject: Scan Data from FX-A0CD7E

Number of Images: 1
Attachment File Type: PDF

Device Name: DocuCentre-IV C2260
Device Location:

CHAIN OF CUSTODY

ALS Laboratory: please tick →

[illegible]

CLIENT:	SANTOS	TURNAROUND REQUIREMENTS :	☐ Standard TAT (List due date):		FOR LABORATORY USE ONLY (Circle)
OFFICE:	Eastern Australia D&C, 60 Flinders Street, Adelaide SA	(Standard TAT may be longer for some tests e.g.. Ultra Trace Organics)	☒ Non Standard or urgent TAT (List due date):	18/09/2012	Custody Seal Intact? (Yes) No (N/A)
PROJECT:	HFRA Fluids Sampling - Extended Analysis	ALS QUOTE NO.:	EN/039/11	COC SEQUENCE NUMBER (Circle)	Free ice / frozen ice bricks present upon receipt? Yes (No) N/A
ORDER NUMBER:	879002/538			COC: **1** 2 3 4 5 6 7	Random Sample Temperature on Receipt: °C
PROJECT MANAGER:	Barry Ritchie	CONTACT PH: 8116		OF: **1** 2 3 4 5 6 7	Other comment: 8-10

SAMPLER: Jim McGowen / Andrew Johnston	SAMPLER MOBILE:	RELINQUISHED BY:	RECEIVED BY:	RELINQUISHED BY:	RECEIVED BY:
COC emailed to ALS? (YES / NO)	EDD FORMAT (or default):	*Richard Durant*			[signature]
Email Reports to (will default to PM if no other addresses are listed): andrew.johnston@santos.com; frac.rig.rep.completions@santos.com; barry.ritchie@santos.com; thomas.delaney@santos.com		DATE/TIME:	DATE/TIME:	DATE/TIME:	DATE/TIME: 14/9, 11:05
Email Invoice to (will default to PM if no other addresses are listed): barry.ritchie@santos.com		*13/9/12 14:30*			

COMMENTS/SPECIAL HANDLING/STORAGE OR DISPOSAL: Dissolved Metals Required are W-3 + Fe, Se, B, Sr, Al, Mo, Sn, U, I

ALS USE ONLY	SAMPLE DETAILS MATRIX: Solid(S) Water(W)			CONTAINER INFORMATION		ANALYSIS REQUIRED including SUITES (NB. Suite Codes must be listed to attract suite price) Where Metals are required, specify Total (unfiltered bottle required) or Dissolved (field filtered bottle required).								Additional Information
LAB ID	SAMPLE ID	DATE / TIME	MATRIX	TYPE & PRESERVATIVE *(refer to codes below)*	TOTAL BOTTLES	EA005, EA015H, EK011	NT-1B, NT-2A, NT-8A	EG052, ENO55-DA, ED009X	EA065, EK025, EK026, EP005	W-3 and EG020F (See Additional Info)	EP117, TRH-CWG	EP074A-H, EP075	EP010, EP050, EP041	Comments on likely contaminant levels, dilutions, or samples requiring specific QC analysis etc.
(1) FR Water	Complete with Sample Name that is written on all sample bottles	Complete with date	W	1L plastic / green; 60ml plastic green; 125ml plastic purple; 60ml plastic blue; 40ml vial purple; 60ml plastic red; 2 x 40ml vial purple; 3x 100ml glass orange; 2 x 40ml amber glass maroon; 3 x 100ml glass orange; 2 x 500ml amber brown;	18	X	X	X	X	X	X	X	X	Describe sample typp etc. HyborH etc and use of distilled water as applicable
(2) Crosslink Gel	Complete with Sample Name that is written on all sample bottles	Complete with date	W	1L plastic / green; 60ml plastic green; 125ml plastic purple; 60ml plastic blue; 40ml vial purple; 60ml plastic red; 2 x 40ml vial purple; 3x 100ml glass orange; 2 x 40ml amber glass maroon; 3 x 100ml glass orange; 2 x 500ml amber brown;	18	X	X	X	X	X	X	X	X	
				TOTAL	36									

Samples sent to lab for
Micro (Nitrate) BOD pH
Colour Turbidity (RP)
Other Nitrite, Formaldehyde.
Date 14-9-12 3.40pm.

SCANNED

Environmental Division
Melbourne
Work Order
14/9 EM1210744
Telephone : + 61-3-8549 9600

Water Container Codes: P = Unpreserved Plastic; N = Nitric Preserved Plastic; ORC = Nitric Preserved ORC; SH = Sodium Hydroxide/Cd Preserved; S = Sodium Hydroxide Preserved Plastic; AG = Amber Glass Unpreserved; AP - Airfreight Unpreserved Plastic
V = VOA Vial HCl Preserved; VB = VOA Vial Sodium Bisulphate Preserved; VS = VOA Vial Sulfuric Preserved; AV = Airfreight Unpreserved Vial SG = Sulfuric Preserved Amber Glass; H = HCl preserved Plastic; HS = HCl preserved Speciation bottle; SP = Sulfuric Preserved Plastic; F = Formaldehyde Preserved Glass;
Z = Zinc Acetate Preserved Bottle; E = EDTA Preserved Bottles; ST = Sterile Bottle; ASS = Plastic Bag for Acid Sulphate Soils; B = Unpreserved Bag.

Ranil Weerakkody

From: on behalf of Samples Melbourne
To: Sarah Hodgson
Subject: EM1210744
Attachments: img-914132707-0001.pdf

Hi Sarah,

For this work order we received unspecified red metal bottles for sample 1 and 2 . please clarify.
Cheers,
RU

-----Original Message-----
From: DocuCentre-IV C2260 [mailto:ALSEMLP011@als.com.au]
Sent: Friday, 14 September 2012 1:27 PM
To: Samples Melbourne
Subject: Scan Data from FX-A0CD7E

Number of Images: 1
Attachment File Type: PDF

Device Name: DocuCentre-IV C2260
Device Location:

Raymond Thai

From: Sarah Hodgson
Sent: Friday, 14 September 2012 4:02 PM
To: Samples Melbourne
Subject: RE: EM1210744

Hi Ray,

I don't think the metals bottle would be filtered -- can you please ask the lab to filter from the green?

Thank you,

Regards,
How was your customer experience? Please send us your feedback

Sarah Hodgson

PROJECT MANAGER

ALS | Environmental
Address
4 Westall Road
Springvale VIC 3171
PHONE +61 3 8549 9600
FAX +61 3 8549 9601
www.alsglobal.com
cid:615291706@05102011-231E

-----Original Message-----
From: Samples Melbourne
Sent: Friday, 14 September 2012 4:01 PM
To: Sarah Hodgson
Subject: RE: EM1210744

Hi Sarah,

I believe there was green bottles also received for both these samples.

Thanks, Ray

-----Original Message-----
From: Sarah Hodgson
Sent: Friday, 14 September 2012 1:52 PM
To: Samples Melbourne
Subject: RE: EM1210744

Hi Ru,

Did you get any other metals bottles for these 2 samples?

Regards,
How was your customer experience? Please send us your feedback

Sarah Hodgson

PROJECT MANAGER

ALS | Environmental
Address
4 Westall Road
Springvale VIC 3171
PHONE +61 3 8549 9600
FAX +61 3 8549 9601
www.alsglobal.com
cid:615291706@05102011-231E

-----Original Message-----
From: Samples Melbourne
Sent: Friday, 14 September 2012 1:36 PM
To: Sarah Hodgson
Subject: EM1210744

Hi Sarah,

For this work order we received unspecified red metal bottles for sample 1 and 2 . please clarify.
Cheers,
RU

-----Original Message-----
From: DocuCentre-IV C2260 [mailto:ALSEMLP011@als.com.au]
Sent: Friday, 14 September 2012 1:27 PM
To: Samples Melbourne
Subject: Scan Data from FX-A0CD7E

Number of Images: 1
Attachment File Type: PDF

Device Name: DocuCentre-IV C2260
Device Location:

golder.com

REPORT

Human Health and Ecological Risk Assessment - Schlumberger Chemicals

Hydraulic Stimulation Risk Assessment - Santos Southwest Queensland Tenements

Submitted to:

Santos Ltd
Santos Centre
60 Flinders Street
ADELAIDE SA 5000

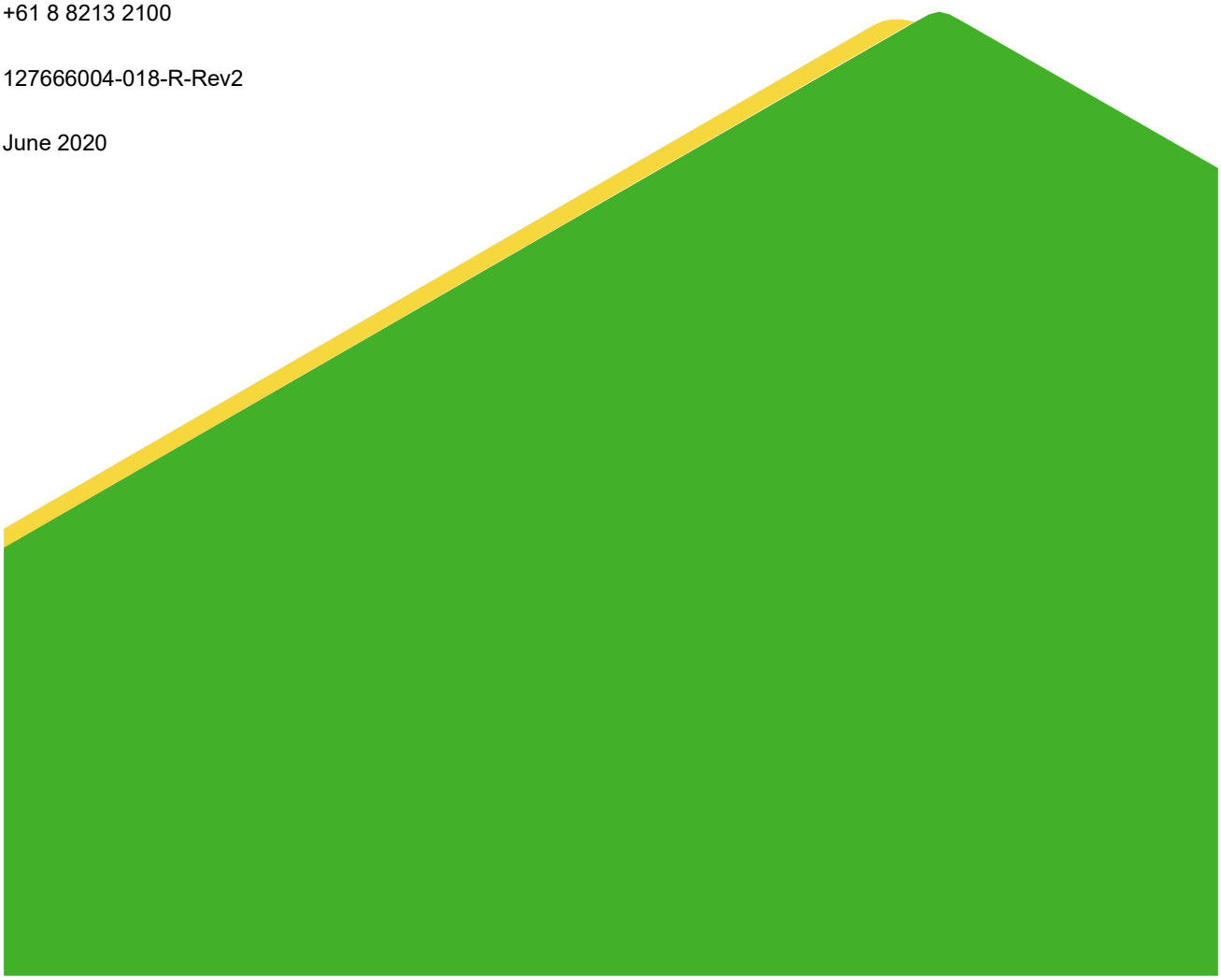
Submitted by:

Golder Associates Pty Ltd
118 Franklin Street Adelaide, South Australia 5000 Australia

+61 8 8213 2100

127666004-018-R-Rev2

June 2020



Distribution List

1 electronic copy: Santos Ltd

1 electronic copy: Golder Associates

Executive Summary

Introduction

Santos Ltd (Santos) engaged Golder Associates Pty Ltd (Golder) to prepare this desktop risk assessment of hydraulic stimulation activities for conventional oil and gas production in their Southwest Queensland (SWQ) tenements. This Hydraulic Stimulation Risk Assessment (HSRA) is undertaken to meet Department of Environment and Heritage Protection (DEHP) Environmental Authority (EA) consent conditions.

This desktop HSRA is presented in two volumes, as follows:

- Volume One (Reference: 127666004-011-R) discusses the environmental and geological settings within which Santos' stimulation operations take place and the general techniques for the drilling, completion and stimulation of wells. The report also discusses why hydraulic stimulation is essential in SWQ and outlines Santos' current forward program for fracture-stimulation, although it should be noted that for a variety of reasons (including but not limited to future production performance and / or access-related issues such as the flooding of the Cooper Creek system), the forward program is frequently viewed and is subject to change.
- Volume Two and Volume Three (this report) relates specifically to the stimulation fluids proposed to be used by Stimulation Service Providers on Santos wells in the SWQ conventional oil and gas fields. This report considers the ecological and human health toxicity of the chemical constituents in the stimulation fluids and includes an exposure pathway assessment and risk characterisation based on a review of complete exposure pathways and controls to mitigate exposure. Volume Two relates to *Halliburton* stimulation fluids, while Volume Three relates to *Schlumberger* fluids.

This report specifically addresses the requirements of EA conditions related to the assessment of Schlumburger chemical constituents for:

- YF140HTD 30Q N2 stimulation fluid
- ThermaFRAC 40 stimulation fluid
- Slickwater stimulation fluid.

This report also considers a lesser volume of 32% HCL also used during stimulation. Chemical information disclosed included each of the chemical constituents in the fluid considered, and the mass of each constituent in a typical fluid mixture.

It should be noted that at the time of reporting Schlumburger products were not in use in SWQ well stimulation activities and as such there has been no changes made to this report.

Comparisons of Conventional Oil and Gas Operations to Coal Seam Gas (CSG) Operations

There are key differences between CSG and conventional oil and gas production, both in the geographic and geological setting of the resource and the methodology for accessing the resource, that have a substantial bearing on the risk profile presented by stimulation activities. These include:

- Santos' conventional oil and gas operations in SWQ are located in an arid, sparsely populated area of central Australia. Whilst groundwater is an important water supply to support the rural land uses, the extent of water supply development is limited (commensurate with the small population base);

- In Santos' SWQ operations, the hydrocarbon reservoirs generally occur in anticlines capped with thick, laterally-extensive low permeability formations that isolate the reservoirs from overlying water-bearing formations; and
- The oil and gas reservoirs in the SWQ study area are very deep, of the order of 1500 to 3000 m below ground level, which provides hundreds to over a thousand metres vertical separation between the formations in which stimulation activities are proposed and the shallow groundwater resources. There is also no requirement to remove formation water in order to facilitate gas flow, with the possible exception of well blow downs on a case by case frequency.

Hence, the combination of the remote project location, low population density (and limited water supply development), and the substantial vertical separation of oil and gas reservoirs from primary groundwater supply aquifers results in an inherently low risk profile with regard to stimulation activities.

Environmental Setting and Environmental Values

Santos operates conventional gas and oil fields within scattered petroleum production tenements that, along with Santos' exploration licences, cumulatively cover approximately 30,000 km^2 of Southwest Queensland. These tenements, exploration licenses and the land surrounding the Santos tenements comprise the Santos SWQ *study area*. The study area is described in detail within Volume One of the SWQ HSRA report.

The terrain in the study area is generally characterised by low undulating topography (hills and ridges) between the various river and creek systems and associated floodplains. The area is sparsely developed, and generally comprises rural communities and homesteads that are largely engaged in farming and livestock. The oil and gas reservoirs which are the targets for hydraulic stimulation lie within the Cooper Basin and the overlying Eromanga Basin.

Based on an understanding of the environmental setting, this risk assessment considered the following key environmental values:

Groundwater Environmental Values:

- Town water supply;
- Stock and domestic water supply;
- Sandstone aquifers of the Great Artesian Basin (GAB); and
- Groundwater Dependant Ecosystems (GDEs).

Surface Water Environmental Values:

- Protection of aquatic ecosystems;
- Recreation and aesthetics: primary recreation with direct contact, and visual appreciation with no contact; and
- Cultural and spiritual values.

Terrestrial Environmental Values:

- Protection of flora and fauna, particularly small mammals, reptiles and birds with a greater potential to come into contact with flowback water in Flare Pits.

Environmental values are further considered and evaluated in Volume One of the SWQ HSRA report.

Hydraulic Stimulation Process Description Summary

With regard to the process of hydraulic stimulation, the requirements of the EA approval conditions are considered within Volume One of the SWQ HSRA report, with the following specific information included:

- Practices and procedures to ensure that the stimulation activities are designed to be contained within the target gas producing formation;
- Indicative details of where, when and how often stimulation is to be undertaken on the tenures covered by this environmental authority;
- A description of Santos' well mechanical integrity testing program;
- Process control and assessment techniques to be applied for determining the extent of stimulation activity(ies) (e.g. microseismic measurements, modelling etc.); and
- A process description of the stimulation activity to be applied, including equipment and a comparison to best international practice.

Evaluation of Exposure Pathways

Potential exposure pathways were evaluated for on-site (i.e. within the well lease), and for off-site (i.e. anything beyond the well lease boundary). Potentially complete exposure pathways were evaluated for workers, trespassers, native fauna and flora and livestock. The environment immediately surrounding the well lease (i.e. off-site) throughout the study area may vary from lease to lease but was considered to potentially include homesteads (adult and child residents), water supply bores, creeks or wetlands/waterholes, livestock and native flora and fauna.

The on-site assessment indicated that the majority of potential exposure pathways were unlikely or incomplete, given the application of operational controls by Santos.

One potentially complete exposure pathway was identified, which is direct contact to the flowback water in the Flare Pit by small fauna (i.e. rodents, lizards and birds). Santos has indicated that all reasonable measures will be implemented to discourage entry of small native fauna into the well lease area during hydraulic stimulation operations. In addition, the potential for this exposure pathway to occur will be substantially reduced by improvement of flowback fluid containment, with Santos trialling new methods from 2013.

Potential off-site exposure pathways were evaluated for homesteads, livestock, native flora and fauna and aquatic ecosystems. Three possible chemical sources were identified: injected hydraulic stimulation fluids, sediments from Flare Pits and flowback water. The exposure assessment concluded:

- Subsurface exposure to stimulation fluids is controlled by Santos' well design, well integrity testing procedures and operational monitoring, and this pathway (whereby stimulation fluids could escape into the formation and contaminate adjacent aquifers that are used for domestic or stock water supply) is considered unlikely or incomplete.
- Based on an understanding of the Eromanga and Cooper Basin geology and hydrogeology, and the nature and extent of groundwater supply development, exposure to residual stimulation chemicals through subsurface pathways is considered unlikely and incomplete, due to:
  - Significant vertical offset between the beneficial use aquifers and the shallowest hydrocarbon reservoirs (oil reservoirs of the Cadna-Owie Formation - 400 to 800 m). These formations are separated by low permeability formations and form a thick, competent and regionally extensive seal. The vertical offset to gas reservoirs is much greater (1,000 m to 1,800 m).
- Within formations that host both aquifers and hydrocarbon reservoirs (e.g. Hooray Sandstone), the water-bearing zones are separated from hydrocarbon reservoirs by intra-formational seals. However, there is not enough information available to discretise the internal stratigraphy of these formations. Where petroleum activities (including stimulation) occur within a formation that hosts both aquifers and hydrocarbon reservoirs, the lateral distance of the water supply bores accessing the aquifer to Santos' tenements was considered.
- The closest beneficial use bore to the Santos tenements targeting the Hooray Sandstone in the DEHP database records is the Whim Well, which is indicated as being located 20 km from the closest tenement

with hydraulic stimulation activities proposed (the existence of this bore was unable to be confirmed during the WBBA). The closest observed bore, the Coothero Bore, is at least 25 km from the closest tenement proposed for hydraulic stimulation and more than 80 km from the closest tenement with activities proposed at a similar formation depth.

- At the surface, a spill or leak of flowback water from the Flare Pit was considered as a potential exposure scenario, however the implementation of operational controls, including use of liners in Flare Pits, removal of fluid and sediment using vacuum techniques and engineering and operational controls (grading of well leases, stormwater controls and maintenance of a minimum of 300 mm freeboard within the Flare Pits) is considered sufficient to limit the potential for uncontrolled releases of flowback water to the environment.
- A further margin of safety is provided by Santos' evaluation of 'environmentally sensitive areas' when establishing well leases, which includes the establishment of buffers between petroleum (and stimulation) activities and features of potential environmental concern. Subsequently, the potential off-site exposure scenarios are considered unlikely and incomplete.

Hazard Assessment

The toxicity of the chemicals used in the hydraulic stimulation process by Schlumberger have been assessed for persistence, bioaccumulation and aquatic toxicity (PBT), terrestrial toxicity and human health toxicity including the physical hazards of fire and explosion. The review of toxicity is qualitative in that it has provided a relative ranking of chemicals considered to represent a high, moderate or low hazard in respect to the ecological or human health end points with qualification of health issues arising from the ranking.

The evaluation of the hazards was based on the available data obtained from a range of literature sources and databases. As a consequence, data are limited to the quantity and quality of information available in those sources. A measure of the data completeness for the toxicological and hazard parameters used has been estimated using a percentage of the parameters for which data were available. An assessment of the quality of the available data is beyond the scope of this report. In the absence of verifying the data by going to the primary literature sources, the data used in this assessment has been confined to established, robust and reputable sources such as the World Health Organisation (WHO) and the United States Environment Protection Agency (US EPA) where available. As new toxicological data are generated and become available in the published literature, the information presented in this hazard evaluation and the associated conclusions may be subject to change. This has recently been realised as a consequence of new human health chemical hazard assessment approaches (NICNAS, 2013) and subsequently the chemicals supplied by Schlumberger (as presented in Table 4) have been reviewed on the basis of a new national approach which incorporates a weighting for specific toxicological parameters. Table 4 includes a number of chemicals that had previously been assessed by Golder using a former methodology. These chemicals have now been re-assessed using the new national approach.

This hazard assessment did not consider the combined effects of the constituents when present in a mixture. Assessment of mixtures is considered beyond the scope of a screening level human health and ecological risk assessment.

Environmental Hazard

Approaches for environmental risk assessment of individual chemicals are inherently conservative and designed to over-estimate risk as a precautionary approach and in recognition of the uncertainty surrounding effects of mixtures.

Aquatic Ecosystems

Of the fifty-two (52) individual hydraulic stimulation chemicals assessed, forty-four (44) were classified for aquatic hazard. Five of the forty-four (44) chemicals: sodium hydroxide, hydrochloric acid, magnesium

chloride, potassium hydroxide and magnesium nitrate, were not scored for persistence as these chemicals readily dissociate in the environment. Two chemicals (guar gum and sodium carboxymethylhydroxypropyl guar) were not assessed due to insufficient data but are qualitatively discussed.

Of the forty-four (44) chemicals classified, the following aquatic hazard classifications were assigned:

- twenty-two (22) were classified low hazard;
- fourteen (14) were classified moderate hazard; and
- eight (8) were classified high hazard.

The eight chemicals classified as a high aquatic hazard were considered to be chemicals of potential concern (COPC), these were:

- Dicoco dimethyl quarternary ammonium chloride;
- Alkyl (C12-C16) dimethylbenzyl ammonium chloride;
- Sodium tetraborate;
- Nitrogen, liquid form;
- Boric acid;
- Magnesium silicate hydrate (talc);
- Hydrogen peroxide (impurity); and
- Zirconium dichloride oxide.

Of the high aquatic hazard chemicals identified, the following further interpretations are provided:

- Nitrogen, liquid form. Nitrogen is only a liquid at low temperature and pressure, conditions which will not prevail in the hydraulic stimulation fluid or at the drill pad. At atmospheric temperature and pressure nitrogen is a gas. The extent that nitrogen will have reacted with other constituents in the hydraulic stimulation mixture before volatilisation, is not known.
- Boric acid, magnesium silicate hydrate (talc), hydrogen peroxide, zirconium dichloride oxide and sodium tetraborate are considered as high hazards in this assessment based primarily on persistence. Review and interpretation of the aquatic toxicity data suggest these five chemicals present a low to moderate aquatic toxicity hazard.
- Dicoco dimethyl quarternary ammonium chloride is considered a high hazard based primarily on its toxicity. The toxicity data available for this chemical are limited (only acute fish and invertebrate data available) however review and interpretation of the persistence and bioaccumulation data suggest this chemical presents a low to moderate aquatic hazard.
- Alkyl (C12-C16) dimethylbenzyl ammonium chloride is considered a high hazard based on its high persistence and aquatic toxicity. As with dicoco dimethyl quarternary ammonium chloride the toxicity data available for this chemical is limited with only acute fish and plant data available.

It is noted that only one (liquid nitrogen) of the eight high aquatic hazard chemicals is expected to be in concentrations greater than 0.1% in a stimulation fluid mixture (as indicated by the fluid disclosures) and five of the high aquatic hazard chemicals are expected to be at concentrations less than 0.01%.

Given the management controls in place to prevent releases to the environment, potential aquatic hazards from individual hydraulic stimulation chemicals, are considered unlikely to be realised.

Terrestrial Ecosystems

Of the 52 hydraulic stimulation chemicals, seven chemicals were not assessed due to insufficient data and six were not assessed because they were considered to be essentially sand, leaving 39 chemicals for assessment of terrestrial toxicity.

The following organic chemicals were assessed to have the potential to pose a higher hazard in the terrestrial environment relative to the other chemicals assessed based on persistence and potential to biomagnify:

- Cetylethylmorpholinium ethyl sulphate;
- Tetramethylammonium chloride;
- Surrogate for Octadecanoic acid, calcium salt;
- Decyldimethyl amine (impurity);
- Declydimethyl amine oxide;
- Surrogate for Vinylidene chloride/methacrylate; and
- Disodium ethylene diamine tetra acetate.

Six of the seven chemicals shown above are expected to be in concentrations less than 0.1% in a stimulation fluid mixture (as indicated by the fluid disclosures), with only one chemical (tetramethylammonium chloride) expected at concentrations up to 1%.

Tetramethylammonium chloride, decyldimethyl amine oxide and disodium ethylene diamine tetra acetate have low volatility but they are not likely to persist in the terrestrial environment as illustrated by a moderate to rapid half-life and low potential to bioaccumulate.

Surrogate for octadecanoic acid, calcium salt and decyldimethyl amine (impurity) both have a high potential to biomagnify but due to a moderate half-life and low to moderate volatility they are not likely to persist in the terrestrial environment.

Surrogate for vinylidene chloride/methacrylate (1,1 DCE) has the potential to persist in the terrestrial environment due to a slow half-life however it has low potential to biomagnify and low volatility.

Given the management controls in place to prevent releases to the environment, potential hazards from individual hydraulic fracturing chemicals to terrestrial ecosystems are not expected to be realised.

Human Health Hazard

The hazard evaluation for human health undertaken on fifty-two chemicals in accordance with the IMAP Framework hazard ranking methodology indicated thirty-five of the chemicals assessed to be a Hazard Rank of 3 or 4.

The hazard evaluation for human health suggests that the dominant concerns are related to occupational hazards such as carcinogenicity, silicosis, skin, eye and respiratory irritancy or corrosivity and sensitisation. In some cases physical hazards of flammability and explosion prevail and are identified in this report. While extensive dilution of the hydraulic stimulation chemicals is anticipated such that potential exposure concentrations would be much reduced for fluids injected into the well and in flowback fluid, there are a number of hazards that are suggested from this human health evaluation. These include the potential for:

- Residual elevation of organic moieties e.g. some salts have an organic part that will be present following dissociation that may increase in environmental (surface or ground) waters.
- Changes in pH of environmental waters due to alkaline or acidic components.
- Certain metal concentrations to be elevated in environmental waters.

- Some additives to exert endocrine disruption effects.
- Certain inorganic substances to generate atmospheric particulates that may impact nearby communities.
- Volatile components to comprise nuisance or irritant effects should atmospheric concentrations be elevated in close proximity to communities.

These human health hazards may be assessed further, and/or managed as required. Diatomaceous Earth - calcined, crystalline silica (quartz), crystalline silica (crystobalite) and ethanol have been identified as a specific concern due to their classifications as confirmed human carcinogens and sodium bromate as a possible carcinogen. Boric acid and sodium tetraborate are also of specific concern due to their reproductive toxicity potential. Tetramethylammonium chloride is of specific concern due to lethal effects if ingested. It is noted, however, that the fluid disclosure information indicates that all but one (crystalline silica) of the highest hazard chemicals are expected to be at concentrations less than 0.1 % mass fraction (of the individual fluids). Furthermore, the evaluation of exposure pathways has indicated that the potential for surface water and groundwater to be impacted by hydraulic stimulation fluid chemicals is considered to be low.

Benzene, toluene, ethylbenzene and xylene (BTEX) and polycyclic aromatic hydrocarbon (PAH) compounds were not identified in the product disclosures of the stimulation fluids provided to Golder.

Qualitative Assessment of Fluids

Schlumberger collected two stimulation fluid samples for chemical testing. The two samples were tested for Polyaromatic Hydrocarbons (PAHs), while a single sample was tested for BTEX.

The reported BTEX and PAH concentrations were below the laboratory LOR. BTEX concentrations were reported below the DEHP regulated criteria for hydraulic stimulation fluid additives in Queensland.

These results may indicate that stimulation fluids are not contributing substantial amounts of BTEX and PAH into the subsurface regions, however, some qualification of this statement is required as a result of residual uncertainties. These uncertainties require further exploration and reflect:

- Sample handling. Samples were heated and potentially volatiles were lost through evaporation.
- Limited sampling frequencies for the respective fluids examined.
- Confidence in the sampling integrity. Typically an environmental consultant would collect and transport environmental samples.
- Quality assurance / quality control (QA/QC). QA/QC samples were not collected, such as an inter- and intra- laboratory split.
- The sampling process and its consistency with hydraulic stimulation procedures at the time of sampling including spatial and temporal references, i.e. what was happening at the time of sampling and process locations, etc.

Overall Risk Evaluation and Management Measures

Considering the hazard assessment, exposure assessment and qualitative assessment of fluids flowback water at surface presents a possible, although unlikely, risk. However, with Santos operational controls and management, the overall risk to human health and environment associated with the chemicals involved in hydraulic stimulation are expected to be low. The management measures implemented through operational controls include:

- OH&S procedures implemented during hydraulic stimulation operations to prevent workers from direct contact with chemicals during spills and when handling makeup and flowback waters, and sediments.
- Santos operational procedures regarding well integrity verification and fracture design to stay within the target formation.

- Assigning buffers during establishment of well leases between petroleum operations and potential “environmentally sensitive areas” identified though database review and site-specific ecological assessments.
- Implementation of spill containment procedures during operations to prevent migration of and exposure to chemicals.
- Vacuum removal of sediments and fluids contained within Flare Pits, to prevent exposure to contaminants in fluids and windborne dust.
- Installation and maintenance of fences around Flare Pits to prevent access by trespassers, and installation of signs to indicate that well leases are work zones to be accessed by authorised personnel only.
- Installation and maintenance of fences around Flare Pits to prevent access by livestock and large native fauna.
- Lining of Flare Pits and improvement of fluid storage and containment methods, to prevent seepage of flowback water into the underlying aquifer; and
- Engineering and operational controls (grading of well leases, stormwater controls and maintenance of a minimum of 300 mm freeboard within Flare Pits) to limit the potential for uncontrolled surface releases of flowback water to the environment.

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List of Acronyms

Acronym	In full
1,1-DCE	1,1-Dichloroethene
AIHC	American Industrial Health Council
ALS	ALS Environmental (Testing Laboratory)
APVMA	Australian Pesticides and Veterinary Medicines Authority
BCF	Bioconcentration Factor
BTEX	Benzene, toluene, ethylbenzene and xylenes
CASRN	Chemical Abstracts Service Registry Number
CHEMS-1	US Chemical Hazard Evaluation for Management Strategies
COC	Chain of Custody
COPC	Chemical of potential concern
CSG	Coal seam gas
DEHP	Department of Environment and Heritage Protection
DERM	Department of Environment and Resource Management
DEWHA	Department of the Environment, Water, Heritage and the Arts
Dfe	Design for the Environment
DNA	Deoxyribonucleic acid
DTA	Direct Toxicity Assessment
EA	Environmental Authority
EC50	Exposure Concentration (that kills 50% of exposed organisms)
ECB	European Chemicals Bureau
E-FAST	Exposure, Fate Assessment Screening Tool
ECHA	European Chemicals Agency
ECOSAR	Ecological Structure Activity Relationships
EIS	Environmental Impact Statement
EPA	Environmental Protection Authority

Acronym	In full
EPHC	Environment Protection and Heritage Council
EPISUITE	Estimation Programs Interface Suite
GAB	Great Artesian Basin
GDE	Groundwater-dependant ecosystem
GHS	Globally Harmonised System of Classification and Labelling of Chemicals
HDPE	High Density Polyethylene
HHEWG	Human Health Expert Working Group
HQ	Hazard Quotients
HSRA	Hydraulic Stimulation Risk Assessment
HSDB	Hazardous Substance Data Bank
IARC	International Agency for Research on Cancer
IMAP	Inventory Multi-tiered Assessment and Prioritisation
K	Potassium
Koc	Soil Adsorption Partition Coefficient
Kow	Octanol / Water Partition Coefficient
L/kg	Litres per kilogram
LD (or LC)50	Lethal dose (or concentration) that kills 50% of exposed organisms
LOEC	Lowest Observed Effects Concentration
LOR	Limit of Reporting
MATC	Maximum Acceptable Toxicant Concentration
mg/L	Milligrams per litre
Na	Sodium
NATA	National Association of Testing Authorities
NChEM	(Australian) National Framework for Chemicals Environmental Management
NH4+	Ammonium
NICNAS	National Industrial Chemicals Notification and Assessment Scheme
NOEC	No Observed Effects Concentration

Acronym	In full
NTP	(US) National Toxicology Program
OECD	Organization of Economic Cooperation and Development
OH&S	Occupational Health and Safety
OSHA	(US) Department of Labour Occupational Safety and Health Administration
PAH	Polycyclic aromatic hydrocarbons
PBT	Persistence, Bioaccumulation and Toxicity
PNEC	Probable No Effect Concentration
PPE	Personal Protection Equipment
QA	Quality Assurance
QC	Quality Control
QSAR	Quantitative-Structure-Activity Relationship
SAR	Structure activity Relationships
SCCS	Scientific Community for Consumer Chemical Safety
SDS	Safety Data Sheet(s)
SRC	Syracuse Research Group
SRN	Sample Receipt Number
SWQ	South West Queensland
TEP	Toxicity Equivalency Potential
TGS	Tight gas sands
UN	United Nations
UNECE	United Nations Economic Commission for Europe
US EPA	United States Environment Protection Agency
WBBA	Water Board Baseline Assessment
WERD	Water Entitlement Register Database
WHO	World Health Organization
WOE	Weight of Evidence

1.0 INTRODUCTION

1.1 Preamble

On 29 June 2012 Santos Ltd (Santos) submitted an application to the Department of Environment and Heritage Protection (DEHP) for Santos' Southwest Queensland (SWQ) Environmental Authorities (EAs). Project activities covered under the application to DEHP included stimulation activities (henceforth referred to as "hydraulic stimulation") of conventional oil and gas reservoirs.

To meet EA consent conditions, a formal risk assessment of hydraulic stimulation activities is required and subsequently, Golder Associates Pty Ltd (Golder) has been engaged by Santos to prepare a Hydraulic Stimulation Risk Assessment (HSRA).

This desktop HSRA is presented in two volumes, as follows:

- Volume One (Reference: 127666004 011 R) discusses the environmental and geological settings within which Santos' stimulation operations take place and the general techniques for the drilling, completion and stimulation of wells. The report also discusses why hydraulic stimulation is essential in SWQ and outlines Santos' current forward program for fracture-stimulation, although it should be noted that for a variety of reasons (including but not limited to future production performance and / or access-related issues such as the flooding of the Cooper Creek system), the forward program is frequently reviewed and is subject to change.
- Volume Two and Volume Three (this report) relates specifically to the stimulation fluids proposed to be used by *Stimulation Service Providers* on Santos wells in the SWQ conventional oil and gas fields. The report considers the ecological and human health toxicity of the chemical constituents in the stimulation fluids and includes an exposure pathway assessment and risk characterisation based on a review of complete exposure pathways and controls to mitigate exposure. Volume Two relates to *Halliburton* stimulation fluids, while Volume Three relates to *Schlumberger* fluids.

This reporting structure has been developed to accommodate the chemical assessment requirements of various hydraulic stimulation fluids as they are introduced to the Australian market, for which the remainder of the EA conditions relating to the environmental setting and stimulation process description remain consistent over time. This reporting structure also affords greater ability to manage commercial-in-confidence issues associated with certain stimulation fluids.

This report specifically addresses the requirements of EA conditions related to the assessment of Schlumberger chemical constituents for:

- YF140HTD 30Q N2 stimulation fluid
- ThermaFRAC 40 stimulation fluid
- Slickwater stimulation fluid

The report also considers a lesser volume of *32%HCL* also used during stimulation. Chemical information disclosed included each of the chemical constituents in the fluids considered, and the mass of each constituent in a typical fluid mixture. The fluid disclosure information is proprietary and has not been included in this report.

This report should be read in conjunction with report entitled, *Hydraulic Fracturing Risk Assessment, Site Setting and Fracturing Process* [Volume One], (reference: 127666004-011-R-Rev0); which discusses the environmental and geological settings within which Santos' stimulation operations take place in Southwest Queensland (SWQ) and the general techniques for the drilling, completion and stimulation of wells. The same report also evaluates exposure pathways and Santos management and control measures.

It should be noted that at the time of reporting Schlumburger products were not in use in SWQ well stimulation activities and as such there has been no changes made to this report.

1.1.1 EA Consent Conditions

The July 2012 model conditions (J11) included in the *Environmental Protection Act 1994, Level 1 Environmental Authority, Chapter 5A Petroleum Activity* (APPENDIX A) indicate that prior to undertaking well stimulation activities, the holder of the EA must develop a risk assessment to ensure that hydraulic stimulation activities are managed to prevent environmental harm. Subsequently, Santos has been negotiating draft EA conditions, although these negotiations have not been finalised and therefore the July 2012 conditions are referenced: *The* **stimulation** *risk assessment must include, but not necessarily be limited to* (refer to Table 1):

Table 1: Summary of Consent Conditions Related to Stimulation Fluid Chemical Assessment

Condition	Report Volume
a) process description of the hydraulic stimulation activity to be applied, including equipment and a comparison to best international practice	One
b) provide details of where, when and how often **hydraulic stimulation** is to be undertaken on the tenures covered by this environmental authority	One
c) a geological model of the field to be stimulated including geological names, descriptions and depths of the target gas producing formation(s)	One
d) naturally occurring geological faults	One
e) seismic history of the region (e.g. earth tremors, earthquakes)	One
f) proximity of overlying and underlying aquifers	One
g) description of the depths that aquifers with environmental values occur, both above and below the target gas producing formation	One
h) identification and proximity of **landholders' active groundwater bores** in the area where **hydraulic stimulation** activities are to be carried out	One
i) the environmental values of groundwater in the area	One
j) an assessment of the appropriate **limits of reporting** for all indicators relevant to **hydraulic stimulation** monitoring in order to accurately assess the risks to environmental values of groundwater	-
k) description of overlying and underlying formations in respect of porosity, permeability, hydraulic conductivity, faulting and fracture propensity	One
l) consideration of barriers or known direct connections between the target gas producing formation and the overlying and underlying aquifers	One
m) a description of the well mechanical integrity testing program	One
n) process control and assessment techniques to be applied for determining extent of **hydraulic stimulation** activities (e.g. microseismic measurements, modelling etc.)	One
o) practices and procedures to ensure that the **hydraulic stimulation** activities are designed to be contained within the target gas producing formation	One

Condition	Report Volume
p) groundwater transmissivity, flow rate, hydraulic conductivity and direction(s) of flow	One
q) a description of the chemicals used in hydraulic stimulation activities (including estimated total mass, estimated composition, chemical abstract service numbers and properties), their mixtures and the resultant compounds that are formed after hydraulic stimulation	Two
r) a mass balance estimating the concentrations and absolute masses of chemicals that will be reacted, returned to the surface or left in the target gas producing formation subsequent to hydraulic stimulation	Three
s) an environmental hazard assessment of the chemicals used including their mixtures and the resultant chemicals that are formed after hydraulic stimulation including: (i). toxicological and ecotoxicological information of chemicals used (ii). information on the persistence and bioaccumulation potential of the chemicals used (iii). identification of the **hydraulic stimulation** fluid chemicals of potential concern derived from the risk assessment	Three
t) an environmental hazard assessment of use, formation of, and detection of polycyclic aromatic hydrocarbons in **hydraulic stimulation** activities	Three
u) identification and an environmental hazard assessment of using radioactive tracer beads in **hydraulic stimulation** activities	One
v) an environmental hazard assessment of leaving chemicals used in **stimulation fluids** in the target gas producing formation for extended periods subsequent to **hydraulic stimulation**	Three
w) human health exposure pathways to operators and the regional population	Three
x) risk characterisation of environmental impacts based on the environmental hazard assessment	Three
y) potential impacts to landholder bores as a result of **hydraulic stimulation** activities	Three
z) an assessment of cumulative impacts, spatially and temporally of the **hydraulic stimulation** activities to be carried out on the tenures covered by this environmental authority	-
aa) potential environmental or health impacts which may result from **hydraulic stimulation** activities including but not limited to water quality, air quality (including suppression of dust and other airborne contaminants), noise and vibration	One and Three

1.2 Risk Assessment Process

This report discusses the constituents used by Schlumberger[1] with regard to toxicity to human health and the environment. The techniques used to assess the human health and environmental hazards of the constituents are described in the following sections. Where there was insufficient chemical and/or toxicological information to assess the hazards of individual constituents, an appropriate surrogate chemical was selected or an assessment was not performed.

The scope of the qualitative risk assessment comprises of:

- **Issue identification** (Volume One) - A description of the current environmental setting (including a description of potential receiving environments and the various factors which act upon them, including climatic influences), detailed geological and hydrogeological information, gas well integrity and a description of the hydraulic stimulation process including an identification of the constituents of the hydraulic stimulation fluid.
- **Exposure Assessment** (This Volume) – The exposure assessment comprises an evaluation of surface and subsurface exposure pathways assessment.
- **Hazard assessment** (This Volume) – An evaluation of the environmental hazard of relevant chemical additives in the hydraulic stimulation fluid based on aquatic toxicity, environmental persistence and bioaccumulation. The environmental hazard assessment provides a relative ranking of the chemical additives and those chemicals considered to represent a high hazard are identified as chemicals of potential concern (COPC) for further assessment. An evaluation of terrestrial and human health toxicity is also presented and chemicals posing the highest relative hazard to human health and terrestrial ecosystems are identified; and
- **Risk Characterisation** (This Volume) – A qualitative evaluation of environmental and human health risk associated with the hydraulic stimulation activities based on the identification of complete exposure pathways and hazard identification.

Human health risk assessment is limited to assessment of effects on one population: *humans*. Ecological risk assessment is concerned with assessment of effects on the ecosystem (populations and communities) and therefore is not limited to one receptor.

Since 2010, Golder has previously assessed many stimulation fluid constituents to meet EA conditions. Throughout this time Golder has updated the assessment approach to reflect national and international regulatory changes, and therefore, chemicals previously assessed using a former approach have now been re-evaluated using the current hazard assessment approach as described in later sections.

The approach for chemicals assessed for ecological risk prior to 2013 considered guidance, such as “Guideline on Ecological Risk Assessment” (NEPC, Schedule B (5), 1999) which refers to draft guidance prepared by EPA Victoria (Gibson *et al.*, 1997). These guidance documents focus on risks to terrestrial environments although the overall approach for assessment or risk is the same. The human health risk assessment was undertaken in general accordance with national guidelines for risk assessment recommended by enHealth (enHealth-Environmental Health Risk Assessment, “Guidelines for Assessing Human Health Risks from Environmental Hazards”, June 2004).

The most recent chemicals assessed (during 2013) entail updates reflecting:

- Recent changes in national hazard assessment frameworks for health (NICNAS, 2013). NICNAS recently documented a national approach (IMAP) to ranking chemicals for evaluation in Australia in order to prioritise their national chemical assessment program. The framework has been developed by an

[1] Water was not assessed because it is an intrinsic constituent of all living organisms and is not inherently toxic.

expert government committee and thus provides a highly defensible position should the Golder hazard assessment be questioned by the Regulator or groups such as the National Toxics Network (NTN).

- Evolving international regulatory changes in hazard classification systems (global harmonisation system) that have been introduced into Australia (e.g. that have changed requirements in Safety Data Sheets) and have focussed on new areas of toxicity.

This hazard assessment did not consider the combined effects of the constituents when present in a mixture. Assessment of mixtures is considered beyond the scope of a screening level human health and ecological risk assessment.

If, in the future, conditions, hydraulic stimulation methodologies and/or regulatory requirements change, and/or additional exposure pathways to additional receiving environments are identified, further evaluation of the associated risks may be warranted.

1.3 Limitations

Your attention is drawn to the document - “Limitations”, which is included in APPENDIX B of this report. The statements presented in this document are intended to advise you of what your realistic expectations of this report should be. The document is not intended to reduce the level of responsibility accepted by Golder, but rather to ensure that all parties who may rely on this report are aware of the responsibilities each assumes in so doing.

2.0 EXPOSURE ASSESSMENT

This aspect of risk assessment provides perspective on the potential for chemicals of potential concern (COPC) to become available and be taken up by human and other ecological species. Exposure assessment seeks to qualify or quantify such uptake by considering the human population groups and other organisms or group of organisms (receptors) which may be exposed to the COPCs identified for the study and outlines the mechanisms (exposure pathways) by which these receptors may be exposed.

The assessment of exposure involves the evaluation of the data available for the study and the arising issues; the details associated with the surrounding environment that influence fate and transport processes; the nature of planned operations that use the COPC; the physico-chemical characteristics of the COPC and the respective potential exposure pathways consistent with the planned operations. This allows the nature of the potential exposure to be identified taking into consideration the fate and transport potential of the COPC.

For an exposure pathway to be considered to be complete there must be all of the following:

- Source of COPC - how the chemical entered the environment and which environmental media are affected.
- A transport media - how the chemical moves or migrates through the environment from one location to another, or from one environmental medium to another.
- An exposure point - how organisms can come into contact with the chemicals (e.g. direct contact or via the food web).
- An exposure route - how the chemical could enter the organism (e.g. inhalation, ingestion or dermal contact).

If any one of these steps (source, transport media, exposure point or route) is not present, the exposure pathway is incomplete and further assessment of risks is not required. Conclusions regarding the completeness of exposure pathways may change over time in response to new information or developments, and as such should be periodically reviewed for verification.

2.1 Identification of Exposure Pathways and Populations

A detailed description of the study area environment is provided in Volume One. In general, the area is sparsely developed, and comprises rural communities and homesteads that are largely engaged in farming and livestock production. The identification of exposure pathways and populations or ecological receptors has been split into those considered relevant for on-site (i.e. within the well lease), and those relevant for off-site (i.e. anything beyond the well lease boundary). A general description of the well lease is provided in Volume One. Individual configurations of well leases may change, however the general layout is considered adequate for the identification of exposure pathways and receptors.

The environment surrounding the well lease (i.e. off-site) may vary. In order to provide a conservative assessment it has been assumed there is a homestead with a water supply bore located down gradient of the well lease. It is further assumed that the distance to the homestead is over two kilometres which thus limits the potential consideration of:

- Vapour intrusion concerns into dwellings.
- The environmental distribution of chemicals as vapours producing odours or particulates that may deposit onto roof tops and indirectly into potable water supplies; and
- The potential for entrainment of chemicals used in and around the well leases into the indoor environment of homesteads and into areas where local (homegrown) food crops may be produced.

It has also been assumed that an ephemeral creek, livestock and native flora and fauna, are present in the surrounding environment. This hypothetical assumption was considered for the purposes of the exposure pathway assessment and may not actually occur in the vicinity of a hydraulically stimulated well.

2.1.1 On-site Exposure Pathways

A well lease is a defined area that contains all of the equipment and infrastructure required to hydraulically fracture a well. A typical well lease is described in Volume One. Of particular note for the exposure assessment are the Flare Pit and the Blender Unit. The Flare Pit is fenced.

As such a well lease is an occupational environment and accordingly it is unnecessary to consider any on-site residential scenarios. Workers are typically housed in existing camps or camps specifically designed for hydraulic stimulation (frac camps). According to Santos procedures (Hydraulic Fracture Stimulation Procedures, Rev1, 2005), '*The frac camp should not be located within one kilometre of operations*. If a camp is located within one kilometre, a risk assessment must be performed, and management approval obtained.

The environmental receptors on a well lease are limited. Livestock and large native animals such as kangaroos are deterred from entering the pad by human activity. However, Santos has indicated that cattle and kangaroos have been noted on well leases infrequently. Smaller fauna such as rodents, lizards, snakes and birds are known to enter well leases.

As described in Volume One, stimulation fluid is blended on site to the specific requirements of the fracture design. The additives required for the fracture are brought onto site and stored in storage containers, blender unit or sand trailer. Blending of the fluid is a contained and completely automated process. A typical stimulation operation is of limited duration (two to three days). As such the chemicals are on site for a short period of time prior to and during the stimulation event. The likelihood of occupational or environmental exposure to these additives prior to injection during normal operation is considered low, as long as robust operational management measures are present and implemented appropriately. Potential occupational exposure to hydraulic stimulation chemicals associated with a spill prior to injection is considered to be dealt with under appropriate occupational health and safety procedures and has not been considered further in this report.

The primary pathways for environmental and occupational exposures outside of spills are considered to be dermal, ingestion and inhalation and ingestion of particulates. Inhalation of volatile chemicals is considered to be of lesser concern as there are limited indoor or confined environments with all activities conducted outside, however, large atmospheric emissions in close proximity to the source would require evaluation from both an acute and chronic exposure perspective.

The main areas on site that are considered for occupational and environmental exposure is the lined Flare Pit used for flowback fluid storage and this is discussed in more detail below.

2.1.1.1 Flare Pit

The Flare Pit is constructed during the drilling phase, to provide containment for fluids associated with well fluids management (flowback fluids etc.) post drilling. The Flare Pit is used during stimulation as the initial reservoir for flowback fluids. The fluid is held in the pit to allow the sediment to settle and until it is removed via vacuum truck for off-site disposal. Santos has indicated that Flare Pits are lined with high-density polyethylene (HDPE) and fenced following the drilling phase and prior to hydraulic stimulation activities.

Human exposure to the water in the Flare Pit during normal operation would be limited but may occur if the Flare Pit or liner becomes damaged and requires repair. Normal OH&S procedures are expected to limit workers exposure to flowback water under these scenarios. Human and/or ecological exposure may occur in the event of a flood where the freeboard is breached.

Exposure to the sediment in the Flare Pit may occur if the Flare Pit is drained and the sediments dry out and contribute to wind borne dust. However, sediments are also removed from the pit via vacuum truck for off-site disposal as soon as practicable. Dust generation from a small volume of residual sediments is not likely to be of concern to human or ecological receptors and has not been considered further. Should the scale of operations result in multiple areas of residual sediments in closer proximity to townships then such an exposure pathway would warrant re-evaluation.

Cooper Basin activities are remote, and trespassers are unlikely to access the site even if the pad is not fully secure and accidental or deliberate exposure to chemicals in the flowback water in the Flare Pit is considered unlikely to occur.

Ecological exposures to stimulation chemicals within the Flare Pit may occur from contact with the flowback water or from contact with sediments following drainage. Although Flare Pits are fenced, ecological receptors may include livestock, kangaroos and other small native mammals, reptiles, plants, soil microorganisms and birds.

Santos has indicated HDPE lined Flare Pits are the minimum standard for the containment of flowback fluids however, continuous improvement is fostered.

2.1.1.2 Measures to Limit Exposure

Typically implemented measures to limit on-site exposure include:

- Exposure to trespassers is limited through ensuring all Flare Pits are securely fenced. Signs are clearly displayed indicating the well lease is a work zone and is to be entered by authorised personnel only.
- Exposure to livestock is limited through regular maintenance of fences.
- Exposure to sediments in the HDPE lined Flare Pits is limited by effective removal and off-site disposal.

A summary of the on-site qualitative exposure assessment is provided in Table 2.

Table 2: On-Site Exposure Assessment Summary

Source	Exposure Scenario	Receptors	Exposure Pathways	Likelihood of Exposure Scenario	Comments
High-density polyethylene (HDPE) lined Flare Pit or tank sediments	Entry to pit or excavation/stockpiling of pit sediments	Workers, trespassers	Ingestion, dermal, inhalation of volatiles	Unlikely	OH&S procedures and PPE limit workers exposure to sediment. Associated risks are covered in inductions that all personnel and contractors must attend.
	Entry to lined Flare Pit or transportable tank	Native terrestrial fauna (small fauna - mammals, reptiles, birds)	Ingestion, dermal, uptake	Possible	The presence of humans and hydraulic stimulation activities are expected to deter majority of wildlife during operations. Flare Pits have stock proof fencing at all times. Flare Pits do not contain food or habitat for terrestrial fauna.
	Flare Pit sediments become windblown dusts	Workers, trespassers	Inhalation of dusts, indirect exposures through re-entrainment mechanisms	Possible	Sediments / residues are removed from site using vacuum truck and appropriately treated and disposed as soon as practicable. Flare Pits have stock proof fencing at all times.
	Flare Pit dries and pit sediments become windblown dusts	Native terrestrial fauna (mammals, reptiles, birds), terrestrial flora	Inhalation of dusts, deposition of dust on foliage	Possible	The presence of humans and hydraulic stimulation activities are expected to deter wildlife during operations, and sediments / residues are removed from site and appropriately treated and disposed as soon as practicable. Volume of dusts is expected to be insufficient to smother terrestrial flora. Risk of smothering is greatest for terrestrial flora in the immediate vicinity of the well lease. Provided flora populations are not unique to the area of the well lease, re-colonisation is expected post-stimulation activities.

Source	Exposure Scenario	Receptors	Exposure Pathways	Likelihood of Exposure Scenario	Comments
	Flare Pit dries and pit sediments become windblown dusts, contaminating surrounding soil.	Native terrestrial fauna (mammals, reptiles, birds), terrestrial flora	Ingestion, inhalation, uptake via roots, deposition of dust on foliage	Unlikely	The presence of humans and hydraulic stimulation activities are expected to deter wildlife during operations. Volume of dusts is expected to be insufficient to smother terrestrial flora. Risk of smothering is greatest for terrestrial flora in the immediate vicinity of the well lease. Sediments / residues are removed from site and disposed as soon as practicable.
Flowback water HDPE lined Flare Pit or tank.	Working with Flare Pit inlet, liner, or extraction.	Workers	Ingestion, dermal, inhalation of volatiles, inhalation/ingestion of aerosols	Possible	OH&S procedures and PPE limit workers exposure to flowback water. Associated risks are covered in inductions that all personnel and contractors must attend.
	Entry (accidental or deliberate) to Flare Pit.	Trespassers	Ingestion, dermal inhalation of volatiles, inhalation/ingestion of aerosols	Possible	Trespassers entry is limited via fencing and signage. Trespassers can be entirely precluded from areas.
	Entry to Flare Pit.	Native terrestrial fauna (small fauna - mammals, reptiles, birds)	Ingestion	Observed	The presence of humans and hydraulic stimulation activities are expected to deter majority of wildlife during operations. Flare Pits have stock proof fencing at all times. Flare Pits do not contain food or habitat for terrestrial fauna.
	Entry (accidental or deliberate) to Flare Pit.	Livestock	Ingestion	Unlikely	Flare Pits have stock proof fencing at all times. Flare Pits do not contain food or habitat for stock. Fences and grids with routine maintenance can be effective at precluding

Source	Exposure Scenario	Receptors	Exposure Pathways	Likelihood of Exposure Scenario	Comments
					livestock from well leases however, some livestock have been observed in well lease areas.
Hydraulic stimulation chemicals	Spill, leak of well delivery system failure during surface handling. Supply or disposal vehicle accident on site	Workers	Ingestion, dermal inhalation of volatiles, inhalation/ingestion of aerosols indirect exposures through re-entrainment mechanisms	Unlikely	OH&S, PPE and spill containment, procedures adequately address this exposure. Associated risks are covered in inductions that all personnel and contractors must attend.
	Spill, leak of well delivery system failure during surface handling. Supply or disposal vehicle accident on site	Terrestrial fauna (mammals, reptiles, birds), terrestrial flora	Ingestion, dermal	Unlikely	The presence of humans and hydraulic stimulation activities is expected to deter wildlife. The greatest hazard is to terrestrial flora in the immediate vicinity of a spill. Provided flora populations are not unique to the area of the well lease, re-colonisation is expected post-completion of stimulation activities.
Flowback water	Spill, leak, delivery system failure or overflow	Workers, trespassers	Ingestion, dermal, inhalation (volatiles and aerosol)	Possible	OH&S procedures and PPE limit workers exposure to flowback water. Associated risks are covered in inductions that all personnel and contractors must attend.
	Spill, leak, delivery system failure or overflow	Terrestrial fauna (mammals, reptiles, birds), terrestrial flora	Ingestion, dermal, uptake via roots	Possible	The presence of humans and hydraulic stimulation activities is expected to deter wildlife. The greatest hazard is to terrestrial flora in the immediate vicinity of a spill. Provided flora populations are not unique to the area of the well lease, re-colonisation is expected post-spill clean-up.

2.1.2 Off-site Exposure Pathways

The off-site environment is considered to be anything outside the boundary of the well lease. As discussed in Volume One the study area is sparsely developed with the predominant land use being for livestock. Volume One indicates the location of wells to be hydraulically stimulated and indicates there are no major towns or homesteads within close proximity of a stimulation well.

As discussed in Volume One, published research indicates, on the basis of water level and water quality analysis (including major and minor ion chemistry and stable isotope analysis), that the surface water features in the study area (typically consisting of semi-permanent waterholes that form between episodic flood event) do not receive shallow groundwater recharge (Hamilton et al., 2005; Bunn et al., 2006; Costelloe et al., 2007, Cendon et al., 2010). The reported characteristic quality of groundwater in the shallow unconsolidated aquifers in the study area is saline, and the water quality and isotopic signature is distinct from that of the fresher water in the water holes of the Channel Country. In addition, reported water levels in the shallow aquifer are inferred to be below the base of the surface water features in the study area, such that water holes, and flowing river channels during flood events, are considered to be losing water features (i.e. exhibit leakage of water into the ground but do not receive groundwater baseflow). Hence, the potential exposure pathway comprising leakage of hydraulic stimulation fluid down to shallow groundwater, off-site migration with groundwater flow and discharge to an aquatic environment associated with a surface water feature is considered to be an incomplete exposure pathway in the study area and has therefore been excluded from further consideration.

In the majority of instances the well lease sites where hydraulic stimulation will be conducted will be remote from water supply bores and will maintain an appropriate buffer distance from environmentally sensitive areas.

Table 3 provides a summary of the possible sources, exposure scenarios, human populations, ecological receptors and exposure pathways considered relevant for off-site. The main possible sources identified are the hydraulic stimulation fluid, sediments in a Flare Pit and flowback water. These are discussed in more detail below.

2.1.2.1 Exposure to Hydraulic Stimulation Fluid

Potential human and ecological exposures to stimulation fluid are unlikely but theoretically could occur due to casing failures or through fractures into overlying aquifers. However, Santos currently uses an extensive system of procedures to minimise the likelihood of the fracture (and then the fluid) leaving the target area and the loss of well integrity; these are described in Volume One. The systems include extensive testing programs and operational and systems monitoring to ensure hydraulic stimulation activities are confined to the target units. If a loss of integrity is identified in a well immediate measures are employed to decommission or rectify the situation.

On this basis it is considered unlikely that exposure to stimulation fluids could occur due to the fluid escaping the target formation and contaminating adjacent aquifers that are used for domestic or stock water supply.

This conclusion is supported by a study completed by Osborn et al (2011) which evaluated aquifers overlying the Marcellus and Utica shale formations of north-eastern Pennsylvania and upstate New York. The study evaluated a number of issues associated with hydraulic stimulation including:

‘*Concerns for impacts to groundwater resources, from (i) fluid (water and gas) flow and discharge to shallow aquifers due to the high pressure of the injected stimulation fluids in the gas wells’*

The study evaluated groundwater from 68 private water wells which ranged in depth from 36 to 190 m. The area of the study is undergoing an expansion of gas well drilling and hydraulic stimulation and is in an area with extensive fracture systems with several major faults and lineaments. The study found:

'*No evidence for contamination of the shallow wells near active drilling sites from deep brines and/or stimulation fluids''*

A second source of possible human and ecological exposure to hydraulic stimulation fluids is residual fluid in the target formation. It is conservatively assumed that up to 40% of fluid may remain in the target formation immediately following stimulation. Based on the depth and separation of the target formations in the Cooper and Eromanga Basin, it is considered unlikely that exposure would occur if chemicals in the residual fluid migrate down gradient in the target formation. Residual stimulation fluids captured during the production stage of the well operations would act to reduce the residual volume in the reservoir over time and would be managed in accordance with the produced formation water management systems.

As indicated in Volume One, the results of the bore inventory in the study area indicated that the closest water supply bores installed in proximity of a hydrocarbon-bearing formation (Hooray Sandstone) to Santos production wells potentially targeting the same formation is 25 km. Residual hydraulic stimulation fluid constituents in groundwater would be expected to attenuate well within this distance. This conclusion is based on review of the information in the DEHP registered bore database, and the available results of an ongoing Water Bore Baseline Assessment program to verify the information in the database. This conclusion is subject to review, if warranted, on the basis of future bore inventory results and fracture locations.

2.1.2.2 Exposure to Sediments in the Flare Pit

Potential off-site human and ecological exposure to the sediment could occur if the Flare Pit is drained and the sediments were left to dry out and contribute to wind-borne dust. However, sediment is removed via vacuum truck and disposed of off-site. The volume of residual sediments in the Flare Pit is considered to be small and unlikely to be of concern to either humans or ecological receptors.

2.1.2.3 Exposure to Flow Back Water

Potential off-site human and ecological exposure to chemicals in the flowback water is unlikely but could possibly occur under a range of conditions. Exposure scenarios are considered unlikely to include the potential for releases or infiltration of flowback water into shallow aquifers that are used for domestic or stock water supply or which discharge to surface water, and direct releases to surface water.

For this exposure pathway to be complete there must be all of the following:

- A failure of the HDPE lining of the Flare Pit.
- A high permeability unit beneath the well lease that is able to transmit the flowback water to an underlying aquifer; and
- A shallow aquifer present in the subsurface beneath the well lease, that is either used as water supply or discharges into a creek.

If any of the above conditions are missing, no exposure will occur. The surface lithology of the Cooper Creek drainage was described as comprising a thick layer of low permeability "mud" overlying sand beds that host the shallow, saline aquifer (e.g. Nanson et al., 2008). The fine-grained surface deposits would substantially reduce the potential for infiltration of leaking flowback water to reach the shallow aquifer, and the shallow "water table" aquifers have been reported to be saline to the extent that they are unsuitable for most beneficial uses (e.g. Cendon et al., 2010). The shallowest groundwater supply in the study area is typically sourced from either the Glendower Formation or the Winton Formation, which underlie the Quaternary unconsolidated sediments. Surface water bodies have been reported to be disconnected from the shallow groundwater system.

The concentrations of stimulation chemicals in the flowback water are expected to be lower than those injected due to the capture of first flush, although flowback water is likely to contain concentrations of

'geogenic' chemicals from the hydrocarbon reservoir. However, the toxicity of those chemicals is expected to rapidly decrease due to dissolution, and the relatively rapid biodegradation and volatilisation of many of the chemicals. The likelihood of exposure to stimulation chemicals under this scenario in concentrations likely to be of concern is considered to be low.

2.1.2.4 Spills and Overflows from Flare Pits

Potential off-site human and ecological exposure to flowback water is considered unlikely but could possibly occur in the event of a spill or overflow from the Flare Pit. However, the Flare Pit has been designed to exclude stormwater and will be operated with a minimum of 300 mm freeboard to limit the potential for overflow. On this basis, a release could only occur during a prolonged period (weeks) of heavy rainfall. The probability of a spill or overflow event occurring is further reduced by minimising the duration that flowback fluids are stored in the Flare Pit. In addition, the toxicity of the chemicals in the flowback fluid is likely to rapidly reduce based on the dissociation of the inorganic chemicals, and the relatively short biotransformation half-lives of the majority of organic chemicals. In the event of a release, human and ecological receptors could possibly be exposed however sampling of soil, groundwater and surface water (if relevant) in the affected area would be required to determine if unacceptable exposures had occurred.

2.1.2.5 Management Measures to Reduce Off-site Exposure

Management measures that are implemented to reduce the potential for off-site exposure or to assess the potential for exposure include:

- HDPE lining of Flare Pits to prevent seepage of flowback water into an underlying aquifer. This is already undertaken as a minimum standard.
- Establishment of buffers during establishment of well leases between petroleum operations and potential "environmentally sensitive areas" identified though database review and site-specific ecological assessment where warranted.
- Establishment of buffers prior to stimulation activities, between the stimulation initiation point and private water bores identified though water bore baseline assessment.
- Vacuum removal and disposal of the sediments during fluid drainage of the Flare Pit.
- Soil, groundwater and surface water sampling of affected area recommended following any spill/ overflow of a Flare Pit.

Table 3 provides a summary of the possible sources, exposure scenarios, populations and receptors and exposure pathways considered relevant for off-site exposure concerns.

Table 3: Off-site Exposure Assessment Summary

Source	Exposure Scenario	Receptors	Exposure Pathways	Likelihood of Exposure Scenario	Comment
Hydraulic stimulation fluids	Stimulation fluid escapes into aquifer via a well casing failure, or a fault/ fracture/ unconformity in formation/strata, and fluids enter aquifer used down gradient for stock and domestic water supply	Residents: adults and children Livestock	Ingestion, dermal, inhalation Ingestion	Unlikely	The exposure scenario is unlikely given the pathway linking source to receptor is predominantly absent. The shallowest occurrence of groundwater is generally at a depth that precludes hydraulic connection with surface water features resulting in a lack of GDEs within the study area. The well lease sites are remote with limited human inhabitants in the proximity of the operations – groundwater supply development is accordingly very limited, with large vertical or lateral separation of water supply wells from hydrocarbon reservoirs. Extraction of groundwater for domestic and livestock use is limited in the study area, as evidenced by the small number of registered bores (and even smaller number whose existence was confirmed during recent bore inventory and baseline assessment). The closest groundwater to surface water discharge points occur at significant distances down-hydraulic gradient of the well lease sites (i.e. of the order of 100 km or more). Exposure concentrations of hydraulic stimulation chemicals at the receptor are likely to be insignificant. Management measures include Santos
	Stimulation fluid escapes into aquifer via a well casing failure, or a fault/fracture/unconformity in formation/strata, and fluids enter aquifer that discharges to surface water	Aquatic ecosystems	Direct exposure	Unlikely	
	Residual stimulation fluid in the formation migrates down gradient and enters a	Residents, aquatic ecosystems, livestock	Ingestion, dermal, inhalation	Unlikely	

Source	Exposure Scenario	Receptors	Exposure Pathways	Likelihood of Exposure Scenario	Comment
	spring or water supply bore				operational procedures i.e. well integrity testing and design of fracture to stay with the target formation. No recorded instances in peer-reviewed literature of stimulation chemicals in down gradient water supplies (Osborn et al 2011).
Flare Pit or tanks sediments	Flare Pit dries and sediments become windblown dusts, contaminating surrounding soil	Native terrestrial flora and fauna, stock, Residents adults and children	Direct exposure/ inhalation/ ingestion of dusts	Unlikely	Sediments / residues are removed from site using vacuum truck and appropriately treated and disposed as soon as practicable.
Flowback water	Seepage of chemicals to a shallow aquifer used downgradient for domestic water supply	Residents: adults and children	Ingestion, dermal, inhalation	Unlikely	Flare Pits are lined as a minimum standard, with improvements planned from 2013. The shallowest aquifer in the Quaternary sediments is reported to be very saline and is covered by a thick layer of low permeability mud which substantially limits infiltration. Extraction of groundwater for domestic and livestock use is limited in the study area, with a small number of bores whose existence was confirmed during a bore inventory. Identified bores are typically remote from the well lease operations, or access groundwater resources that would be very unlikely to be affected by surface seepage
	Seepage of chemicals to a shallow aquifer used downgradient for stock water supply	Livestock	Ingestion	Unlikely	
	Seepage of chemicals to a	Aquatic ecosystems	Direct exposure	Unlikely	

Source	Exposure Scenario	Receptors	Exposure Pathways	Likelihood of Exposure Scenario	Comment
	shallow aquifer that discharges to surface water				of flowback fluid; hence exposure pathway is considered to be incomplete.
	Spill or leak from Flare Pit or tank overflow	Terrestrial fauna (mammals, reptiles, birds), terrestrial flora	Ingestion, dermal, uptake	Possible	Possible overflows during prolonged periods of high rainfall (>300 mm of rainfall required) based on freeboard control requirements. Freeboard is closely monitored and managed to prevent overflow. The greatest hazard is to terrestrial flora in the immediate vicinity of an overflow. Provided flora populations are not unique to the area, re-colonisation is expected post-overflow event. Likelihood of occurrence can be reduced through minimising storage duration, and transition to storage tanks for flowback water storage. The toxicity of fluid is likely to decrease rapidly due to short biotransformation half-lives of most chemicals.

2.2 Identification of Complete Exposure Pathways

2.2.1 On-Site Exposure Pathways

The potential on-site exposure pathways are discussed in Section 2.1.1. Potential exposures were evaluated for workers, trespassers, small fauna, flora and soil microorganisms.

Based on information provided by Santos, there does not appear to be complete exposure pathways identified for on-site workers under normal circumstances, provided the following conditions are met:

- Adequate OH&S procedures are adhered to that prevent direct contact and inhalation exposure with chemicals during spills and when handling flowback water or sediments; and
- Sediments in the Flare Pits are disposed of appropriately.

Exposure of trespassers is considered to be an unlikely occurrence. Exposure to sediments or flowback water is a complete exposure pathway (ingestion, dermal and inhalation) if trespassing occurs on unsecured sites. Exposure will be limited through ensuring all Flare Pits are securely fenced with signage clearly displayed to indicate that the well lease is a work zone and access is restricted to authorised personnel.

Exposure pathways to the flowback water in the Flare Pit for large native fauna (i.e. kangaroos) and livestock can be considered incomplete on the basis of the fencing that Santos will establish and maintain around the Flare Pit, during operations and while flowback water is stored on site.

Exposure pathways (direct contact) for small fauna (i.e. soil microorganisms, plants, small mammals, snakes, lizards and birds) is considered complete for exposure to the flowback water in the Flare Pits, with practical measures implemented by Santos to minimize potential exposures.

2.2.2 Off-Site Exposure Pathways

The on-site exposure pathways are discussed in Section 2.1.2. The most likely potential exposures were evaluated for residents, livestock, native flora and fauna and aquatic ecosystems. Three possible sources were identified: hydraulic stimulation fluids, sediments from the Flare Pit and flowback water.

Exposures were considered unlikely for all scenarios based on the engineering (liners) and operational controls that are being implemented by Santos, and the geographical remoteness of the stimulation activities. In the unlikely event that an uncontrolled release was to occur potential exposures could include direct contact and inhalation exposures for residents, livestock, native flora and fauna and aquatic ecosystems. The probability of a release from a Flare Pit occurring can be reduced through minimising the duration of flowback fluid storage. In addition, the toxicity of the chemicals in the flowback fluid are likely to rapidly reduce through dissociation of organic chemicals and the relatively short biotransformation half-lives of the majority of the organic chemicals, although it is noted that additional assessment of flowback fluid quality is recommended to support this conclusion.

The potential exposure to stimulation fluids due to entry into an overlying water supply aquifer via a well casing breach or a natural preferential pathway (fault/fracture) is considered unlikely. Santos has established operational procedures to foster well integrity and that fractures are contained within the target formation. The exposure pathways associated with residual fluid in the target formation is discussed in Section 2.1.2.1.

The potential exposure to sediments in the Flare Pit becoming windblown dusts (direct contact/inhalation and ingestion of dust) and contaminating surrounding soil is considered unlikely. Sediments are removed via a vacuum truck during fluid removal and the residual volume of pit sediments is likely to be insufficient to result in concentrations in soil that would be of concern in the surrounding terrestrial environment.

The potential for seepage of flowback fluids from the Flare Pit into an underlying aquifer and migration to a domestic water supply or discharge into a creek are considered unlikely. Santos is designing Flare Pits with

liners to prevent the loss of fluids into the subsurface. If releases were to occur, the typical surface lithology in the study area comprises a thick layer of fine-grained material overlying the sand beds that host a saline aquifer (e.g. Nanson et al., 2008). The fine-grained material will substantially reduce the infiltration potential of released fluids, and the shallowest aquifer is generally too saline for most beneficial uses (e.g. Cendon et al., 2010). The shallowest groundwater resource developed for water supply in the study area is the Tertiary Glendower Formation, which underlies the unconsolidated Quaternary sediments.

2.2.3 Residual Stimulation Fluids in Target Formations

The depths to oil target formations in the study area exceed a depth of 1,300 mbgl, and typical depths of hydraulic stimulation operations targeting gas formations occur at depths greater than 2,000 m bgl. The exposure pathways associated with injected hydraulic stimulation fluids are considered to include water supply bores screened either within the oil target formation itself, or in an aquifer formation immediately adjacent to the target formation.

2.2.3.1 Groundwater Extraction in the Eromanga Basin

Due to the depth (1,300 mbgl) and variable water quality of the oil target formations in the Eromanga Basin, and of the presence of shallower resources of suitable quality and yield, groundwater from the target formations is not typically used by the few pastoralists and residential users within the study area.

The following observations are made based on the proximity of water supply wells to oil and gas well locations in Volume One:

- The average offset between the base of the deepest (Hutton Sandstone) aquifer and the top of the Permian gas reservoirs is of the order of 200 to 300 m, with most of the intervening section consisting of impermeable mudstones and shales. However, landholder bores generally access the shallowest viable aquifer which, in the vicinity of the site, can be the shallow Glendower or Winton Formations. The vertical offset between these aquifers and the top of the gas-bearing Permian interval is of the order of 1,300 m to 1,800 m for the Glendower and 1,000 m to 1,500 m for the Winton.
- The active landholder bores in the oil fields of the *study area* range from approximately 3 to 10 km from the nearest proposed oil fracture stimulation target well. The upper-most formation proposed for hydraulic stimulation is the Wyandra Sandstone (Upper Cadna-Owie). The nearest bore, Mt Margaret No 14, targets the relatively shallow Winton formation for stock purposes. The vertical distance at this location between the Winton Formation and the Wyandra Sandstone is at least 750 m.
- The active landholder bores within, or near, the gas fields of the *study area* range from approximately 25 to 90 km away from the nearest proposed hydraulic stimulation location. The upper-most targets proposed for hydraulic stimulation are formations within the Nappamerri Group. The vertical distance between the Hooray Sandstone and the Nappamerri group at this location is greater than 600 m; and
- The Coothero Bore was observed during the WBBA, and according to DEHP, targets the Hooray Sandstone for stock water. The Coothero Bore is located approximately 44 km from the nearest proposed location for gas production, and more than 80 km from the nearest location proposed for oil production from the Hooray Sandstone.

Hence, based on the available information, it appears unlikely that a complete exposure pathway exists in the study area for hydraulic stimulation fluids to reach a water supply well.

2.2.3.2 Groundwater Extraction in the Cooper Basin

Due to the significant depth of the Cooper Basin aquifers, these have not been accessed for water supply and are only intercepted while targeting gas production. This is supported by WERD and DEHP Groundwater Databases and a recent Water Bore Baseline Assessment.

While no known water supply wells are completed within the Cooper Basin, although significantly separated, water supply development in the Eromanga Basin is considered as the next vertically closest aquifer in the

study area (as discussed above). However, the important water supply aquifers of the Eromanga Basin are separated from the Cooper Basin reservoir formations by a major structural unconformity and basal aquitard units of the Eromanga Basin, and therefore, hydraulic connection is limited.

Based on the absence of water supply development in the Cooper Basin formations, and the limited hydraulic connectivity and significant vertical distance between the Cooper Basin and Eromanga Basin formations, the potential for a complete exposure pathway for either an environmental or water supply receptor is considered to be very low.

3.0 PRODUCT DESCRIPTION

This report specifically addresses the requirements of EA conditions related to the assessment of chemical constituents for the *Schlumberger YF140HTD 30Q N2* stimulation fluid, ThermaFRAC 40 stimulation fluid and Slickwater stimulation fluid. The report also considers a lesser volume of *32%HCL* also used during stimulation.

3.1 Chemical Constituents

A list of the individual hydraulic stimulation fluid chemicals considered in this risk assessment (52 in total) and their respective Chemical Abstracts Service Registry numbers (CAS RN) is provided in Table 4. This list is similar to, but will inevitably vary from, other published sources of hydraulic stimulation fluid compositions, as the specific hydraulic stimulation fluid mixtures are proprietary products of the hydraulic stimulation contractors and their product suppliers.

None of the stimulation fluid chemical constituents presented contained benzene, toluene, ethylbenzene, xylenes (BTEX) or polycyclic aromatic hydrocarbons (PAHs). It is noted, however, that total petroleum hydrocarbons (TPH), PAHs and BTEX occur naturally in conventional oil and gas condensate and it is possible that these chemicals may naturally be present in the reservoir groundwater used in the hydraulic stimulation process. In terms of the reaction by-products of these chemicals, none of the known reaction by-products are likely to exhibit higher toxicity than the parent compounds. However, it is recognised that geochemical the hazard assessment approach developed for assessment of hydraulic stimulation chemicals used herein has been refined since the initial assessment prepared by Golder in 2010. The refinements are summarised below and in the referred sections of this report:

- Assessment of terrestrial toxicity hazard was included in the assessments conducted after 2011.
- Since 2012 the assessment of aquatic toxicity has been updated and is described in more detail in Section 4.4 (Environmental Hazard Classes).
- The human health hazard assessment was refined in 2013 to reflect changes in NICNAS as described in Section 6.4 (New Hazard Assessment Approach – IMAP Framework).

At Santos' request, chemicals which have been previously assessed by Golder (of which there were 36 in total, refer Golder Report 127666004-018-R-Rev A) have been included herein. Seventeen of the 36 previously assessed chemicals were classified for hazard using the former environment hazard and human health approaches, with the remainder assessed using the refined approaches (described above). For this current report, the environment and human health hazard assessments have all been updated to the new method where applicable.

Table 4: Hydraulic Stimulation Chemicals Sorted into Organic and Inorganic

Chemical Type	Chemical Name	CAS RN
Organic (33)	Cholinium chloride	67-48-1
	Guar gum	9000-30-0
	Vinylidene chloride/methacrylate copolymer	25038-72-6
	Tetrasodium ethylene diamine tetra acetate	64-02-8
	Polyethylene glycol monolaurate	9005-64-5
	5-chloro-2-methyl-2h-isothiazolol-3-one	26172-55-4

Chemical Type	Chemical Name	CAS RN
	Propan-2-ol	67-63-0
	2-methyl-2h-isothizol-3-one	2682-20-4
	Sodium gluconate	527-07-1
	Polylactide resin	9051-89-2
	2,2,2”-nitrilotriethanol	102-71-6
	Polyethylene glycol monohexyl ether	31726-34-8
	Sodium glycolate (impurity)	2836-32-0
	Dicoco dimethyl quarternary ammonium chloride	61789-77-3
	Disodium ethylene diamine tetra acetate	139-33-3
	Trisodium ethylene diamine tetra acetate	150-38-9
	Trisodium nitriloacetate (impurity)	5064-31-3
	Cetylethylmorpholinium ethyl sulfate	78-21-7
	Ethanol	64-17-5
	Acrylamide, 2-acrylamido-2-ethylpropanesulfonic acid, sodium salt polymer	**38193-60-1**
	Alkyl (C12-16) dimethylbenzyl ammonium chloride	**68424-85-1**
	Butyl diglycol	**112-34-5**
	Decyldimethyl amine (impurity)	**1120-24-7**
	Decyl-dimethyl amine oxide	**2605-79-0**
	Fumaric Acid	**110-17-8**
	Hydroxypropyl cellulose	**9004-64-2**
	Pentaethylenehexamine	**4067-16-7**
	Sodium-carboxyl-methyl-hydroxyl-propyl guar	**68130-15-4**
	Tetraethylenepentamine	**112-57-2**
	Tetramethylammonium chloride	**75-57-0**
	Triethylenetetramine	**112-24-3**

Chemical Type	Chemical Name	CAS RN
	L-Glutamic Acid	**56-86-0**
	Octadecanoic acid calcium salt	**1592-23-0**
Inorganic (19)	Crystalline Silica, Quartz	14808-60-7
	Hydrochloric Acid	7647-01-0
	Sodium Hydroxide	1310-73-2
	Crystalline silica, cristobalite	14464-46-1
	Nitrogen, liquid form	7727-37-9
	Boric acid	10043-35-3
	Diatomaceous earth, calcined	91053-39-3
	Magnesium nitrate	10377-60-3
	Magnesium silicate hydrate (talc)	14807-96-6
	Magnesium chloride	7786-30-3
	Ceramic materials and wares, chemicals	66402-68-4
	Sodium bromate	7789-38-0
	Sodium thiosulphate	7772-98-7
	Non-crystaline silica	7631-86-9
	Potassium hydroxide	1310-58-3
	Sodium tetraborate	1330-43-4
	Silica gel	112926-00-8
	Hydrogen Peroxide (impurity)	**7722-84-1**
	Zirconium dichloride oxide	**7699-43-6**

3.2 Mass Balance Calculations

A quantitative mass balance assessment of hydraulic stimulation fluid components was undertaken based on the information provided by Schlumberger. Three fluids systems were provided by Schlumberger: *YF140HTD 30Q N2* with an acid spearhead, named *32%HCL*, *ThermaFRAC 40* and *Slickwater*. For the combined fluid mixtures, Schlumberger provided the total volume of each fluid, a list of individual chemical names and mass fraction (%) of each.

In a typical stimulation stage, approximately 930L of 32*%HCL* is used, while approximately 227,000L of *YF140HTD 30Q N2* is used. In a typical *ThermaFRAC 40* or *Slickwater* stimulation stage, approximately 2.6 ML of fluid is used for each stimulation system. However, each individual well stimulation stage is specifically designed and therefore, exact volumes of fluids will vary to suit the stimulation stage design.

For the combined fluid mixture, Schlumberger provided the total volume of each fluid, a list of individual chemical names and mass fraction (%) of each. The composition of the hydraulic stimulation fluids and calculated total mass and injected concentrations of the individual chemicals are summarised in Table D1, APPENDIX D. The fluid compositions in Table D1 were divided into chemical additives, proppants and water.

Mass and mass fraction calculations were based on information provided by the stimulation service provider in their "Stimulation Fluid Disclosure" (note that mass and volumes were provided in imperial units and were converted to SI units) (APPENDIX G). Table 5 presents the estimated mass of additives, proppant and water included in the stimulation fluid systems *per stimulation stage*. It is noted that up to 10 *stimulation stages* may be undertaken per gas production well.

Table 5: Indicative Component Mass per Stimulation Stage

Fluid System	32%HCL and YF140HTD 30Q N2	Slickwater	ThermaFRAC 40
Typical fluid Volume[1]	~ 228,027L	~ 2,649,500L	~ 2,649,500L
Additives	~ 52,423kg (~23 %)** N2 additive	~ 174 kg (~0.01 %)	105,085 kg (~3 %)
Proppant	~ 27,386 kg (~12 %)	~ 476,270 kg (~17 %)	344,726 kg (~13 %)
Water*	~ 148,218 kg (~65 %)	~ 2,173,000 kg (~82 %)	2,225,580 kg (~84 %)

Notes: Fluid volume per stimulation stage, as indicated in the stimulation service provider's fluid disclosure. *Assuming that density of total typical fluid volume is 1 kg/l.

The additives for each of the hydraulic stimulation formulations comprises predominantly of water (65 – 84 %), with a secondary component consisting of proppant (12 – 17%) and a minor fraction which consists of additives (0.007 – 3%).

Following completion of the hydraulic stimulation process, a percentage fraction of the injected hydraulic stimulation fluids are recovered upon flowback. However, it should be noted that most of the additives would have undergone chemical transformations in the sub-surface. In addition, the formation also contributes certain amount of water and dissolved salts to the flowback. Studies performed by the USEPA (2004) indicated that approximately 60% of the hydraulic stimulation fluid volume is recovered in the first three weeks. The volume of flowback is heavily dependent if the shales are considered to contain water or not. If it is conservatively assumed that 40% of the hydraulic stimulation fluid volume remains in the formation (reasonable "worst case") this would correspond to 174 – 105,085 kg per stimulation stage; or 1740 – 1,050,850 kg per production well where up to ten stimulation stages are performed (excluding proppant).

4.0 AQUATIC HAZARD ASSESSMENT

An environmental hazard assessment was undertaken to classify the hydraulic stimulation chemicals based on persistence (P), bioaccumulation (B) and toxic (T) potential (hereafter referred to as PBT). Using PBT, hydraulic stimulation chemicals were classified into one of three hazard groups: low, moderate or high. Chemicals classified as high hazard were considered to be chemicals of potential concern (COPC). Identification of a chemical as a COPC did not indicate an unacceptable hazard, nor did it include an evaluation of whether there was a link between source, pathway, and receptor. A high hazard classification indicated the need to evaluate exposure to these chemicals in greater detail. A discussion of possible exposure pathways (to people and the environment) is presented earlier in Section 2.0 and a qualitative (in the absence of exposure concentrations) characterisation of risk is presented in Section 7.0.

The environmental hazard assessment approach developed for this study used national and international guidance for assessment of PBT in the risk assessment, classification, and regulation of chemicals. The guidance used is predominantly focussed on hazard to aquatic receptors. The available guidance for assessment of hazard to terrestrial receptors is somewhat limited. Consequently, in the assessment of environmental hazard, aquatic and terrestrial toxicity were considered separately. This section presents the environmental hazard and includes assessment of toxicity to aquatic receptors. Section 5.0 presents the assessment of toxicity to terrestrial ecological receptors. Section 6.0 presents the human health toxicity assessment.

4.1 Chemical Information Sheets

In order to assess environmental hazard, readily available chemical and physical properties and aquatic ecotoxicological data were collated for the chemicals assessed. This information was compiled into a chemical information sheet for each chemical. The chemical information sheets are presented in APPENDIX F. The data used in the environmental hazard assessment of each chemical, are discussed in the following paragraphs.

4.1.1 Chemical and Physical Properties

Physical and chemical properties that affect the fate and behaviour of chemicals in the environment and that were used in the assessment of environmental P and B were obtained from the following sources in order of priority:

1) The Safety Datasheets (SDS) provided to Golder by Schlumberger (provided in APPENDIX C for reference).
2) Hazardous Substances Databank (HSDB), a toxicology database on the U.S. National Library of Medicine's Toxicology Data Network.
3) Modelled data from USEPA (2012) EPISUITE™ (Estimation Programs Interface Suite™ for Microsoft® Windows) modelling software (only when data were not available from the SDS or the HSDB); and
4) For data poor chemicals, an internet search for reputable agencies or researchers who may have published data.

USEPA (2012) EPISUITE™ software was developed by Syracuse Research Corporation (SRC) for the USEPA Office of Pollution Prevention and Toxics. EPISUITE™ provides a package of modelling software programs that can estimate physical/chemical, environmental fate and ecotoxicity data for organic chemicals. Inorganic chemicals should not be evaluated using EPISUITE™ because the estimation methods used are developed based on organic chemicals.

In using EPISUITE™, the following limitations for modelling organic chemicals are noted:

1) Chemicals that rapidly hydrolyse are unsuitable to be modelled namely, acid halides[2], isocyanates[3], sulphonyl chlorides[4], siloxanes[5], and alpha-chloro ethers. No chemicals meeting this description in the list of hydraulic stimulation chemicals considered for this risk assessment were subject to modelling.

2) Data generated for organic salts may not be reliable, namely cationic salts of Group I, Group II, transition metals, Actinides, and Lanthanides. These should not be profiled because there are not adequate data in the estimation models databases to predict properties with confidence. Organic salts however of Sodium (Na), Potassium (K), and Ammonium (NH_4^+) may be evaluated reliably. No chemicals meeting this description in the list of hydraulic stimulation chemicals considered for this risk assessment were subject to modelling.

3) Organo-metallic compounds should not be evaluated. No chemicals meeting this description in the list of hydraulic stimulation chemicals considered for this risk assessment were subject to modelling.

4) Highly reactive compounds should not be modelled. No chemicals meeting this description in the list of hydraulic stimulation chemicals considered for this risk assessment were subject to modelling; and

5) High molecular weight compounds with a molecular weight greater than 1000 should not be modelled. No chemicals meeting this description in the list of hydraulic stimulation chemicals considered for this risk assessment were subject to modelling.

The EPISUITE™ estimation programs are simple to use, requiring only one input (e.g., CAS RN or SMILES notation[6]) from the user and a nomination of the program to be used based on the data required by the user. EPISUITE™ includes a database of chemical and physical properties, algorithms, and Quantitative Structure Activity Relationships (QSAR) models with which to estimate parameters. The following programs were used to generate physical and chemical data for this study:

- KOWWIN™ - octanol/water partition coefficient (K_{ow}).
- HENRYWIN™ - Henry's Law Constant.
- BIOWIN™ - Biodegradation rate.
- LEV3EPI™ - Fugacity model to estimate partitioning to soil air, water and sediment.
- KOCWIN™ - Soil organic carbon partition coefficient (K_{oc}); and
- BCFBAF™ - Bioconcentration factor.

4.1.2 Aquatic Toxicity Information

Acute and chronic aquatic ecotoxicological data were obtained from the following sources in order of priority:

1) Safety Data Sheets (SDS) provided to Golder under this contract.

2) USEPA (2012) ECOTOXicology Database Version 4.0.

3) Australasian Journal of Ecotoxicology; and

4) HSDB.

[2] Acid halides are organic compounds containing the group -COX where X is a halogen atom (e.g., fluorine, chlorine, bromine, iodine). The inherent reactivity of acid halides precludes their free existence in nature; all are made by synthetic processes.

[3] Isocyanates are salts or esters of isocyanic acid, they are nitrogen based and may be described as neutral derivatives of primary amines. Isocyanates are represented by the general formula RNCO where R typically represents an alkly (a monovalent radical, such as ethyl or propyl, having the general formula CnH2n +1) or aryl (an organic group derived from an aromatic hydrocarbon by removal of one hydrogen), but sometimes is linked to elements such as sulphur (S), silicon (Si), phosphorous (P), nitrogen (N), or the halogens (e.g., fluorine, chlorine, bromine, iodine).

[4] Sulfonyl chlorides have the general formula R-SO_2-Cl which hydrolyse readily and are reactive with alcohols and amines.

[5] Siloxanes may be organic or inorganic and are made up of silicon, oxygen, plus (usually) carbon and hydrogen. They have the structural unit R_2SiO, where R is an alkyl group, usually methyl.

[6] SMILES (**S**implified **M**olecular **I**nput **L**ine **E**ntry **S**ystem) string is a linear notation for chemical structures.

Where ecotoxicological data were not available for the chemicals of interest or a suitable surrogate, data were modelled using ECOSAR™ software version 1.11 dated July 2012. ECOSAR™ (which stands for Ecological Structure Activity Relationships) estimates the toxicity of chemicals to fish, aquatic invertebrates and microalgae in water. Toxic effect predictions are made using a set of QSARs models. QSARs predict the aquatic toxicity of untested chemicals based on their structural similarity to chemicals for which aquatic toxicity data are available. The toxicity data used to build the QSARs come from a database of publicly available and confidential data submitted to the US EPA New Chemicals Program. The QSARs used in ECOSAR™ correlate a compound's physicochemical properties and its aquatic toxicity within specific chemical classes and applies rules for selecting the appropriate chemical class for the compound. ECOSAR™ generates acute (short-term) toxicity and, when available, chronic (long-term or delayed) toxicity.

In using ECOSAR™, the following limitations are noted:

1) ECOSAR™, is designed to be used by individuals with some knowledge of environmental toxicology and organic chemistry, it is not designed to be used by individuals without experience in these fields.

2) Inorganic chemicals (e.g., sodium chloride, and non-polar inorganics such as titanium dioxide) should not be evaluated using ECOSAR™. No chemicals meeting this description in the list of hydraulic stimulation chemicals considered for this risk assessment were subject to modelling.

3) Organo-metallic chemicals[7] should not be evaluated using ECOSAR™. No chemicals meeting this description in the list of hydraulic stimulation chemicals considered for this risk assessment were subject to modelling.

4) For chemicals that rapidly hydrolyse or highly reactive chemicals it is suggested that evaluations using ECOSAR™ should take into consideration the degradation products in addition to the parent compounds. As a general rule, where:

   - Half-life < 1 hour, an assessment of degradation products may be recommended.
   - Half-life = 1 hour – 14-days, an assessment of parent and degradation products may be recommended.
   - Half-life > 14-days, an assessment of the parent product may be recommended.

5) Complex salts[8] with a complex organic cation and anion are difficult to model using ECOSAR™. In cases such as these the anion, cation and dissociation products should be taken into consideration. Based on the individual compounds it should be modelled as a single compound (neutralized with both cation and anion attached) or as separate individual compounds (dissociated with no charge). No chemicals meeting this description in the list of hydraulic stimulation chemicals considered for this risk assessment were subject to modelling, either as compounds or as individual components.

6) Compounds with a molecular weight greater than 1,000 should not be evaluated using ECOSAR™. However, many polymers are made up of dimers, trimers and oligomers with a molecular weight of less than 1,000 and therefore the individual components could be assessed using the ECOSAR™ model separately. No chemicals meeting this description in the list of hydraulic stimulation chemicals considered for this risk assessment were subject to modelling, either as compounds or as individual components.

7) The ECOSAR™ model does not have the ability to take into consideration molecular conformation, and therefore cannot distinguish between stereoisomers, optical isomers, tautomers, or specific conformations. This is important as three dimensional molecular properties or molecular conformation

[7] Organo-metalls are chemicals that contain carbon bonded to a metal species such as methyl mercury compounds.

[8] Complex salts such as potassium ferricyanide ($K_3Fe(CN)_6$) which consists of a complex ion that does not dissociate in solution, differ from simple inorganic salts such as sodium chloride (NaCl) that readily dissociates in solution.

can be important as this relates to absorption, binding, and resulting toxicity potential of a chemical; and

8) Chemicals with unknown or variable composition (UVCs, such as oligomers, natural fats, or a product mixture) may have different results using ECOSAR™ depending on the composition assessed with the model. For chemicals such as these the representative structures would need to be identified and noted or all possible compositions would need to be assessed. No chemicals meeting this description in the list of hydraulic stimulation chemicals considered for this risk assessment were subject to modelling.

4.2 Hazard Versus Risk

The approach presented in the following paragraphs is an assessment of environmental hazard, rather than environmental risk. Risk assessment of chemicals in the environment is based on a comparison between the levels to which an organism in a particular environmental compartment (e.g. water) is exposed, and a maximum level which an organism can tolerate based on a defined exposure scenario (in an environmental compartment) without significant adverse effect. The environmental hazard assessment presented herein, is not a risk assessment *per se* because it does not consider likely exposure concentrations for most of the hydraulic stimulation chemicals. A qualitative assessment of the risk will be conducted based on an identification of relevant exposure pathways associated with the hydraulic stimulation fluid COPC.

Approaches to ranking or screening chemicals for the purposes of assessing relative “hazard” or “risk” can include likelihood and consequence matrices. In these matrices, a chemical may be scored high for consequence (which may be a function of PBT) but low for likelihood (which may be a function of whether the chemical is considered likely to be present in the environment at hazardous concentrations). Overall, such a chemical may then score a relatively lower hazard or risk than would be identified from its consequence (or PBT) score alone. The environmental hazard assessment approach here works on the premise of potential for PBT; that is, the data that may apply to “consequence”. “Likelihood” of exposure was assessed for fluid and flowback mixtures, not individual chemicals (refer Section 2.0).

4.3 Hazard Assessment Approach

The environmental hazard assessment approach developed for this study is consistent with national and international guidance for assessment of potential for PBT in the risk assessment, classification, and regulation of chemicals. Physical and chemical properties that affect the fate and behaviour of chemicals in the environment (including degradation rates, partition coefficients, and aquatic ecotoxicological data) were used in assessment of environmental PBT potential.

The Australian National Framework for Chemicals Environmental Management (NChEM) guidance manuals were consulted in preparation of the environmental hazard assessment approach, namely:

- EPHC (2009a). Environmental Risk Assessment Guidance Manual for Industrial Chemicals; and
- EPHC (2009b). Environmental Risk Assessment Guidance Manual for Agricultural and Veterinary Chemicals.

These guidance manuals present the data requirements and methodology for assessment for environmental hazard and risk assessment of industrial and agriculture and veterinary chemicals, consistent with international best practice. NChEM guidance was prepared by the National Environment Protection and Heritage Council (EPHC) for the Department of the Environment, Water, Heritage and the Arts (DEWHA). DEWHA undertakes environmental risk assessments of industrial chemicals for the National Industrial Chemicals Notification and Assessment Scheme (NICNAS) and agricultural and veterinary chemicals for the Australian Pesticides and Veterinary Medicines Authority (APVMA).

In addition, the following literature was consulted for PBT assessment guidance:

- ANZECC and ARMCANZ (2000). Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand, National Water Quality Management Strategy, Australian and New Zealand Guidelines for Fresh and Marine Water Quality, October 2000.
- CCME (2008) Canadian Council of Ministers of the Environment, The National Classification System for Contaminated Sites (NCSCS) Guidance Document.
- Christensen et al. (2003) Assessment Tools under the New European Union Chemicals Policy.
- Environment Canada (2003) Existing Substances Branch Guidance Manual for the Categorization of Organic and Inorganic Substances on Canada's Domestic Substances List, Determining Persistence, Bioaccumulation Potential, and Inherent Toxicity to Non-human Organisms.
- European Commission (2003) Technical Guidance Document on Risk Assessment in support of Commission Directive 93/67/EEC on Risk Assessment for New Notified Substances, Part II Chapter 3 Environmental Risk Assessment.
- ECETOC (2005) Risk Assessment of PBT Chemicals.
- Franke et al. (1994) The Assessment of Bioaccumulation.
- Langley (1993) Refining Exposure Assessment. In: The Health Risk Assessment and Management of Contaminated Sites. Proceeding of the Second National Workshop on the Health Risk Assessment and Management of Contaminated Sites.
- Swann et al. (1983) A rapid method for the estimation of the environmental parameters octanol/water partition coefficient, soil sorption constant, water to air ratio, and water solubility. Residue Reviews; and
- UNECE (2011) Globally Harmonised System (GHS) of Classification and Labelling of Chemicals. Revision 4. Part 4 Environmental Hazards and Annex 9 Guidance on hazards to the aquatic environment.

The above guidance is predominantly focussed on hazard to aquatic receptors. Guidance for assessment of hazard to terrestrial receptors is limited. The following sources were consulted in developing an approach for assessment of hazard to terrestrial receptors:

- European Commission (2003) Technical Guidance Document on Risk Assessment in support of Commission Directive 93/67/EEC on Risk Assessment for New Notified Substances, Part II Chapter 3 Environmental Risk Assessment; and
- National Environment Protection Council (NEPC) (2013). National Environment Protection (Assessment of Site Contamination) Amendment Measure.

4.4 Environmental Hazard Classes

The environmental hazard assessment approach presented herein uses several lines of evidence (LOE) that were assessed in a weight of evidence (WOE) framework. Physical, chemical and toxicological parameters selected for assessment of potential for PBT were assigned values that equate to the following hazards:

- High Hazard
- Moderate Hazard; and
- Low Hazard

Golder has refined this approach on a variety of projects including for assessment of hydraulic stimulation chemicals. The specific refinements for stimulation fluid risk assessment are described in the paragraphs

below and were implemented in stimulation fluid risk assessment prepared during and after 2012. The changes were made to increase the reliability and robustness of the assessment and entailed:

- Replacing chemical scoring with chemical classifications of low, moderate and high hazard. Hazard may be assigned using numeric or non-numeric approaches. Golder's experience using numeric indices is that greater sensitivity (than is possible) in the assessment of hazard is implied when generating statistical averages (e.g., to one or more decimal place). For example, using a numeric score of 1, 2, and 3 for low, moderate, and high hazard respectively for a variety of parameters, average scores of 1.7 or 2.2 may be calculated but do not reflect reality. These scores imply differences in hazard where none may be determined. Assessment of hazard via a non-numeric, descriptive approach avoids this implied sensitivity.
- Assessment of additional aquatic toxicity data and benchmarks to provide greater weight in the hazard assessment towards chronic aquatic toxicity in order to capture the available chronic effect data, which are frequently limited[9].
- Measured and predicted biodegradation studies[10] to capture the available biodegradation data. The previous approach was limited to a single study of anaerobic biodegradation in water for which data were often limited.
- Revision of the bioconcentration factor (BCF) benchmarks to better reflect the Australian guidance[11].
- A percentage calculation of data gaps in an individual chemical assessment as a measure of reliability.

At Santos' request, chemicals which had been previously assessed by Golder have been included herein. Some of the previously assessed chemicals were classified for hazard using the PBT approach in use prior to 2012, whereas others had been assessed using the refined PBT approach (described above) post-2012. For the current report, all chemicals were evaluated using the post 2012 methodology, which necessitated updating some previously assessed chemicals.

Hazard was assigned to individual parameters representative of P, B, or T. The LOE were used to assign an overall hazard classification (based on the WOE) for each chemical. There were no minimum data requirements (i.e. in some instances a hazard was evaluated on few data for each of P, B, or T). In order to quantify this uncertainty, a measure of data gaps was calculated for each chemical. In the assessment of T, the highest hazard assigned to either acute or chronic data was adopted as the final hazard classification for T. The approach for assessment of T differed from P and B because some chemicals have few aquatic ecotoxicological data. This resulted in weighting of the assessment towards T and is considered conservative and appropriate for a screening level risk assessment.

Not all the physical and chemical parameters collated for the hydraulic stimulation chemicals presented in the chemical information sheets (refer to APPENDIX F) were used in the environmental hazard assessment.

The hazard benchmarks set for this study are considered a relative assessment. The benchmarks were assigned with the intent of incorporating the precautionary principle(i.e., designed to be inherently conservative and therefore biased towards capturing, rather than rejecting chemicals that are likely to pose PBT hazard).

The individual hazards assigned to the respective benchmarks for each parameter are presented in Section 4.6.

[9] The previous approach considered two assessments for each of chronic and acute toxicity. As acute toxicity data tends to predominate for data poor substances, the assessments were expanded to nine assessments (six for chronic studies, three for acute studies) to increase weighting towards chronic toxicity studies where data were available.

[10] Measured and predicted studies include: aerobic ready biodegradation, inherent aerobic biodegradadation, ultimate biodegradation, primary biodegradation, and anaerobic biodegradation.

[11] BCF benchmarks were revised from 30 and 100 to 1,000 and 5,000.

4.5 Assessment of Organic Versus Inorganic Substances

The approach for the aquatic hazard assessment of inorganic and organic substances differs. The approach for the assessment of inorganic substances was devised based predominantly on guidance published by Environment Canada (2003). Following the Environment Canada (2003) approach, toxicity is considered in conjunction with persistence. The assessment of bioaccumulation potential of inorganic chemicals is more difficult to interpret in hazard assessment and was not included in the approach presented herein.

Non-metal-containing inorganic substances may be assessed following guidance for organic substances.

Justification for the hazard assigned to the individual parameters and the adopted ranges are discussed in the following section.

4.6 Environmental Hazard Assessment Parameters

The physical, chemical and aquatic ecotoxicological data collated and assessed in the aquatic environmental hazard assessment are presented in the chemical information sheets (refer to APPENDIX F) and summarised in Table 6 below.

Table 6: Physical, Chemical and Toxicological Parameters used in Environmental Hazard Assessment

PBT	Applicable to Organic / Inorganic Chemicals	Parameter	Units
Persistence	Inorganic / Organic	Solubility	mg/L
	Organic	Henry's Law constant	atm m^3/mol
	Organic	log K_{oc}	L/kg
	Organic	EPISUITE™ Ready biodegradability	Qualitative
	Organic	EPISUTE™ Ultimate Biodegradation (Biowin 3)	Qualitative
	Organic	EPISUTE™ Primary Biodegradation (Biowin 4)	Qualitative
	Organic	EPISUTE™ Anaerobic Biodegradation (Biowin 7)	Qualitative
Bioaccumulation	Organic	BCF	unitless
	Organic	log K_{ow}	unitless
Toxicity	Inorganic / Organic	Aquatic ecotoxicological data for: Plants Invertebrates Fish Acute L(E)C50 Chronic NOEC Chronic LOEC/MATC//EC50	mg/L

The following sections describe in more detail the parameters used, the benchmarks set, and the hazard assigned.

4.6.1 Data gaps

Where data were unavailable for a chemical, and/or data could not be modelled using EPISUITE™ the parameter was excluded from the environmental hazard assessment. An overall hazard was assigned for each of grouping for P, B and T based on the WOE (i.e., there were no minimum data requirements). In some instances a hazard was evaluated on few data for each of P, B, or T. Because of this it was necessary to quantify the extent of data gaps. This is expressed as a percentage in the PBT summary in Table D2 (APPENDIX D).

4.6.2 Surrogates

In the environmental hazard evaluation, consideration was given to the available environmental fate, persistence and toxicity information presented in the SDS. Where additional information was required to assess environmental hazard, data were sought for the appropriate chemical constituent namely, the active ingredient(s). Where data for active ingredients were unavailable, data for a suitable surrogate chemical were adopted. Surrogate chemicals were selected on the basis of structural similarity (or structure activity relationships, SAR), functional groups present, relevant precursors or breakdown products, data availability, and professional judgement. The approach taken assumes that the chemical and physical parameters of the surrogate are predominantly the same as the chemical in question. Use of surrogates is supported by relevant guidance (Environment Canada, 2003; NEPC, 1999; and UNECE, 2011) and is considered to be scientifically defensible.

Where chemicals were assessed using a surrogate, this is documented in this report for transparency. Where chemicals could not be assessed using a surrogate, a hazard value could not be assigned due to insufficient data.

4.6.3 Persistence

The approach for assessment of persistence for inorganic and organic chemicals differs.

Inorganic chemicals were assessed based on solubility, and solubility was considered in conjunction with toxicity.

Organic chemicals were assessed based on solubility, Henry's Law Constant, K_{oc}, and degradation rates.

4.6.3.1 Solubility

Aqueous solubility is measured in units of mg/L (or g/m^3) at temperatures of 20°C – 25°C. Aqueous solubility is temperature dependent. The solubility of a chemical will influence the rate of migration (or mobility) of that chemical in the environment. An increase in solubility leads to a decrease in adsorption to soil and greater mobility (Langley, 1993). Poor solubility may result in low bioavailability and lower biodegradation rates. A poorly soluble chemical may be considered to have a tendency to persist and therefore have more time to exert a toxic effect. Conversely, high solubility could also imply greater mobility, greater bioavailability and greater hazard. Solubility, rather than effective solubility[12], was adopted in this hazard assessment for simplicity. Effective solubility is a more accurate measure of chemical availability and mobility. However, effective solubility cannot be reliably predicted or modelled and is dependent on the chemical mixture and environmental factors (e.g. pH, temperature, oxidising or reducing conditions, etc.). Solubility is a conservative

[12] Effective Solubility is the solubility of a compound that will dissolve from a chemical mixture (e.g., gasoline). The effective solubility of a compound from a chemical mixture is less than its aqueous solubility

and simple measure of mobility and availability of a chemical in groundwater and hence was used in this hazard assessment.

Organic substances with low water solubility typically have high predicted bioaccumulation factors and / or high log K_{ow} and hence may be considered highly bioaccumulative unless there is evidence to suggest otherwise (Environment Canada, 2003).

Inorganic substances generally need to be dissolved in water to exert deleterious effects (to aquatic receptors) and consequently solubility should be considered in conjunction with aquatic toxicity, as recommended by Environment Canada (2003). Environment Canada (2003) recommends that when the solubility of the substance is greater than the acute toxicity, the substance is likely to pose a hazard. Herein, the lowest acute ecotoxicological endpoint obtained for the chemical of interest was used for data considered in assessment of toxic potential). Where solubility data were not found for the inorganic chemicals considered, solubility was assumed to be greater than acute toxicity. This is conservative and results in a high hazard classification.

Low solubility was signed a high hazard (based on likelihood of persistence and high bioaccumulation tendency) for organic chemicals. Conversely, low solubility was assigned a low hazard for inorganic chemicals. The hazard category benchmarks adopted in this study are summarised in Table 7 and Table 8 for organic and inorganic substances, respectively. These were derived based on professional judgement (noting that the UNECE (2009) consider a substance with a solubility of less than 1 mg/L to be poorly soluble).

Table 7: Solubility Benchmarks for Organic Substances

Hazard Category	Hazard Symbol	Solubility (mg/L)
High Hazard	■	<10
Moderate Hazard	◖	10 – 100
Low Hazard	■	>100

Table 8: Solubility Benchmarks for Inorganic Substances

Hazard Category	Hazard Symbol	Solubility (mg/L)
High Hazard	■	>10
Moderate Hazard	◖	1 – 10
Low Hazard	■	<1

The benchmarks for the assessment of solubility in conjunction with aquatic toxicity for inorganic chemicals are presented in Table 9. The benchmarks were set following Environment Canada (2003). Because only two categories exist, a moderate hazard is not possible.

Table 9: Benchmarks for Solubility Considered in Conjunction with Acute Toxicity (Inorganic Substances)

Hazard Category	Hazard Symbol	Solubility & Toxicity (mg/L)
High Hazard	■	Solubility > Acute toxicity
Low Hazard	■	Solubility < Acute toxicity

4.6.3.2 Henry's Law Constant

Henry's Law is a partition coefficient which is a measure of the tendency of a substance to partition into air from water at constant temperature and pressure. It can be used as a measure of environmental fate and transport of a substance. Henry's Law Constant is calculated using vapour pressure, molecular weight and water solubility for a chemical and is commonly expressed either as 'dimensionless' (i.e., no units) or in 'dimensions' (i.e., units of atmospheres (atm) m^3/mol or Pa m^3 mol-1). Henry's Law Constant data were used in the environmental hazard assessment even though one of the parameters on which it is based (namely solubility) is assessed and scored separately.

Organic chemicals with a low Henry's Law Constant (i.e., low volatility and high solubility) are likely to be more persistent in the environment. Organic chemicals with a high Henry's Law Constant (i.e., high volatility, low water solubility) are likely to be less persistent in the environment. Organic chemicals with a low Henry's Law Constant were considered to present a greater environmental hazard in this assessment.

Henry's Law Constant benchmarks were assigned based on ranges provided in CCME (2008), Langley (1993) and professional judgement. The benchmarks are summarised in Table 10.

Inorganic chemicals were not assessed using Henry's Law Constant.

Table 10: Benchmarks for Henry's Law Constant

Hazard Category	Hazard Symbol	Henry's Law Constant (atm m3/mol)
High Hazard	■	$<6.1x10^{-09}$
Moderate Hazard	◖	$6.1x10^{-09}$- $6.1x10^{-05}$
Low Hazard	■	$>6.1x10^{-05}$

4.6.3.3 Soil Adsorption Partition Coefficient (K_{oc})

The soil organic carbon-water partitioning coefficient is the ratio of the mass of a chemical that is adsorbed in the soil per unit mass of organic carbon in the soil. It is a measure of the tendency for organic substances to be adsorbed by soil or sediment. K_{oc} values are useful in predicting the mobility of organic contaminants in soil and sediment. Higher K_{oc} values correlate to less mobile organic chemicals while lower K_{oc} values correlate to more mobile organic chemicals. Organic chemicals with lower mobility (greater persistence) are considered in this assessment to be a greater environmental hazard. The benchmarks for K_{oc} used are presented in Table 11. These benchmarks were derived after consideration of information provided in CCME (2008); Langley (1993) and Swann et al. (1983) and professional judgement.

Table 11: Log K_{oc} Benchmarks

Hazard Classification	Hazard Symbol	Log Koc Range (L/kg)
High Hazard	■	<3.7
Moderate Hazard	◖	2.7-3.7
Low Hazard	■	>2.7

4.6.3.4 Biodegradation

Degradation takes into account physical, biological, and chemical changes in a chemical over time (Langley, 1993). Biodegradation is "the process by which organic substances are decomposed by micro-organisms (mainly aerobic bacteria) into simpler substances such as carbon dioxide, water and ammonia" (UN, 1997 cited in OECD, 2010). The rate of biodegradation is generally described as percentage degradation over a period of days (28 days is often the benchmark), but sometimes longer or shorter exposure periods are reported. The longer the time taken for a substance to degrade, the more environmentally persistent that chemical is considered to be. Lower percentages of biodegradation over 28 days were considered to be indicative of higher environmental hazard.

The benchmarks assigned were based on guidance in Environment Canada (2003), UNECE (2011), the European Commission (2003) and professional judgement.

The following biodegradation data were sought:

- Aerobic Ready Biodegradability;
- Ultimate Biodegradation;
- Primary Biodegradation; and
- Anaerobic Biodegradation.

The use of more than one biodegradation measure was to capture appropriate measures of biodegradation for the likely environmental exposures to hydraulic stimulation chemicals. Summary details of the tests are described below.

i) **Aerobic Ready Biodegradation**. The aerobic ready biodegradability test is considered a stringent test likely to generate slower degradation rates than may actually occur in the natural environment or in a sewage treatment plant. It employs a high concentration of the test chemical and biodegradation rates are measured via non-specific parameters such as dissolved organic carbon, biological oxygen demand, and carbon dioxide production. Ready biodegradability testing is commonly used as the first screen to test for biodegradation potential and employs the use of microorganisms that are not pre-adapted to degradation of the chemical substance. A negative result in a test for ready biodegradability does not necessarily mean that the chemical will not be degraded under relevant environmental conditions;

ii) **Anaerobic Biodegradation**. Anaerobic biodegradation testing is a screening test to measure the potential for biodegradation under anoxic conditions. The test substance (the only source of added organic carbon in the test) is exposed to diluted anaerobically digested sludge. Biodegradability of the test substance is measured via increased headspace pressure resulting from the evolution of carbon dioxide, methane and total inorganic carbon. The test is performed at 35°C to simulate the temperature in heated digesters or anaerobic sludge treatment. This temperature favours anaerobic biodegradation of chemicals with low or moderate toxicity to anaerobic bacteria. On the other hand, because this test uses a high concentration of test substance, negative results may be observed for some chemicals that would otherwise be biodegradable at lower concentrations. Anaerobic biodegradation half-lives were sought on the basis that the groundwater environment is likely to be anaerobic;

iii) **Ultimate Biodegradation**. Ultimate biodegradation[13] testing aims to measure the time taken for a test substance to biodegrade completely into simple molecules e.g. carbon dioxide, biomass, water and other inorganic substances like ammonia; and

iv) **Primary Biodegradation**. Primary biodegradation[14] testing measures the disappearance of the compound as a result of its biotransformation to another product

A summary of the nominated aerobic ready biodegradation and anaerobic biodegradation benchmarks and the associated hazards assigned are presented in Table 12. These data were generated by EPISUTE™ BIOWIN™ and represent one of two potential outputs and hence a moderate hazard is not possible.

Table 12: Ready Aerobic and Anaerobic Biodegradation Benchmarks

Hazard Classification	Hazard Symbol	Aerobic Ready Biodegradability (EPISUITE™)	Anaerobic Biodegradation (EPISUITE™ BIOWIN 7)
High Hazard	■	No	≤0.5 Does not biodegrade fast
Low Hazard	■	Yes	≥0.5 Biodegrades fast

A summary of the nominated Ultimate Survey Biodegradation and Primary Biodegradation benchmarks and associated hazards are presented in Table 13. These data were generated using EPISUITE™ and BIOWIN™.

Table 13: Ultimate and Primary Biodegradation Benchmarks

Hazard Classification	Hazard Symbol	Ultimate Survey Biodegradability (EPISUITE™ BIOWIN 3)	Primary Biodegradation (EPISUITE™ BIOWIN 4)
High Hazard	■	<2 (2 equates to months, 1 equates to longer than months)	<2 (2 equates to months, 1 equates to longer than months)
Moderate Hazard	◖	2 – 3 (2 equates to months, 3 equates to weeks)	2-3 (2 equates to months, 3 equates to weeks)
Low Hazard	■	>3 (3 equates to weeks, 4 equates to days, 5 equates to hours)	>3 (3 equates to weeks, 4 equates to days, 5 equates to hours)

[13] Ultimate biodegradation is a measure of inherent biodegradability. Inherent biodegradability is similar to ready biodegradability testing with the exception that a low concentration of the test substance is used with a greater proportion of microorganisms that may be pre-adapted to the test substance. The conditions of an inherent biodegradation test are optimised to achieve rapid biodegradation. Inherent aerobic biodegradation data may over estimate the potential for biodegradation in the natural environment.

[14] Primary biodegradation is a measure of inherent biodegradability.

4.6.4 Bioaccumulation

Bioaccumulation potential was assessed for organic chemicals only and using two parameters: BCF and log K_{ow}, as discussed below.

Bioaccumulation was not assessed for inorganic chemicals because the bioaccumulation of inorganic chemicals is difficult to predict and was considered beyond a screening level risk assessment.

4.6.4.1 Octanol / Water Partition Coefficient (K_{ow})

The octanol-water partition coefficient (K_{ow}) is the ratio of the solubility of a chemical in octanol divided by its solubility in water. It is a measure of the preference for an organic substance to dissolve in an organic solvent or water and is used as a measure of lipophilicity and movement of a substance across a cell membrane. It is usually expressed as Log K_{ow}. It can be used to estimate environmental fate and transport of a chemical.

There is general consensus in the literature that a Log K_{ow} of less than 3.5 represents low or moderate potential to bioaccumulate, and a Log K_{ow} of greater than 3.5 represents an increased potential to bioaccumulate. UNECE (2009) consider that substances with Log K_{ow} less than 4 have no potential to bioaccumulate. UNECE (2009) and CCME (2008) consider that substances with Log K_{ow} greater than 4 have the potential to bioaccumulate. The European Commission (2003) consider that substances with Log K_{ow} greater than 4.5 have the potential to bioaccumulate. The benchmarks used in this study are summarised in Table 14 and were largely based on the classes provided by European Commission (2003), UNECE (2009), CCME (2008) and professional judgment.

Log K_{ow} is assessed for organic chemicals only.

Table 14: Log K_{ow} Benchmarks

Hazard Classification	Hazard Symbol	Log Kow (unitless)
High Hazard	■	>5
Moderate Hazard	◖	3-5
Low Hazard	■	<3

4.6.4.2 Bioconcentration Factor (BCF)

The bioconcentration factor (BCF) is a measure of the tendency for a substance in water to accumulate in organisms, in particular fish. This parameter is an important determinant for uptake into organisms, potential for biomagnification and secondary poisoning (food chain transfer to higher trophic levels). The higher the BCF, the greater the potential for bioconcentration and secondary poisoning. The benchmarks assigned are summarised in Table 15. These benchmarks were assigned after consideration of information provided in ANZECC and ARMCANZ (2000), Franke et al. (1994), European Commission (2003), UNECE (2009) and professional judgment. The benchmarks presented by Franke et al. (1994) were more conservative than those presented by ANZECC and ARMCANZ (2000), the European Commission (2003) and UNECE (2009). As ANZECC and ARMCANZ (2000), European Commission (2003) and UNECE (2011) guidance were prepared with significant peer review by international scientific experts in their development, these guidance frameworks were given precedence over Franke et al. (1994). BCF was assessed for organic chemicals only.

Table 15: BCF Benchmarks

Hazard Classification	Hazard Symbol	BCF (unitless)
High Hazard	■	>5000
Moderate Hazard	◖	1000 - 5000
Low Hazard	■	<1000

4.6.5 Toxicity

There were frequently insufficient data to enable an assessment of both acute and chronic toxicity hence the highest hazard assigned to either the acute and chronic data was adopted as the classification of hazard for toxic (T) potential for the hydraulic stimulation chemicals. This resulted in weighting of the assessment towards T. This was considered conservative and appropriate for a screening level hazard assessment.

4.6.5.1 Aquatic Ecotoxicology

To assess the toxic (T) potential of the chemicals, readily available acute (i.e., predominantly L(E)C_{50}[15]) and chronic (i.e., NOEC[16], LOEC[17], MATC[18] and non-lethal EC_{50}) data for aquatic organisms were collated.

Chronic aquatic ecotoxicology data are preferred over acute because exposure occurs over a longer time-period, usually during a significant period of the organism's life-cycle or during a sensitive life-stage. However, acute ecotoxicological data dominate in the literature compared to chronic data. Acute toxicity is relevant if the anticipated environmental exposure concentrations are in the acute toxicity concentration range. The receptor groupings considered (plants, invertebrates and fish) and endpoints considered (acute, chronic) were given equal weighting.

As freshwater aquatic organisms were considered the most likely aquatic receptor exposed to hydraulic stimulation chemicals albeit the likelihood for exposure is low (refer Section 2.0), freshwater ecotoxicological data were used in the assessment of toxic potential. There are generally few aquatic ecotoxicological data available for amphibians and reptiles, and no guidance was found in the international literature on the assessment of hazard for these receptor groups. Hence these receptors groups were excluded from the assessment of T.

The data obtained from USEPA ECOTOX database were screened as follows:

- Endpoints selected included mortality (acute), growth (chronic) and reproduction (chronic) for plants, invertebrates and fish;
- Chronic mortality exposures were not considered;
- Studies longer than 7 d were considered to be chronic (with the exception of microalgae);
- Studies shorter than 24 hrs were not considered; and
- L(E)C_x endpoints other than L(E)C_{50} were not considered (namely EC_0, EC_{100}, EC_{10}, EC_{20}, etc).

[15] Lethal (or effect) concentration that kills (or effects) 50% of the test population.

[16] No observed effect concentration.

[17] Lowest observed effect concentration.

[18] Maximum acceptable tolerable concentration.

Although included in the environmental hazard assessment, NOECs are not statistical or empirical point estimates of ecological effect. NOECs are hypothesis-based and reflect the test design (i.e., concentrations of exposure) rather than the dose-response curve. However, NOECs are well documented in the literature and are commonly used in ecological risk assessment and in derivation of risk-based ecological guidelines. Additional chronic endpoints namely LOEC, MATC and EC_{50} were included in the hazard assessment to reduce the uncertainly associated with NOEC data.

Chronic data modelled using ECOSAR™ represent the geomean of NOEC and LOEC endpoints. Because the hazard assessment differentiated between NOEC and LOEC in assessment, these ECOSAR data were not used.

The chronic aquatic ecotoxicology ranges (for plants, invertebrates and fish) were assigned after consideration of information provided in European Commission (2003); UNECE (2009) and professional judgement. As a conservative approach to assessment of T, the lowest chronic effect concentration for each of NOEC, LOEC/MATC/EC_{50}, and the lowest acute effect concentration for L(E)C_{50} were used. The benchmarks adopted for chronic aquatic toxicological data are summarised in Table 16 and Table 17.

Table 16: Chronic Aquatic Toxicity NOEC Benchmarks

Hazard Classification	Hazard Symbol	Chronic Aquatic NOEC (mg/L)
High Hazard	■	<0.01
Moderate Hazard	◖	0.01 – 0.1
Low Hazard	■	>0.1

Table 17: Chronic Aquatic Toxicity LOEC/MATC/EC50 Benchmarks

Hazard Classification	Hazard Symbol	Chronic Aquatic NOEC (mg/L)
High Hazard	■	<0.1
Moderate Hazard	◖	0.1 – 1
Low Hazard	■	>1

The acute aquatic ecotoxicity benchmarks (for plants, invertebrates and fish) were assigned after consideration of information provided in European Commission (2003); UNECE (2005) and professional judgement. The acute aquatic toxicity benchmarks are summarised in Table 18. The acute toxicity studies represent lethal endpoints.

Table 18: Acute Aquatic Toxicity L(E)C/50 Benchmarks

Hazard Classification	Hazard Symbol	Acute Aquatic L(E)C50 (mg/L)
High Hazard	■	<1
Moderate Hazard	◖	1 – 100
Low Hazard	■	>100

4.6.6 Environmental Hazard Classification

The environmental hazard classification assigned was based on the WOE for multiple LOE. The classifications were based on the available data, even if there were data gaps. Consequently, a measure of data gaps was assigned to quantify this uncertainty.

It should be noted that T classifications for a number of chemicals were based on modelled, rather than measured data. The modelled ecotoxicological data were from ECOSAR™ (discussed in Section 4.1.2). There is uncertainty associated with modelled data. The twenty-three (23) chemicals for which modelled toxicological data were used are shown below in Table 19.

Table 19: List of Chemicals Assessed Using Modelled ECOSAR™ Data

Chemical	CAS RN
Surrogate for sodium gluconate	526-95-4
Surrogate for polylactide resin	50-21-5
Polyethylene glycol monohexyl ether	31726-34-8
Sodium glycolate	2836-32-0
Cetylethylmorpholinium ethyl sulphate	78-21-1
2,2’2”-nitrilotriethanol	102-71-6
Polyethylene glycol sorbitan monolaurate	9005-64-5
Dicoco dimethyl quarternary ammonium chloride	61789-77-3
Disodium ethylene diamine tetra acetate	139-33-3
Trisodium ethylene diamine tetra acetate	150-38-9
Tetrasodium ethylene diamine tetra acetate	64-02-8
Trisodium nitriloacetate	5064-31-3
5-chloro-2-methyl-2h-isothiazol-3-one	26172-55-4
2-methyl-2h-isothiazol-3-one	2682-20-4
Propan-2-ol	67-63-0
Alkyl (C12-C16) dimethylbenzyl ammonium chloride	68424-85-1
Decyldimethyl amine	1120-24-7
Decyl-dimethyl amine oxide	2605-79-0
L-Glutamic acid	56-86-0
Pentaethylenehexamine	4067-16-7
Triethylenetetramine	112-24-3

Chemical	CAS RN
Surrogate for acrylamide, 2-acrylamido-2-methylpropanesulfonic acid, sodium salt polymer	38193-60-1
Surrogate for hydroxpropyl cellulose	9004-64-2

Surrogate chemicals were used for chemicals where the physico-chemical and/or toxicological data were insufficient. The six (6) chemicals assessed using surrogates are presented in Table 20.

Table 20: List of Surrogate Chemicals

Chemical	CAS RN	Surrogate descriptor
1,1 DCE	75-35-4	Surrogate for Vinylidene chloride/methacrylate
Gluconic acid	526-95-4	Surrogate for sodium gluconate
Lactic Acid	50-21-5	Surrogate for polylactide resin
2-Acrylamido-2-methylpropanesulfonic acid	5165-97-9	Surrogate for acrylamide, 2-acrylamido-2-methylpropanesulfonic acid, sodium salt polymer
Decanoic acid	57-11-4	Surrogate for octadecanoic acid, calcium salt
Hydroxypropyl methylcellulose	9004-65-3	Surrogate for hydroxypropyl cellulose

A further group of six (6) inorganic chemicals presented in Table 21 below were not assessed as these were considered to chemically equivalent to sand and / or chemically inert.

Table 21: Chemicals Equivalent to Sand and / or Chemically Inert

Chemical	CAS RN
Crystalline silica, quartz	14808-60-7
Crystalline silica, cristobalite	14464-46-1
Non-crystalline silica	7631-86-9
Surrogate for Ceramic materials and wares	1335-58-7
Diatomaceous earth	91053-39-3
Silica gel, pptd., cryst.-free	112926-00-8

Of the fifty-two (52) hydraulic stimulation chemicals assessed, forty-four (44) were classified for aquatic hazard. Of these forty-four (44) chemicals, twenty-two (22) were classified low hazard, fourteen (14) were classified moderate hazard, and eight (8) were classified high hazard. Of the remaining eight (8) chemicals, six (6) were not subject to PBT assessment as discussed earlier and presented in Table 21, while the remaining two, guar gum and sodium carboxymethylhydroxypropyl guar, are discussed below.

Guar gum and sodium carboxymethylhydroxypropyl guar, were not assessed for PBT as there were insufficient data to quantitatively assess persistence or bioaccumulation. However, the USEPA (2005) reviewed human and ecological hazards of hydroxypropoyl guar gum (a similar compound to carboxymethylhydroxypropyl guar and guar gum and considered likely to exhibit similar properties). Hydroxypropyl guar gum is used as a thickener in pesticide formulations. USEPA (2005) considered hydroxypropyl guar to be readily biodegradable and of low acute and chronic toxicity to aquatic and terrestrial organisms. On this basis, carboxymethylhydroxypropyl guar and guar gum are considered to be a low hazard to aquatic receptors.

Five chemicals, sodium hydroxide, hydrochloric acid, magnesium chloride, potassium hydroxide and magnesium nitrate were not scored for persistence as these chemicals readily dissociate in the environment.

The hydraulic stimulation chemical environmental hazard classifications of the forty-four (44) chemicals are summarised in Table 22, with the detailed PBT values for each chemical provided in Table D2, APPENDIX D.

Table 22: Hydraulic Stimulation Chemicals Environmental Hazard Classifications

Rank	Name for Report	CAS RN	Overall Hazard Classification	Data Gaps %
High	Dicoco dimethyl quarternary ammonium chloride	61789-77-3	■	39%
	Alkyl (C12-C16) dimethylbenzyl ammonium chloride	68424-85-1	■	39%
	Sodium tetraborate	1330-43-4	■	55%
	Nitrogen, liquid form	7727-37-9	■	55%
	Boric acid	10043-35-3	■	9%
	Magnesium silicate hydrate (talc)	14807-96-6	■	64%
	Hydrogen peroxide (impurity)	7722-84-1	■	27%
	Zirconium dichloride oxide	7699-43-6	■	64%
Moderate	Polyethylene glycol monohexyl ether	31726-34-8	◖	39%
	Cetylethylmorpholinium ethyl sulfate	78-21-7	◖	39%
	5-chloro-2-methyl-2h-isothiazolol-3-one	26172-55-4	◖	17%
	2-methyl-2h-isothizol-3-one	2682-20-4	◖	44%
	Decyldimethyl amine (impurity)	1120-24-7	◖	22%
	Decyl-dimethyl amine oxide	2605-79-0	◖	11%
	Pentaethylenehexamine	4067-16-7	◖	28%
	Tetramethylammonium chloride	75-57-0	◖	22%

Rank	Name for Report	CAS RN	Overall Hazard Classification	Data Gaps %
	Ethanol	64-17-5	◖	22%
	Sodium hydroxide	1310-73-2	◖	64%
	Sodium thiosulfate	7772-98-7	◖	45%
	Potassium hydroxide	1310-58-3	◖	73%
	Magnesium chloride	7786-30-3	◖	64%
	Surrogate for Octadecanoic acid, calcium salt	57-11-4	◖	44%
Low	Cholinium chloride	67-48-1	■	28%
	2,2',2"-nitrilotriethanol	102-71-6	■	22%
	Sodium bromate	7789-38-0	■	82%
	Sodium glycolate (impurity)	2836-32-0	■	33%
	Disodium ethylene diamine tetra acetate	139-33-3	■	11%
	Trisodium ethylene diamine tetra acetate	150-38-9	■	50%
	Trisodium nitriloacetate (impurity)	5064-31-3	■	33%
	Surrogate for sodium gluconate	526-95-4	■	50%
	Surrogate for polylactide resin	9051-89-2	■	33%
	Tetrasodium ethylene diamine tetra acetate	64-02-8	■	39%
	Polyethylene glycol sorbitan monolaurate	95005-64-5	■	44%
	Propan-2-ol	67-63-0	■	39%
	Butyl diglycol	112-34-5	■	33%
	Fumaric acid	110-17-8	■	39%
	L-glutamic acid	56-86-0	■	33%
	Tetraethylenepentamine	112-57-2	■	33%
	Triethylenetetramine	112-24-3	■	28%
	Hydrochloric acid	7647-01-0	■	64%

Rank	Name for Report	CAS RN	Overall Hazard Classification	Data Gaps %
	Magnesium nitrate	10377-60-3	■	73%
	Surrogate for vinylidene chloride/methacrylate copolymer	75-35-4	■	22%
	Surrogate for acrylamide, 2-acrylamido-2-methylpropanesulfonic acid, sodium salt polymer	5165-97-9	■	28%
	Surrogate for hydroxypropyl cellulose	9004-65-3	■	50%

4.6.7 Identification of Chemicals of Potential Concern (COPC) to Aquatic Ecosystems

Based on the hazard classification of the individual hydraulic stimulation chemicals (as presented in Table 22), the eight chemicals classified as a high hazard were considered to be COPC, these were:

- Dicoco dimethyl quarternary ammonium chloride;
- Alkyl (C12-C16) dimethylbenzyl ammonium chloride;
- Sodium tetraborate;
- Nitrogen, liquid form;
- Boric acid;
- Magnesium silicate hydrate (talc);
- Hydrogen peroxide (impurity); and
- Zirconium dichloride oxide.

The certainty of the hazard classification varies depending on the extent of data gaps and the reliance on modelled data. The percent of data gaps was calculated for all chemicals and is presented in Table 22. The percentage data gaps ranged from 9% to 82% for the chemicals assessed.

Of the eight high aquatic hazard chemicals identified in Table 22, the following further interpretations are provided:

- Only one (liquid nitrogen) chemical is expected to be in concentrations greater than 0.1% in a stimulation fluid mixture (as indicated by the fluid descriptions), and five of the high aquatic hazard chemicals (dicoco dimethyl quaternary ammonium chloride, sodium tetraborate, zirconium dichloride oxide, magnesium silicate hydrate (talc) and hydrogen peroxide (impurity)) are expected to be at concentrations less than 0.01%.
- Nitrogen is only a liquid at low temperature and pressure, conditions which will not prevail in the hydraulic stimulation fluid or at the drill pad. Nitrogen is a gas at atmospheric temperature and pressure. The extent that nitrogen will have reacted with other constituents in the hydraulic stimulation mixture before volatilisation, is not known. Mixtures and their assessment are discussed further in section 4.6.8.
- Boric acid, magnesium silicate hydrate (talc), hydrogen peroxide, zirconium dichloride oxide and sodium tetraborate are considered as high hazards in this assessment based primarily on persistence. Review

and interpretation of the aquatic toxicity data suggest these five chemicals present a moderate to low aquatic toxicity hazard.

- Dicoco dimethyl quarternary ammonium chloride is considered a high hazard based primarily on its toxicity. The toxicity data available for this chemical is limited (only acute fish and invertebrate data available) however and review and interpretation of the persistence and bioaccumulation data suggest this chemical presents a moderate to low aquatic hazard in terms of P and B.
- Alkyl (C12-C16) dimethylbenzyl ammonium chloride is considered a high hazard based on its high persistence and aquatic toxicity. As with dicoco dimethyl quarternary ammonium chloride, the toxicity data available for this chemical is limited, with only acute fish and plant data available.

Given the management controls in place to prevent releases to the environment, potential aquatic hazards from individual hydraulic stimulation chemicals, are considered unlikely to be realised.

4.6.8 Evaluation of Mixture Toxicity

It is noted that the EA requirements in (s) refer to the provision of "...assessment of the chemicals used including their mixtures and the resultant chemicals that are formed after stimulation".

The environmental hazard assessment did not consider the combined effects of the hydraulic stimulation chemicals when present in a mixture. Assessment of mixtures is considered beyond the scope of a screening level assessment. Approaches for environmental risk assessment of individual chemicals are inherently conservative and designed to over-estimate risk as a precautionary approach and in recognition of the uncertainty surrounding effects of mixtures.

Methodologies for estimating combined effects of mixtures are being developed. There are two recognised models for joint action, these are:

- Predictive concentration addition; and
- Response addition.

Predictive concentration addition applies to mixtures of chemicals with the same mechanisms of action. That is, the toxic effect manifests in the same manner (e.g., narcosis) at the same location (e.g., central nervous system) for the different chemicals assessed.

Response addition applies to chemical mixtures with different mechanisms of action.

The majority of chemical mixtures (based predominantly on the research of mixture toxicity of organic chemicals) conform to concentration addition (NEPC, 2013). Warne (in NEPC, 2013) concluded following review of the literature on mixture toxicity that the concentration addition approach over-estimated toxicity (i.e., is more conservative) compared to response addition. This is consistent with opinion in the current, international literature where the approach for assessment of mixtures remains the concentration addition approach as a default, conservative position. Following this approach, the assessment of mixture effects in a risk assessment is concluded by summing hazard quotients (HQ) into a hazard index (HI).

The Australian national water quality management strategy (ANZECC & ARMCANZ, 2000) guidance recommends the use of direct toxicity assessment (DTA) for assessment of mixture impacts on the environment. Direct toxicity assessment (DTA) entails collection of an environmental sample containing the chemical mixture and undertaking ecotoxicological testing (exposing test organisms to the environmental sample and measuring effect).

Recent international reviews on mixture toxicity by Kortenkamp et al., (2009) and the European Commission (2012) have documented the current scientific knowledge and regulatory approaches for assessment of mixtures. These reviews acknowledge the constraints in assessing impacts from mixtures on the environment

but do not offer new approaches for mixture assessment. Instead these reviews make recommendations for identified chemical mixtures (generally with widespread commercial and global usage) to be prioritised for risk assessment in order to better evaluate possible human and environmental health effects.

Given the limited, endorsed mixture toxicity assessment guidance for Australia or elsewhere, assessment of the hydraulic stimulation fluid mixtures by identification and assessment of the individual chemicals (based on the identified active ingredients or their surrogates) is considered conservative and appropriate for a screening level assessment. However, as the EA requires provision of "...*assessment of the chemicals used including their mixtures and the resultant chemicals that are formed after stimulation"*, further assessment of hazards from the hydraulic stimulation fluid mixture is recommended. The scope of the mixture assessment should be confirmed with DEHP given the uncertainties, cost and timeframe implications associated with desktop studies (e.g., adoption of a hazard index approach) as opposed to laboratory-based studies (e.g., DTA testing).

4.7 Exclusions and Limitations

The environmental hazard assessment is a qualitative assessment of environmental hazard. The following limitations with regard to the hazard assessment and source data are noted:

- The approaches consulted for assessment of PBT in devising the environmental hazard assessment approach were predominantly focussed on the assessment of organic chemicals. There was limited guidance for PBT assessment of inorganic chemicals.
- The hazard assessment approach relied in part on professional judgment and the evaluator's subjectivity in designating the parameter ranges for each parameter assessed.
- The assessment did not consider, *inter alia*.
  - Breakdown or reactive products of the chemicals that may pose more or less of an environmental hazard than the parent compound.
  - The quality, adequacy or accuracy of the available information sourced, noting that only sources considered to be reputable were used.
  - Endocrine disruption effects that are not assessed by standard ecotoxicological tests.
  - The combined effects of these chemicals when present in mixture (see comments in Section 4.6.8 regarding mixture toxicity information).
- The environmental hazard assessment approach did not adequately assess chemicals which were:
  - Hydrophilic i.e., highly soluble with low K_{ow}. Where aquatic ecotoxicological data were limited for these types of chemicals, toxicity may be underestimated because there is potential for these chemicals to be highly toxic.
  - Poorly biodegradable, of low acute toxicity, but were bioaccumulative (based on the BCF or K_{ow}). These chemicals may exert chronic effects via accumulation in tissues over time.
- The data collated in the chemical information sheets (presented in APPENDIX F) were treated the same regardless of whether the data were measured experimental values or modelled / calculated values.
- It is noted in relation to the aquatic ecotoxicological data:
  - The species *Daphnia magna* are a sensitive species, displaying sensitivity to chemicals greater than other invertebrate species.
  - The test endpoint description in the (secondary) sources consulted was relied upon although it should be noted that true chronic and acute NOEC, LOEC, MATC and L(E)C50 depend on a variety of factors such as test duration, species tested, stage in the life-cycle, etc. which can only be verified by review of the primary literature.

  - Sources of Australian aquatic ecotoxicological data were consulted but the information was very limited. Furthermore, many species reported in the Australian literature were not necessarily indigenous species; and

- There were no minimum data requirements (i.e. some chemicals were assessed based on few data for each of P, B, or T). In order to quantify this uncertainty, a measure of data gaps expressed as a percentage is identified in Table 22.

5.0 TERRESTRIAL TOXICITY ASSESSMENT

The previous section presented the assessment of environmental hazard based on P, B and T, where the toxic (T) potential was limited to aquatic receptors. As the following terrestrial receptors (soil microorganisms, plants and animals (vertebrates and invertebrates)) are considered possible or likely receptors[19] that may come into contact with hydraulic stimulation fluid chemicals, an assessment of hazard to terrestrial receptors was developed in accordance with guidance presented in the following frameworks:

- European Commission (2003) Technical Guidance Document on Risk Assessment in support of Commission Directive 93/67/EEC on Risk Assessment for New Notified Substances, Part II Chapter 3 Environmental Risk Assessment; and
- National Environment Protection Council (NEPC) (2013). National Environment Protection (Assessment of Site Contamination) Amendment Measure.

5.1 Methodology

The methodology for selection, collation and assessment of terrestrial toxicological data for the purposes of assessing potential hazard to terrestrial receptors from the stimulation fluid chemicals is described in the following paragraphs.

Note that the approach for assessment of hazard to terrestrial receptors differs from the assessment of hazard presented in Section 4.3. Collation of physico-chemical and toxicological data for PBT hazard assessment (as was done with the aquatic toxicological data) was not undertaken. The available physical, chemical, and toxicological data were not considered sufficiently robust for a PBT assessment. Consequently the COPC to terrestrial receptors were identified based on the terrestrial toxicological data. Physico-chemical data was then used to assess the likelihood for environmental exposure (discussed in Section 5.1.2 below). This approach results in a semi-quantitative or qualitative assessment of hazard to terrestrial receptors.

5.1.1 Terrestrial Toxicological Data Sources

Where terrestrial toxicological data are available, this may be limited to results from short-term tests using earthworms and plants, rather than (preferred) long-term test results (European Commission, 2003). Studies that assess effects on soil function are rarely available in the literature, and the potential for food chain transfer (e.g., secondary poisoning via bioaccumulation) is not assessed via ecotoxicological studies. This can pose challenges for development of soil screening criteria protective of terrestrial receptors. To address these data deficiencies, the approach developed was to use QSARs to predict toxicity (using aquatic data), and laboratory mammal toxicological data as lines of evidence to identify COPC for terrestrial receptors. This approach has been adopted in this report based on guidance in the European Commission (2003) and NEPC (2013). However, guidance on assessment of effects on soil function was not found during the preparation of this report.

The European Commission (2003) suggest that the equilibrium partitioning method can be applied to aquatic data to identify a probable no effect concentration (PNEC) for soil organisms. The equilibrium partitioning method uses aquatic toxicological data combined with chemical partitioning properties (between soil and water) and soil density to predict the toxicity to soil organisms. This method cannot replace toxicity data for soil organisms and should only be considered as a screen for identifying substances requiring further testing (EC, 2003). The Amended NEPM (NEPC 2013) similarly recommends the use of the equilibrium partitioning method only where QSARs are unavailable.

[19] Note that the exposure pathway assessment of this report (Section 7.0) lists the sources, pathways of exposure, and receptors that may come into contact with the hydraulic stimulation fluid chemicals.

The approach adopted was to draw from the large dataset of laboratory mammal (rat, mouse, and rabbit) toxicological data and use these animals as surrogates for the potential mammalian terrestrial receptors (e.g., livestock and native mammalian fauna) that may come in contact with stimulation fluid chemicals on or near to a well lease. It is acknowledged that these data are limited in application as they generally comprise acute (LC50) data for receptors that are not of direct interest for the possible stimulation fluid exposures involved. Moreover, toxicological data from laboratory mammals are unsuitable surrogates for other terrestrial receptors such as reptiles, birds, invertebrates and plants.

The following sections (5.1.1.1 to 5.1.1.2) list the sources of information and data used to collate and generate terrestrial toxicological data.

5.1.1.1 Toxicological Databases

Laboratory mammalian, earthworm, and plant data were sourced from readily available databases and literature. Acute oral LD50 laboratory data for rats, mice and rabbits were selected from sources such as the European Chemicals Bureau (ECB IUCLID), HSDB and USEPA ECOTOX. The studies used to generate laboratory mammal data are designed with the aim of assessing chemical hazard to human health. Consequently the relevance of these studies to Australian mammalian receptors is uncertain. Given the paucity of terrestrial toxicological data for the stimulation fluid chemicals on Australian fauna, rabbits and mice were considered as the best surrogates for mammalian receptors potentially present on well leases.

Earthworm data (e.g., from USEPA ECOTOX database) were used where the toxicological endpoint was mortality or reproduction and reported in units of milligrams of chemical per kilogram soil (mg/kg). Earthworm studies with other endpoints (e.g., behaviour) and/or units in other forms (e.g., micro-grams per cm^2) were not considered.

Similarly, plant data (e.g., from USEPA ECOTOX database) were used where the toxicological endpoint (e.g., NOEC) was reproduction or population (e.g., biomass or abundance) and reported in milligrams of chemical per kilogram of soil (mg/kg). Plant studies with other endpoints (e.g., foliar damage) and/or units in other forms (e.g., % or mg/mL of applied solution) were not considered.

5.1.1.2 QSARs

As indicated previously, QSARs are empirical relationships between the toxicity of contaminants to a particular test organism and one or more physicochemical properties of the contaminant (NEPC 2013). QSARs are derived for contaminants with either the same mechanism of action or similar molecular structure (NEPC 2013).

Three QSARs were used to derive additional terrestrial data for this report. NEPC (2013) reference the QSAR of Huzelbos et al. (1991) which predicts the concentration at which 50% growth inhibition (EC50, in units of micro-mol per litre) in lettuce (*Lactuca sativa*) would occur. The equation for the QSAR uses the chemical property log K_{ow} (described in Section 4.6.4.1 and recorded on the chemical information sheets). The QSAR equation of Huzelbos et al. (1991) is:

$$\log EC50 = -0.72 \log K_{ow} + 3.37$$

The Hulzelbos et al. (1991) QSAR was used to predict toxicity of organic chemicals to terrestrial plants, acknowledging that lettuce is not a native flora species, nor of relevance as receptor on a well lease. This QSAR provided the main dataset of terrestrial plant toxicity for the chemicals assessed. It could not be used for inorganic chemicals.

The second QSAR used was that of van Gestel (1992), which predicts the toxicity of earthworms (as the NOEC) in units of mg chemical per kg soil. This QSAR is referenced both by the European Commission (2003) and NEPC (2013) and uses equilibrium partitioning to predict the toxicity of a chemical in soil using

aquatic toxicity data. It is not suitable for chemicals with a log K_{ow} greater than 4 or for chemicals with a specific mode of action (e.g., endocrine disruptors).

The van Gestel (1992) QSAR was used to predict the toxicity of organic chemicals to earthworms and uses soil density (RHO in kg soil per m^3 of soil) and the soil to water partitioning coefficient (K_d in m^3 water per m^3 soil), in combination with the NOEC (in mg/L) for the aquatic environment. The equation is:

$NOEC_{soil} = K_d/RHO_{soil} * NOEC_{water} * 1000$

The soil to water partitioning coefficient (K_d, m^3water/m^3soil) is a function of both the fraction organic carbon content (f_{oc} in kg organic carbon per kg of soil) of soil and the soil organic carbon partitioning coefficient (K_{oc} in L water per kg organic carbon), and the equation is:

$K_d = f_{oc} \times K_{oc}$

A f_{oc} of 0.01 and bulk density of 1.6 g/cm^3 for soil was assumed in the use of this QSAR.

The third QSAR used was that used in the ECOSAR™ modelling programme. The programme uses the log K_{ow} to estimate toxicity (14-day LC50) to earthworms in units of mg/L. The equation is:

Log 14-d LC50 (mmol/L) = - 0.1037 log K_{ow} + 0.4476

The programme converts the units from mmol/L to mg/L. ECOSAR™ was used to estimate the toxicity of the stimulation fluid chemicals to earthworms.

5.1.2 Use of Physico-chemical Data

Following guidance in NEPC (2013), the relative importance of an exposure pathway to a terrestrial receptor can be determined by assessment of the chemicals-specific properties, and the soil-specific properties that affect chemical bioavailability and environmental fate. Some physicochemical properties of chemicals, for example, partitioning between octanol and water (K_{ow}), partitioning from soil to water (K_d), and volatility (using Henry's law constant (K_H)), can be used to predict the most important exposure pathways for a chemical in terrestrial environments. Organic and inorganic chemicals have different physicochemical properties that control their environmental fate. Consequently, different methods apply to assessment of organic vs. inorganic chemical exposures in terrestrial environments.

The environmental fate of organic chemicals is largely controlled by the following physicochemical properties:

- Half-life (t ½), Table 23.
- Henry's Law Constant (K_H), Table 24; and
- The octanol-water partition coefficient (K_{ow}) which, in general, determines a chemicals potential to cause secondary poisoning.

5.1.2.1 Half-life

The half-life (t½) of a chemical is a measure of persistence (P) in the environment. It represents the time taken for 50% of the chemical to be lost from the environment. The loss may occur through biodegradation (microbial mediated degradation) or abiotic pathways (hydrolysis, oxidation, reduction, etc.). The more persistent a contaminant in the environment (that is, larger t½), the longer is the potential exposure time of species to the contaminant and the more deleterious the effects that could occur (NEPC 2013).
Table 23 (taken from NEPC 2013) provides benchmarks for assessment of persistence in terrestrial ecosystems using half-life.

Table 23: Half Life Benchmarks

Classification	T ½ (days)
Degrades Fast	<22.5
Degrades Moderately Fast	22.5 – 45
Degrades Slow	>45

5.1.2.2 Henry's Law Constant

Henry's law constant (K_H) is a measure of the volatility of a chemical. The higher the volatility (or value of K_H) the more of the contaminant will volatilise and be found in the soil air spaces and in the atmosphere. K_H is a temperature-dependent constant. Vapour transport for many contaminants may constitute an important pathway of loss and exposure to organisms (NEPC 2013). Together with half-life (t ½) of the chemical, K_H was used to assess the potential for transfer and persistence of the chemical in the soil.

NEPC (2013) have provided benchmarks for assessment of volatility of chemicals in terrestrial ecosystems. This is reproduced in Table 24 below.

Table 24: Henry's Law Constant Benchmarks

Classification	Henry's Law Constant (dimensionless)
Highly volatile (H)	>2.5 x 10^{-3}
Moderately volatile (M)	2.5 x 10^{-7} - 2.5 x 10^{-3} *
Not volatile (L)	< 2.5 x 10^{-7}

* It is noted that NEPC (2013) provides a range for moderately volatile of 2.5x10^{-7} to 2.5x10^{-5}, leaving two orders of magnitude (2.5x10^{-5} to 2.5x10^{-3}) unclassified. It was assumed that this was an error and the moderately volatile range has been extended from 2.5x10^{-5} to 2.5x10^{-3}.

5.1.2.3 Octanol-water Partition and Organic Carbon-water Coefficient

The octanol-water partition coefficient (K_{ow}) is the ratio of the concentration of a chemical that is dissolved in n-octanol to that dissolved in water at equilibrium and at a specified temperature. It is used to estimate the potential for chemicals to accumulate in tissue, both plant and animal (NEPC, 2013).

Chemicals with high log K_{ow} values are more likely to accumulate in plants and soil invertebrates than chemicals with low K_{ow} values. If further magnification of these chemicals occurs in the food chain, a predator might experience toxicity while its prey does not. This effect is known as secondary poisoning. Chemicals with log K_{ow} values below 3 were not considered to biomagnify. Chemicals with log K_{ow} values greater than 4 were considered to be highly fat soluble and lipophilic, and therefore posing the potential to biomagnify and result in secondary poisoning.

For the purpose of this report, and consistent with NEPC (2013), the log K_{ow} values of chemicals were divided into two classes. These were:

- Low, log K_{ow} <4: the chemical has a low potential to biomagnify.
- High, log K_{ow} ≥ 4: the chemical has a high potential to biomagnify.

5.1.3 Summary of Approach

In summary, toxicological data, as measured endpoints (e.g., LD50) or based on measurement data (e.g. PNEC) or as modelled data from QSAR were collated in a step-wise process. Figure 1 indicates that steps followed for the collection of terrestrial toxicological data.

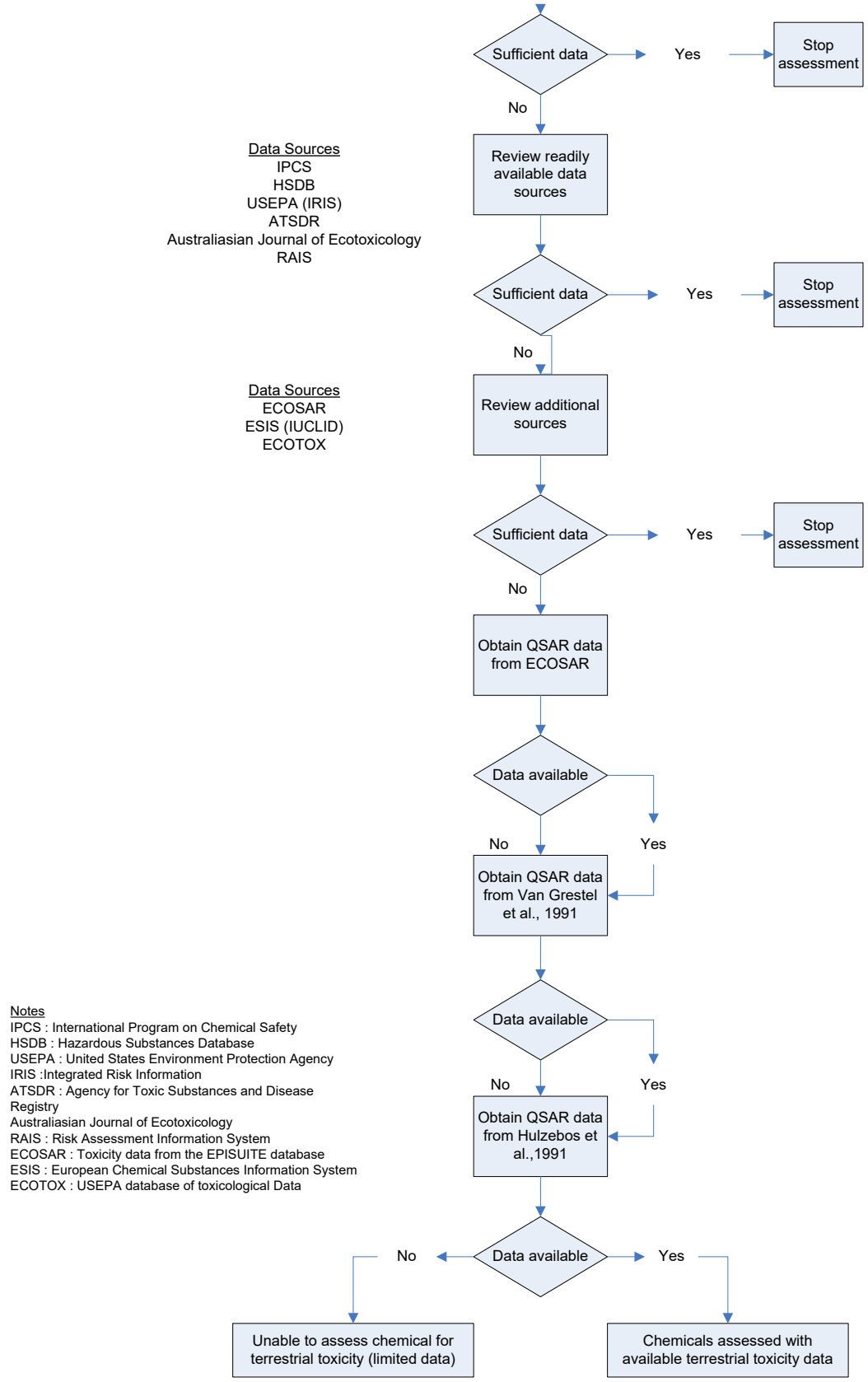

Figure 1: Approach Used for Collation and Generation of Terrestrial Toxicological Data

5.2 Results

Out of the fifty-two stimulation chemicals:

- seven chemicals were not assessed for terrestrial hazard due to insufficient data. These chemicals were liquid nitrogen, magnesium nitrate, magnesium silicate hydrate (talc), sodium thiosulfate, hydrogen peroxide (impurity), guar gum and sodium carboxymethylhydroxypropyl guar.
- six chemicals were not assessed because they were considered to be sand, (refer to Table 21 in Section 4.6.7), and
- thirty-nine were assessed for terrestrial hazard.

5.2.1 Mammalian Acute Oral LD50

Acute oral LC50 data for mammals were found for thirty (30) of the chemicals. The lowest LD50 values for rats, mice and rabbits were selected and are presented in Table 25.

5.2.2 QSAR Data

The lettuce QSAR of Huzelbos et al. (1991) was used to predict plant toxicity for thirty-one of the organic chemicals. The EC50 for this QSAR reports in micromole per litre, however, these units were converted to mg/L for ease of comparison. The results of this QSAR are also shown in Table 25.

The earthworm QSAR of van Gestel (1992) was used to predict soil invertebrate toxicity for twenty-seven organic chemicals. The results of this QSAR are also shown in Table 25.

The earthworm QSAR of the ECOSAR programme in EPISUITE was used to predict toxicity to earthworms of eighteen chemicals. The results of this QSAR are shown in Table 25.

5.2.3 Summary of Toxicological Data

A summary of the terrestrial toxicological data (including measured and modelled) collated is presented in Table 25 below.

Table 25: Summary of Terrestrial Toxicological Data

Chemical	CAS RN	Earthworm[4] (mg/L)	Lowest LD50 (mg/kg/bw)	Lettuce EC50[5] (mg/L)	Earthworm QSAR LC50[6] (mg/kg)
Choline chloride	*67-48-1*	1,340	3,400[1]	1.70E+05	5.11
Hydrochloric acid	*7647-01-0*		50[3]		
Sodium hydroxide	*1310-73-2*		140[1]		
Boric acid	*10043-35-3*		2,660[1]		
Surrogate for Vinylidene chloride/methacrylate	*75-35-4*	121	194[1]	6.65E+00	3.65
Tetrasodium ethylene diamine tetra acetate	*64-02-8*			2.71E+12	961
Polyethylene glycol sorbitan monolaurate	*9005-64-5*	261,000	18,000[1]	8.74E+04	5.25E+08

Chemical	CAS RN	Earthworm[4] (mg/L)	Lowest LD50 (mg/kg/bw)	Lettuce EC50[5] (mg/L)	Earthworm QSAR LC50[6] (mg/kg)
5-chloro-2-methyl-2h-isothiazolol-3-one	*26172-55-4*	278	481[2]	6.16E+02	0.0232
Magnesium chloride	*7786-30-3*		2,800[7]		
Propan-2-ol	*67-63-0*	158	3,600[1]	1.30E+02	9.68
2-methyl-2h-isothiazol-3-one	*2682-20-4*			1.07E+03	0.0053
Surrogate for sodium gluconate	526-95-4	8,584		1.02E+04	
Surrogate for polylactide resin	9051-89-2	2,948	1,810[1]	6.97E+02	3.56
2,2',2"-nitrilotriethanol	102-71-6		2,200[7]	1.84E+03	20.6
Polyethylene glycol monohexyl ether	31726-34-8	812		3.58E+02	0.0105
Sodium glycolate (impurity)	2836-32-0	2,750	6,700[1]	1.25E+06	219
Dicoco dimethyl quarternary ammonium chloride	61789-77-3	241		1.68E-02	6,680
Disodium ethylene diamine tetra acetate	139-33-3		400[1]	2.09E+11	5.41
Trisodium ethylene diamine tetra acetate	150-38-9		2,150[1]	2.47E+12	
Trisodium nitriloacetate (impurity)	5064-31-3		681[1]	1.13E+10	30.3
Cetylethylmorpholinium ethyl sulphate	78-21-7	299		3.94E-02	
Potassium hydroxide	1310-58-3		273[1]		
Alkyl (C12-C16) dimethylbenzyl ammonium chloride	68424-85-1	406	426[7]	1.32E+00	631
Butyl diglycol	112-34-5	424	2,000[1]	1.50E+02	389
Decyldimethyl amine (impurity)	1120-24-7			2.67E-01	0.0006
Decyl-dimethyl amine oxide	2605-79-0			1.04E+00	0.0004
Fumaric acid	110-17-8	3,212	9,300[1]	1.27E+02	38.9
L-Glutamic acid	56-86-0		2,300[1]	1.56E+05	0.0084

Chemical	CAS RN	Earthworm[4] (mg/L)	Lowest LD50 (mg/kg/bw)	Lettuce EC50[5] (mg/L)	Earthworm QSAR LC50[6] (mg/kg)
Pentaethylenehexamine	4067-16-7		1,600[7]	2.39E+05	1.73
Tetraethylenepentamine	112-57-2		2,100[1]	5.36E+03	52.3
Tetramethylammonium chloride	75-57-0	834	50[7]	2.63E+05	0.0002
Triethylenetetramine	112-24-3		1,600[7]	2.77E+04	1.77
Ethanol	64-17-5	134	5,600[1]	1.81E+02	0.172
Sodium bromate	7789-38-0		301[8]		
Sodium tetraborate	1330-43-4		2660[1]		
Zirconium dichloride oxide	7699-43-6		1,227[7]		
Surrogate for Acrylamide, 2-acrylamido-2-methylpropanesulfonic acid, sodium salt polymer	5165-97-9		16,000[9]	7.16E+05	0.0625
Surrogate for Octadecanoic acid	57-11-4	1,196	4,600[1]	7.92E-04	53,200
Surrogate for Hydroxypropyl cellulose	9004-65-3	4,675		7.22E+06	

1 Hazardous Substances Data Bank (HSBD) (2012).
2 International Uniform Chemical Information Database (IUCLID) (2012).
3 International Program for Chemical Safety (INCHEM)(2012).
4 ECOSAR (2012)
5 Huzelbos et al. (1991)
6 van Gestel (1992)
7ChemIDplus (2013)
8QSAR Toolbox (2013)
9United States Environmental Protection Agency (USEPA) (2012)

5.3 Hazard Assessment

5.3.1 Toxicological Data

Examination of the data in Table 25 shows some consistencies and inconsistencies in findings between data sources for highest hazard chemicals. Tetramethylammonium chloride ranks highest for mammalian toxicity and the van Gestel (1992) earthworm QSAR model but does not rank in the top three for the Huzelbos et al (1991) lettuce QSAR or earthworm ECOSAR QSAR model. Surrogate for Vinylidene chloride/methacrylate copolymer ranks highest for the earthworm ECOSAR QSAR model and ranks in the top three for mammalian toxicity but does not rank in the top three for the other two models. Surrogate for Octadecanoic acid, calcium salt ranks highest for the Huzelbos et al. (1991) lettuce QSAR but does not rank in the top three for the other models. Decyldimethyl amine (impurity) ranks in the top three for the Huzelbos et al. (1991) lettuce QSAR and the van Gestel (1992) earthworm QSAR but does not rank in the top three for the other two models. Disodium ethylene diamine tetra acetate, Cetylethylmorpholinium ethyl sulphate, Propan-2-ol, decyl dimethyl amine oxide and ethanol appear only once in the top three ranks for each of mammalian toxicity, Huzelbos et al (1991) lettuce QSAR, earthworm ECOSAR QSAR and van Gestel 1992 earthworm QSAR models.

For the organic chemicals, for which the most data are available, the three most hazardous chemicals using the different techniques are shown in Table 26 below:

Table 26: Highest Hazard Organic Chemicals for Terrestrial Receptors Using the Different Datasets

Mammalian LD50 data	Lettuce QSAR (Huzelbos et al. 1991)	Earthworm QSAR (van Gestel 1992)	Earthworm QSAR (EPISUITE)
Tetramethylammonium chloride	Surrogate for Octadecanoic acid, calcium salt (Decanoic acid 57-11-4)	Tetramethylammonium chloride	*Surrogate for Vinylidene chloride/methacrylate (1,1 DCE 75-35-4)*
Surrogate for Vinylidene chloride/methacrylate (1,1 DCE 75-35-4)	Cetylethylmorpholinium ethyl sulphate	Decyl dimethyl amine oxide	Ethanol
Disodium ethylene diamine tetra acetate	Decyldimethyl amine (impurity)	Decyldimethyl amine (impurity)	Propan-2-ol

Chemical names in italics – indicate chemicals that were assessed using the pre-2012 PBT approach.

On the basis of Table 26, nine (9) organic chemicals: tetramethylammonium chloride, surrogate for ocatdecanoid acid, calcium salt, surrogate for vinylidene chloride/methacrylate, disodium ethylene diamine tetra acetate, cetylethylmorpholinium ethyl sulphate, propan-2-ol, decyl dimethyl amine oxide, decyldimethyl amine (impurity) and ethanol have the highest toxicity to terrestrial plants and invertebrates. These chemicals were assessed for persistence and bioaccumulation using the physico-chemical data described in Section 5.1.2 and is discussed further in Section 5.3.2.

Data for the inorganic chemicals were limited. The three QSARs could not be used. NEPC (2013) provides only limited discussion on how the environmental fate and persistence of inorganic substances should be assessed. Further assessment of the hazards of the inorganic chemicals to terrestrial receptors has not been undertaken. The three highest hazard inorganic chemicals ranked using the mammalian LD50 data are:

- Hydrochloric acid;
- Sodium hydroxide; and
- Potassium hydroxide.

5.3.2 Persistence and Bioaccumulation of the Organic Chemicals

The nine (9) high hazard organic chemicals identified in Section 5.3.1 were classified based on the half-life as described in Section 5.1.2.1. Surrogate for vinylidene chloride/methacrylate, and cetylethylmorpholinium ethyl sulphate, were shown to be the most persistent with the slowest half life. Tetramethylammonium chloride, surrogate for octadecanoic acid, calcium salt, decyldimethyl amine (impurity), decyldimethyl amine oxide and propan-2-ol were assessed to be moderately persistent. Disodium ethylene diamine tetra acetate and ethanol were the least persistent (Table 27).

Table 27: Soil Half-life (t ½) Classification for High Hazard Organic Chemicals

Chemical	CAS RN	Half-life in Soil (days)	Half-life in Soil (t ½) Classification
Tetramethylammonium chloride	75-57-0	30	Moderate
Surrogate for Octadecanoic acid, calcium salt (Decanoic acid 57-11-4)	1592-23-0	30	Moderate
Cetylethylmorpholinium ethyl sulphate	78-21-7	75	Slow
Decyldimethyl amine (impurity)	1120-24-7	30	Moderate
Decyldimethyl amine oxide	2605-79-0	30	Moderate
Surrogate for Vinylidene chloride/methacrylate (1,1 DCE 75-35-4)	25038-72-6	75	Slow
Ethanol	64-17-5	17.3	Fast
Propan-2-ol	67-63-0	30	Moderate
Disodium ethylene diamine tetra acetate	139-33-3	17.3	Fast

The nine high hazard organic chemicals identified in section 5.3.1 were classified based on the Henry's Law constant benchmarks presented in Section 5.1.2.2; the results are summarised in Table 28. Tetramethylammonium chloride, cetylethylmorpholinium ethyl sulphate, decyldimethyl amine oxide and disodium ethylene diamine tetra acetate were classified as having low volatility and are therefore considered likely to persist longer than the other organic chemicals. Surrogate for octadecanoic acid, calcium salt, ethanol and propan-2-ol were classified as moderately volatile. Decyldimethyl amine (impurity) and surrogate for vinylidene chloride/methacrylate was classified as having the highest volatility and are therefore the least persistent.

Table 28: Henry's Law Constant Classification for High Hazard Organic Chemicals

Chemical	CAS RN	Henry's Law (atm m^3/mol at 25°C)	Henry's Law (dimensionless)	Henry's Law Constant Classification
Tetramethylammonium chloride	75-57-0	4.20E-12	1.72E-11	Low volatility
Surrogate for Octadecanoic acid, calcium salt (Decanoic acid 57-11-4)	1592-23-0	4.67E-07	1.91E-06	Moderately volatility
Cetylethylmorpholinium ethyl sulphate	78-21-7	3.56E-16	1.46E-15	Low volatility
Decyldimethyl amine (impurity)	1120-24-7	4.68E-04	1.92E-03	Highly volatile
Decyldimethyl amine oxide	2605-79-0	3.67E-10	1.50E-09	Low volatility
Surrogate for Vinylidene chloride/methacrylate (1,1 DCE 75-35-4)	25038-72-6	2.61E-02	1.07E-01	Highly volatile
Ethanol	64-17-5	5.00E-06	2.05E-05	Moderately volatile
Propan-2-ol	67-63-0	8.10E-06	3.32E-06	Moderately volatile
Disodium ethylene diamine tetra acetate	139-33-3	1.18E-23	4.84E-23	Low volatility

Based on the octanol-water partitioning coefficient classification in Section 5.1.2.3, surrogate for octadecanoic acid, calcium salt, cetylethylmorpholinium and decyldimethyl amine (impurity) were classified as high potential to biomagnify. The remaining six chemicals are considered to have low potential for biomagnification (refer to Table 29).

Table 29: Low Kow Classification for High Hazard Chemicals

Chemical	CAS RN	Log Kow	Potential to Biomagnify
Tetramethylammonium chloride	75-57-0	-4.18	Low
Surrogate for Octadecanoic acid, calcium salt (Decanoic acid 57-11-4)	1592-23-0	8.23	High
Cetylethylmorpholinium ethyl sulphate	78-21-7	6.17	High
Decyldimethyl amine (impurity)	1120-24-7	4.46	High
Decyldimethyl amine oxide	2605-79-0	3.69	Low

Chemical	CAS RN	Log Kow	Potential to Biomagnify
Surrogate for Vinylidene chloride/methacrylate (1,1 DCE 75-35-4)	25038-72-6	2.13	Low
Ethanol	64-17-5	-0.31	Low
Propan-2-ol	67-63-0	0.05	Low
Disodium ethylene diamine tetra acetate	139-33-3	-11.17	Low

5.3.3 Identification of Terrestrial Chemicals of Potential Concern (COPC)

Using the three physico-chemical measures in combination it was possible to identify the COPC to terrestrial receptors posing a potential high hazard (see Table 30).

Table 30: Henry's Law Constant Classification for High Hazard Organic Chemicals

Chemical	CAS RN	Half-life in Soil (t ½) Classification	Potential to Biomagnify	Henry's Law Constant Classification	Primary Exposure Route
Tetramethylammonium chloride	75-57-0	Moderate	Low	***Low volatility***	Direct toxicity
Surrogate for Octadecanoic acid, calcium salt (Decanoic acid 57-11-4)	1592-23-0	Moderate	***High***	Moderately volatile	Direct toxicity
Cetylethylmorpholinium ethyl sulphate	78-21-7	***Slow***	***High***	***Low volatility***	Direct toxicity
Decyldimethyl amine (impurity)	1120-24-7	Moderate	***High***	Highly volatile	Direct toxicity
Decyldimethyl amine oxide	2605-79-0	Moderate	Low	***Low volatility***	Direct toxicity
Surrogate for Vinylidene chloride/methacrylate (1,1 DCE 75-35-4)	25038-72-6	***Slow***	Low	Highly volatile	Direct toxicity
Ethanol	64-17-5	Fast	Low	Moderately volatile	Direct toxicity
Propan-2-ol	67-63-0	Moderate	Low	Moderately volatile	Direct toxicity
Disodium ethylene diamine tetra acetate	139-33-3	Fast	Low	***Low volatility***	Direct toxicity

Cells in bold, underline and italics = Classified as persistent or possessing a high potential to biomagnify.

The organic chemicals classified as high hazard in Section 5.3.2 were assessed according to their toxicological and physio-chemical properties. The following organic chemicals were assessed to have the potential to pose a higher environmental hazard relative to the other chemicals assessed based on persistence and potential to biomagnify:

- Cetylethylmorpholinium ethyl sulphate;
- Tetramethylammonium chloride;
- Surrogate for Octadecanoic acid, calcium salt;
- Decyldimethyl amine (impurity);
- Decyldimethyl amine oxide;
- Surrogate for Vinylidene chloride/methacrylate; and
- Disodium ethylene diamine tetra acetate (impurity).

Of the seven high terrestrial hazard chemicals identified above, the following further interpretations are provided:

- Six of the seven chemicals are expected to be in concentrations less than 0.1% in a stimulation fluid mixture (as indicated by the fluid descriptions), with only one chemical (tetramethylammonium chloride) expected at concentrations up to 1%.
- Tetramethylammonium chloride, decyldimethyl amine oxide and disodium ethylene diamine tetra acetate have low volatility but they are not likely to persist in the terrestrial environment as illustrated by a moderate to rapid half-life and low potential to bioaccumulate.
- Surrogate for octadecanoic acid, calcium salt and decyldimethyl amine (impurity) both have a high potential to biomagnify but due to a moderate half-life and moderate to high volatility they are not likely to persist in the terrestrial environment.
- Surrogate for vinylidene chloride/methacrylate (1,1 DCE) has the potential to persist in the terrestrial environment due to a slow half-life however it has low potential to biomagnify and high volatility.

Given the management controls in place to prevent releases to the environment, potential terrestrial hazards from individual hydraulic stimulation chemicals, are considered unlikely to be realised.

5.4 Limitations and Uncertainties

The terrestrial environmental hazard assessment is a relative assessment and not a comprehensive evaluation of environmental hazards. The following limitations with regard to the terrestrial hazard assessment and source data were noted:

- Sources of Australian terrestrial ecotoxicological data were consulted but the information was limited. No terrestrial ecotoxicological data on the assessed chemicals were available for Australian birds, mammals, reptiles or flora.
- The terrestrial toxicological data used in this report do not include endpoints that assess effects on soil function or secondary poisoning via bioaccumulation in the food chain. Assessment of impacts via secondary poisoning has been assessed qualitatively from the chemical-specific physical and chemical data.
- The terrestrial toxicity assessment was largely based on modelled data of lettuce and earthworm that may not be receptors present in soil on well leases. Modelled data introduces greater uncertainty compared to use of measured data.

- The effects of exposure to the inorganic chemicals identified as posing a higher hazard relative to other chemicals could not be fully assessed.
- The terrestrial toxicity assessment identifies chemicals with the highest hazard relative to the chemicals assessed. Actual hazard is based on the exposure concentration and exposure scenario, as discussed in Section 2.0.
- Toxicological data were obtained for surrogates for a number of chemicals; and
- The data collated in the chemical information sheets (presented in APPENDIX F, where presented) were treated the same regardless of whether the data were measured experimental values or modelled / calculated values.

6.0 HUMAN HEALTH TOXICITY ASSESSMENT

6.1 Objective

As discussed in Section 4.2, the assessment of toxicity represents an assessment of hazard rather than risk for 52 the chemicals nominated by Santos as present in the Schlumberger stimulation fluids *YF140HTD 30Q N2*, ThermaFRAC 40 and Slickwater.

In terms of elements of the risk assessment process, the hazard assessment identifies a potential due to intrinsic properties of the chemical of interest, the exposure assessment provides information on the likelihood of the hazard being realised, and the risk characterisation provides a qualitative or semi-quantitative measure of the potential for the hazard to be realised.

The aim of the hazard assessment is therefore to provide a qualitative hazard ranking of chemicals based on human health toxicity and other hazardous endpoints to identify COPC. Further evaluation of the risk posed by the COPC is provided with an evaluation of exposure pathways. There are qualifiers related to the hazard ranking process. These are summarised in the concluding comments of each human health hazard profile presented in APPENDIX E.

The end result of the human health hazard assessment is to provide direction for the mitigation of environmental and occupational health hazards that have the potential to be realised. This may be achieved by suitable management measures or in some cases, additional investigations (e.g., sampling and analytical programs and further risk assessment).

The human health hazard ranking methodology used by Golder has evolved with changes in methodological approaches to chemical toxicity hazard ranking processes and hazard classification methodology. Golder initially devised a human health hazard ranking system in 2010. Since then a national chemical hazard ranking methodology has been introduced. In addition, a large number of chemical hazard data and classifications have become available via the European Chemicals Agency. The ranking method used in the current report incorporates these updates, and has been used for each of the chemicals, as described in Section 6.4. Overall conclusions (Sections 7.0 and 8.0) for the three Schlumberger stimulation fluids are based on an assessment of all 52 chemicals.

6.2 Human Health Hazard Ranking

Human health hazard ranking may adopt a variety of approaches depending on the project or site-specific needs. A variety of hazard ranking or chemical screening methods are available in the published, peer-reviewed literature. Some of these methods are described in the following paragraphs.

Pennington and Bare (2001) described two methods developed by the US EPA: the Waste Minimisation Prioritization Tool (WMPT); and the Toxic Equivalency Potential (TEP). The WMPT examines screening in terms of key physical-chemical properties and includes measures for persistence, bioaccumulation and toxicity (PBT) that are calculated. Each PBT measure is scored to provide a single measure of relative concern. TEPs evaluate chemical fate, multi-pathway exposure and toxicity using a model-based approach. The TEP approach was considered by the authors to represent a less subjective and thus improved approach. TEPs are based on a generic version of CalTox - an integrated multimedia fate, multi-pathway exposure and toxicity model initially developed for human health risk assessments. The authors further stated that "*in typical applications and given the currently available transformation data, neither approach should be used to provide insights beyond a qualitative basis such as high, medium and low concern*" (p 910).

Pittinger et al. (2003) described seven discrete hazard and risk assessment tools and proposed a systematic framework to assist users in selecting the appropriate tool for a given application. The framework used a hazard-risk continuum with varying amount and specificity of data requirements. The continuum commenced

with toxicity and physical-chemical properties on the hazard end and progressed to site-specific risk assessment. Pittinger et al. (2003) discussed approaches from:

- The American Industrial Health Council (AIHC).
- European Risk Ranking Method (EURAM).
- US Chemical Hazard Evaluation for Management Strategies (CHEMS-1).
- US Risk Screening Environmental Indicators.
- US EPA Clusters Scoring System for particular tasks.
- Exposure, Fate Assessment Screening Tool (E-FAST) used in US EPA's New Chemicals Program; and
- The OECD's "Tools for R&D Screening" which is part of the OECD's Chemical Risk Management Program.

Logue et al. (2011) published an approach that used indoor air exposure data and air guidelines to rank 267 chemicals. Thirty-one chemicals were identified as posing hazards with nine as priority pollutants. Dunn (2009) presented an approach for a relative risk ranking of select substances on the Canadian National Pollutant Release Inventory using the CHEMS-1 model listed by Pittinger et al. (2003) discussed above.

OECD (2001) published an initial approach to a harmonised integrated classification system for human health and environmental hazards of chemical substances and mixtures, which was updated to a Globally Harmonised System of Classification and Labelling of Chemicals (GHS) in 2003, with subsequent updates in 2005, 2007, 2009 and then in 2011 (UNECE, 2011). These guidelines provide categorisation across ten toxicity parameters and provide specific guidance for separation into those categories based on available toxicological data. The approach ranks within the respective categories but not across the toxicological parameters.

While the paper by Dunn (2009) highlights the use of CHEMS-1 in the Canadian approach to the National Pollutant Release inventory, the model does not include some elements that have more recently been included in evaluations by agencies such as the US EPA Design for the Environment (DfE). DfE focuses on the principles of green chemistry and applies these principles to work towards the replacement of hazardous chemicals by safer chemicals and considers a broader range of variables.

Recent green chemistry initiatives such as "*The Green Screen for Safer Chemicals*" (Clean Production Organisation, 2009) provide comprehensive ranking approaches embodying health risk assessment principles with the objectives of achieving safer chemical use. These approaches integrate data and categorisations from the following environment agencies: US EPA, the European Union/Commission (EU), United Nations Economic Commission for Europe (UNECE) GHS, International Agency for Research on Cancer (IARC), and US National Toxicology Program (NTP) sources to establish Very High (VH), High (H), Moderate (M), and Low (L) categories. The basis of these evaluations is to produce an overall categorisation into four benchmarks with 'Benchmark 4' reflecting a preferred safer chemical – a "green" objective. While the green chemistry initiative objectives differ somewhat from the objectives of the hydraulic stimulation hazard ranking described in this report, the basis to the use of data reflects current approaches in hazard categorisation and includes toxicological parameters drawn from the UN GHS, IARC and other reputable sources. The hydraulic stimulation hazard approach also includes a consideration of endocrine disruptor potential and physical hazards such as explosive capability and flammability. The approach has been employed with suitable adjustments for human health hazard ranking of hydraulic stimulation chemicals. This is discussed in the following sections.

6.3 Human Health Hazard Assessment Parameters

A description of each parameter is provided below, along with the threshold values for each parameter as presented in the "*Green Screen for Safer Chemicals*". The threshold values for these parameters as presented in the "*Green Screen for Safer Chemicals*" are drawn from the following sources:

- EU's recently enacted chemicals policy legislation (Registration, Evaluation and Authorization of Chemicals–REACH) (EU 2006).
- UNECE (2011) Globally Harmonized System of Classification and Labelling of Chemicals (GHS). Fourth revised edition. United Nations, New York and Geneva.
- The International Agency for Research on Cancer (IARC) monographs on Carcinogens, available at http://monographs.iarc.fr.
- US Environmental Protection Agency, Design for Environment Program. (USEPA DfE) 2005a. Environmental Profiles of Chemical Flame-Retardant Alternatives for Low-Density Polyurethane Foam.
- US Department of Health and Human Services, Public Health Service, National Toxicology Program (US NTP). 2005. Report on Carcinogens, Eleventh Edition.
- State of California, Environmental Protection Agency, Office of Environmental Health Hazard Assessment. 2006. Chemicals Known to the State to Cause Cancer or Reproductive Toxicity.
- Japan Ministry of Environment. 1998. Endocrine Disrupting Chemicals Database, Table of Chemicals Suspected of Having Endocrine Disrupting Effects; and
- US Department of Labour Occupational Safety and Health Administration (OSHA) List of OSHA carcinogens.

6.3.1 Acute Toxicity

Acute toxicity refers to the occurrence of adverse effects following exposure to a single dose of a substance or multiple doses within a 24 hour period (OECD 2009). In toxicity studies acute effects are often characterised by lethality, commonly reported in lethal dose or concentration at which 50% of the animals tested die (LD50 or LC50). Non-lethal acute effects are sometimes included. Routes of administration commonly used are the oral, dermal and inhalation pathways. The threshold values for acute toxicity are presented in Table 31.

Table 31: Acute Toxicity (oral, dermal or inhalation) Threshold Values

High	Medium	Low
■ LD50 <50 mg/kg bodyweight (oral) ■ LD50 <200 mg/kg bodyweight (dermal) ■ LC50 <500 ppm (gas) ■ LC50 <2.0 mg/L (vapour) ■ LC50 <0.5 mg/L (dust or mist) ■ US EPA Extremely Hazardous Substance List ■ GHS Category 1 or 2	■ LD50 50-2000 mg/kg bodyweight (oral) ■ LD50 200-2000 mg/kg bodyweight (dermal) ■ LC50 500-5000 ppm (gas) ■ LC50 2-20 mg/L (vapour) ■ LC50 0.5-5 mg/L (dust or mist) ■ GHS Category 3 or 4	■ No basis for concern identified

6.3.2 Corrosion/Irritation of the Skin or Eye/s

Skin corrosion is the production of irreversible damage to the skin namely, visible necrosis through the epidermis and into the dermis following the application of a substance for up to four hours (OECD, 2009). Corrosion is often indicated by ulcers and bleeding and after 14 days discolouration of the skin, alopecia and scars. Skin irritation is the production of reversible damage to the skin following application of a substance (OECD, 2009).

Serious eye damage (i.e. corrosion) is indicated by tissue damage of the eye or serious physical decay of vision following application of the anterior surface of the eye which is not fully reversible within 21 days (OECD, 2009). Eye irritation is indicated by changes in the eye following application of the anterior surface of the eye which is fully reversible within 21 days (OECD, 2009).

The threshold values for corrosion/Irritation of the skin or eye are presented in Table 32.

Table 32: Corrosion/Irritation of the Skin or Eye Threshold

High	Medium	Low
■ Evidence of irreversible effects in studies of human populations ■ Weight of evidence of irreversible effects in animal studies ■ GHS Category 1 (skin or eye)	■ Evidence of reversible effects in humans or animals ■ GHS Category 2 or 3 — skin irritation ■ GHS Category 2A or 2B — eye	■ No basis for concern identified

6.3.3 Sensitisation of the Skin or Respiratory System

A respiratory sensitiser is a substance that will lead to hypersensitivity of the airways following inhalation of the substance (OECD, 2009). A skin sensitiser is a substance that will lead to an allergic response following skin contact (OECD 2009).

The threshold values for sensitisation of the skin or respiratory system are presented in Table 33.

Table 33: Sensitisation of the Skin or Respiratory System Threshold

High	Medium	Low
■ Evidence of adverse effects in humans; ■ Weight of evidence demonstrates potential for adverse effects in humans ■ GHS Category 1 – (skin or respiratory) ■ Positive responses in predictive Human Repeat ■ Insult Patch Tests (HRIPT) (skin)	■ Suggestive animal studies of adverse effects ■ Analogue data ■ Chemical class known to produce toxicity	■ No basis for concern identified

6.3.4 Carcinogenicity

A carcinogen is a substance or a mixture which induces cancer or increases its incidence. The classification of a substance or mixture as a carcinogenic hazard is based on its inherent properties and does not provide information on the level of human cancer risk which the use of a substance may represent (OECD, 2009).

The threshold values for carcinogenicity are presented in Table 34

Table 34: Carcinogenicity Thresholds

High	Medium	Low
■ Evidence of adverse effects in humans ■ Weight of evidence demonstrates potential for adverse effects in humans ■ NTP known or reasonably anticipated to be human carcinogen ■ OSHA carcinogen ■ California Prop 65 ■ IARC Group 1 or 2A ■ EU Category 1 or 2 ■ GHS Category 1A or 1B	■ Suggestive animal studies of adverse effects ■ Analogue data ■ Chemical class known to produce toxicity ■ IARC Group 2B ■ EU Category 3 ■ GHS Category 2	■ No basis for concern identified ■ IARC Group 3 or 4

6.3.5 Developmental Toxicity

Developmental toxicity refers to the *in utero* effects such as death, malformations, functional deficits and developmental delays (enHealth, 2004). It can also include delayed toxicity associated with epigenic effects during the sensitive phases of foetal development.

The threshold values for developmental toxicity are presented in Table 35.

Table 35: Developmental Toxicity Threshold

High	Medium	Low
■ Evidence of adverse effects in humans ■ Weight of evidence demonstrates potential for adverse effects in humans ■ NTP Centre for the Evaluation of Risks to Human Reproduction ■ California Prop 65	■ Suggestive animal studies of adverse effects ■ Analogue data ■ Chemical class known to produce toxicity	■ No basis for concern identified

6.3.6 Mutagenicity/Genotoxicity

Mutagenesis occurs when chemicals cause changes in the genetic material which can be transmitted during cell division. The OECD (2009) indicates a mutagen is a chemical that may cause mutations in the germ cells of humans that can be transmitted to the progeny. A mutation is defined as a permanent change in the amount or structure of the genetic material in a cell. The more general terms genotoxic and genotoxicity apply to agents or processes which alter the structure, information content or segregation of deoxyribonucleic acid (DNA) (OECD, 2009).

The threshold values for mutagenicity and genotoxicity are presented in Table 36.

Table 36: Mutagenicity/Genotoxicity Thresholds

High	Medium	Low
■ Evidence of adverse effects in humans ■ Weight of evidence demonstrates potential for adverse effects in humans ■ EU Category 1 or 2 ■ GHS Category 1A or 1B	■ Suggestive animal studies of adverse effects ■ Analogue data ■ Chemical class known to produce toxicity ■ EU Category 3 ■ GHS Category 2	■ No basis for concern identified

6.3.7 Reproductive Toxicity

Reproductive toxicity includes adverse effects on sexual function and fertility in adult males and female as well as developmental toxicity in the offspring (OECD, 2009). This may include effects on mating behaviour, gonadal function, oestrous cycling, conception, implantation, parturition and lactation (Draft enHealth, 2010).

The threshold values for reproductive toxicology are presented in Table 37.

Table 37: Reproductive Toxicity Thresholds

High	Medium	Low
■ GHS Category 1A or 1B ■ EU Category 1 or 2 ■ Evidence of adverse effects in humans ■ Weight of evidence demonstrates potential for adverse effects in humans ■ NTP Centre for the Evaluation of Risks to Human Reproduction	■ GHS Category 2Suggestive animal studies of adverse effects ■ EU Category 3 ■ Analogue data ■ Chemical class known to produce toxicity	■ No basis for concern identified

6.3.8 Neurotoxicity

Neurotoxicity refers to any adverse effects on the structure or functional integrity of the developing or adult nervous system. Neurotoxic effects may involve a spectrum of biochemical, morphological, behavioural, and physiological abnormalities whose onset can vary from immediate to delayed following exposure to a toxic substance, and whose duration may be transient or persistent (US Department of Food and Drug Administration, 2000).

The threshold values for neurotoxicity are presented in Table 38

Table 38: Neurotoxicity Thresholds

High	Medium	Low
■ Evidence of adverse effects in humans ■ Weight of evidence demonstrates potential for adverse effects in humans	■ Suggestive animal studies of adverse effects ■ Analogue data ■ Chemical class known to produce toxicity	■ No basis for concern identified

6.3.9 Endocrine Disruption

Endocrine disruptors are chemicals that may interfere with the body's endocrine system and produce adverse developmental, reproductive, neurological, and immune effects (OECD, 2009).

The threshold values for endocrine disruption are presented in Table 39.

Table 39: Endocrine Disruption Thresholds

High	Medium	Low
■ Evidence of adverse effects in humans ■ Weight of evidence demonstrates that mechanisms of action lead to adverse effects	■ Suggestive animal studies of adverse effects ■ Analogue data ■ Chemical class known to produce toxicity ■ EU Draft List - Category 1 or 2 ■ Japanese list	■ No basis for concern identified

6.3.10 Systemic Toxicity/Organ Effects

This relates to substances that produce specific non- lethal organ toxicity arising either from a single or repeated dose. All significant health effects that can impair function, reversible and irreversible, immediate and/or delayed are included (OECD, 2009).

The threshold values for systemic toxicity / organ effects are presented in Table 40.

Table 40: Systemic Toxicity Thresholds

High	Medium	Low
■ GHS Category 1 — organ/systemic toxicity following single or repeated exposure ■ Evidence of adverse effects in humans ■ Weight of evidence demonstrates potential for adverse effects in humans	■ GHS Category 2 or 3 single exposure ■ Category 2 repeated exposure ■ Suggestive animal studies of adverse effects ■ Analogue data ■ Chemical class known to produce toxicity	■ No basis for concern identified

6.3.11 Immune System Effects

The threshold values for immune system effects are presented in Table 41.

Table 41: Immune System Effect Thresholds

High	Medium	Low
■ Evidence of adverse effects in humans ■ Weight of evidence demonstrates potential for adverse effects in humans	■ Suggestive animal studies of adverse effects ■ Analogue data ■ Chemical class known to produce toxicity	■ No basis for concern identified

6.3.12 Explosive Potential

An explosive substance is a solid or liquid which is capable by chemical reaction of producing gas at such high temperature and pressure and at such a speed as to cause damage to the surroundings (OECD, 2009).

The threshold values for explosive potential effects are presented in Table 42

Table 42: Explosive Potential Threshold Values

High	Medium	Low
■ GHS Category: Unstable Explosives or Divisions 1.1, 1.2 or 1.3	■ GHS Category: Divisions 1.4, 1.5	■ No basis for concern identified

6.3.13 Flammable Potential

A flammable liquid has a flash point of not more than 93˚C (OECD, 2009). A flammable solid is readily combustible or may cause or contribute to fire through friction. A readily combustible solid is a powdered, granular or pasty substance which is dangerous if it can be ignited by brief contact with an ignition source and the flame spreads rapidly (OECD, 2009).

The threshold values for flammable potential effects are presented in Table 43.

Table 43: Flammable Potential Thresholds

High	Medium	Low
■ GHS Category 1 - Flammable Gases ■ GHS Category 1 - Flammable Aerosols ■ GHS Category 1 or 2 — Flammable Liquids	■ GHS Category 2- Flammable Gases ■ GHS Category 2- Flammable Aerosols ■ GHS Category 3 or 4 — Flammable Liquids	■ No basis for concern identified

6.4 Hazard Assessment Approach (IMAP Framework)

Each of the 52 chemicals present in the three Schlumberger stimulation fluids assessed in this report have been assessed using the methodology based on the Inventory Multi-tiered Assessment and Prioritisation (IMAP) Framework recently published by the National Industrial Chemicals Notification and Assessment Scheme (NICNAS, 2013).

This framework has been designed to enable prioritisation of chemicals by hazard, exposure and use in the community for the purposes of national chemical assessment programs. This involves hazard bands, exposure bands and five broad categories: cosmetic, domestic, commercial, site-limited and non-industrial. The exposure assessment considers volumes and uses multipliers in conjunction with the hazard assessment to provide the risk characterisation for prioritisation and subsequent national assessment of the chemical. Integral to this process is review of international classifications and assessments following the prioritisation process with further increasingly detailed Tier I, Tier II and Tier III assessments.

The IMAP Framework for hazard assessment uses a hierarchy of indicators developed and agreed by the Human Health Expert Working Group (HHEWG) which reflects the following weighting:

- Carcinogenicity, Genotoxicity, Reproductive/developmental toxicity, Endocrine disruption, Neurotoxicity
- Acute toxicity
- Repeat dose toxicity
- Sensitisation

- Irritation.

This facilitates a Hazard Banding which is structured across five bands from Hazard Band 4 (highest) to Hazard Band 0 (lowest). The approaches employed within the IMAP framework adopt global harmonisation practices for classification and labelling of chemicals with assessment thresholds.

Table 44 summarises the classification of the 52 stimulation chemicals for human health hazard.

Of the 52*[20] Chemicals assessed:

- 8 were ranked as non-hazardous (Hazard Rank 0)
- 8 were ranked as low hazard (Hazard Rank 1)
- 1 was ranked as medium hazard (Hazard Rank 2)
- 28 were ranked as high hazard (Hazard Rank 3)
- 7 were ranked as very high hazard (Hazard Rank 4).

Of the seven substances that were classified as IMAP Hazard Rank 4, crystalline silica (quartz) has the highest concentration of up to 1% in a stimulation fluid mixture (as indicated by the fluid disclosures). Note that the carcinogenicity of this substance is via the inhalation pathway which is not considered to be relevant when the substance is present within the fluid mixture. The remaining six Hazard Rank 4 substances (ethanol, crystalline silica (cristobalite), diatomaceous earth, boric acid, sodium bromate and sodium tetraborate) are expected to be at concentrations of less than 0.1%.

[20] Note that 5-chloro-2-methyl4-isothiazolol-3-one and 2-methyl-4-isothizol-3-one classified together

Table 44: Summary of Human Health Hazard Classification and Potential Outcomes (as per the IMAP Framework Ranking Approach)

Substance	CAS No	IMAP Hazard Ranking	Environmental Behaviour	Key Determinants and Potential Hazard Outcomes
Cholinium Chloride	67-48-1	1	Readily dissociates / dilutes in water.	Mild skin irritant effects.
Guar Gum	9000-30-0	3	Insoluble in water. Unlikely to bioaccumulate.	Classified as a respiratory sensitiser, mildly irritating to the skin
Poly(vinylidene chloride-co-methyl acrylate)	25038-72-6	1	Insoluble in water. Physiochemical properties are not readily available.	Potential respiratory tract and skin irritant.
Tetrasodium ethylene diamine tetra acetate	64-02-8	3	Dilutes in water. Binds to metal substances. Unlikely to bioaccumulate.	Serious eye irritation (irreversible eye damage)
Polyethylene glycol monolaurate	9005-64-5	1	Physiochemical properties are not readily available.	Mild skin irritation
5-chloro-2-methyl-4-isothiazolol-3-one	26172-55-4	3	Rapid metabolisation. Does not bioaccumulate in tissues.	Acutely toxic (corrosive when ingested), skin sensitiser, serious eye damage/irritation, skin corrosion/irritation.
2-methyl-4-isothizol-3-one	2682-20-4			
Propan-2-ol	67-63-0	1	Miscible in water and is chemically stable.	Irritation of the eyes and the respiratory tract and acute toxicity
Sodium glucolate	527-07-1	0	Dilutes in water. Likely to be biodegradable, unlikely to bioaccumulate.	Non-hazardous substance.
Polylactide resin	9051-89-2	1	Dispersible in water. Likely to be biodegradable, unlikely to bioaccumulate.	Can be an irritant to skin and eyes.

Substance	CAS No	IMAP Hazard Ranking	Environmental Behaviour	Key Determinants and Potential Hazard Outcomes
2,2,2,-nitrilotriethanol	102-71-6	2	Readily dissociates / dilutes in water.	Potential local effects (irritation) in the respiratory tract, skin sensitisation.
Polyethylene glycol monohexyl ether	31726-34-8	3	Readily dissociates / dilutes in water. Environmental distribution and adverse outcomes anticipated to be negligible.	Respiratory tract and skin irritant. Serious eye damage.
Sodium glycolate (impurity)	2836-32-0	3	Readily dissociates to Glycolic acid which is soluble in water	Severe skin burns and eye damage. Irritation of the respiratory tract.
Dicoco dimethyl quaternary ammonium chloride	61789-77-3	3	Dilutes in water. Likely to be biodegradable, unlikely to bioaccumulate.	Severe skin burns and eye damage.
Disodium ethylenediamine tetra acetate	139-33-3	3	Soluble in water and doesn't adsorb strongly to soil and sediments. Not readily biodegradable but can biodegrade under certain conditions.	Mild irritation of the skin and severe irritation of the eye.
Trisodium ethylenediaminetetraacetate	150-38-9	3	Dilutes in water. Binds to metal substances. Unlikely to bioaccumulate.	Serious eye irritation (irreversible eye damage). Causes skin irritation and may cause respiratory irritation. Harmful if swallowed or inhaled.
Trisodium nitrilotriacetate	5064-31-3	3	Dilutes in water. Binds to metal substances. Unlikely to bioaccumulate.	Serious eye irritation (irreversible eye damage). Harmful if swallowed.
Cetylethylmorpholinium ethyl sulphate	78-21-7	3	Dilutes in water. Likely to be biodegradable, unlikely to bioaccumulate.	Serious eye irritation (irreversible eye damage).

Substance	CAS No	IMAP Hazard Ranking	Environmental Behaviour	Key Determinants and Potential Hazard Outcomes
Ethanol	64-17-5	4	Fully water miscible at ambient temperatures. degradation characteristics preclude sustained environmental persistence and distribution.	Group 1 Carcinogen. Systemic and organ toxicity, mutagenic, developmental and reproductive effects and cancer at various sites following sustained repeated ingestion.
Surrogate for Acrylamide, 2-acrylamido-2-ethylpropanesulfonic acid, sodium salt polymer (2-Acrylamido-2-methylpropane sulfonic acid)	5165-97-9, surrogate for 35641-59-9	1	Dilutes in water. Unlikely to be biodegradable.	Skin irritant effects.
Alkyl (C12-16) dimethylbenzyl ammonium chloride	68424-85-1	3	Dilutes in water. Limited aqueous microbial degradation, potential for persistence and distribution.	Severe skin burns and eye damage (corrosive – irreversible effects).
Butyl diglycol	112-34-5	3	Dilutes in water, evaporates slowly. Highly mobile in soil. Exists only as vapour in the atmosphere and is biodegradable in aerobic environments.	Severe eye irritation. It has a low order of acute oral toxicity but moderate chronic toxicity following inhalation.
Decyldimethyl amine (impurity)	1120-24-7	3	High volatilisation potential. Dilutes in water. Expected to undergo rapid degradation in agueous systems. Environmental persistence / distribution not expected.	Severe skin burns and eye damage (corrosive – irreversible effects). Harmful if swallowed.

Substance	CAS No	IMAP Hazard Ranking	Environmental Behaviour	Key Determinants and Potential Hazard Outcomes
Decyl-dimethyl amine oxide	2605-79-0	3	Low volatilisation potential. Dilutes in water. Expected to undergo rapid degradation in agueous systems. Environmental persistence / distribution not expected.	Eye irritant effects (corrosive – irreversible effects).
Fumaric Acid	110-17-8	1	Readily dissociates / dilutes in water.	Eye irritant effects (reversible).
Hydroxypropyl cellulose (Hydroxypropyl methylcellulose used as a surrogate; CAS #9004-65-3)	9004-64-2	0	Readily dissociates / dilutes in water.	Non-hazardous substance.
Pentaethylenehexamine	4067-16-7	3	Readily dissociates / dilutes in water.	Severe skin burns and serious eye damage (corrosive – irreversible effects). Harmful if swallowed or when in contact with skin. May cause an allergic skin reaction.
Sodium-carboxyl-methyl-hydroxyl-propyl guar	68130-15-4	3	Dilutes in water. Likely to be biodegradable, unlikely to bioaccumulate.	Respiratory effects (asthma). Skin and eye irritant effects
Tetraethylenepentamine	112-57-2	3	Dilutes in water. Likely to be biodegradable. Exists in vapour and particulate phases if released to atmosphere.	Severe skin burns and serious eye damage. May cause an allergic skin reaction and respiratory tract irritation. Harmful if swallowed or when in contact with the skin (acute toxicity) with repeat dose studies demonstrating oral and dermal effects.
Tetramethylammonium chloride	75-57-0	3	Dilutes in water. Not readily biodegradable. Exists in vapour and	Acute toxicity – fatal if swallowed. Toxic when in contact with the skin. Skin irritant effects.

Substance	CAS No	IMAP Hazard Ranking	Environmental Behaviour	Key Determinants and Potential Hazard Outcomes
			particulate phases if released to atmosphere. High mobility if released to soil.	
Triethylenetetramine	112-24-3	3	Dilutes in water. Limited information on environmental behaviour	Acute dermal toxicity. Skin sensitiser and severe irritant to eyes and skin.
L-Glutamic Acid	56-86-0	0	Readily dissociates / dilutes in water.	Non-hazardous substance.
Octadecanoic acid calcium salt	1592-23-0	0	If released into water is expected to adsorb to suspended solids and sediment. Expected to be biodegradable in water.	Non-hazardous substance.
Crystalline Silica, Quartz	14808-60-7	4	Does not degrade under standard temperature and pressure conditions and thus distribution is widespread	Carcinogenicity via the inhalation pathway.
Hydrochloric Acid	7647-01-0	3	Dissociates readily to chloride and hydronium ions, decreasing the pH of the water.	Acute toxicity via inhalation and corrosive properties (lung, eyes, skin and mucous membranes)
Sodium Hydroxide	1310-73-2	3	Dissociates readily in water. Effects on water alkalinity and direct effects on plants and animal tissues from acute environmental exposures where	Acute toxicity and corrosive and irritating to the skin and eyes.

Substance	CAS No	IMAP Hazard Ranking	Environmental Behaviour	Key Determinants and Potential Hazard Outcomes
			exposure to dusts and concentrated solutions may result.	
Crystalline Silica, cristobalite	14464-46-1	4	Does not degrade under standard temperature and pressure conditions and thus distribution is widespread	Carcinogenicity via the inhalation pathway.
Nitrogen, liquid form	7727-37-9	3	Liquid nitrogen would rapidly convert to gaseous form and be lost to atmosphere. The release of liquid nitrogen to atmosphere can lead to the condensation of oxygen, which presents a physical fire and explosion risk as it creates a localised enrichment of oxygen.	The risks associated with liquid nitrogen arise from the physical conditions (i.e. extremely low temperature and high pressure) under which it exists. These include the potential for frostbite and burns.
Boric Acid	10043-35-3	4	Dissociates in water to form a weak acid.	Potential reproductive toxicity and eye irritant.
Diatomaceous earth, calcined	91053-39-3	4	Insoluble in water. Unlikely to bioaccumulate. Would settle into soils and sediments and become indistinguishable from those materials	Carcinogenicity via the inhalation pathway (due to presence of the crystalline silica fraction)
Magnesium nitrate	10377-60-3	3	Water soluble inorganic salt. It is very hygroscopic and in air quickly forms the hexahydrate with the formula Mg(NO3)2.6H2O.	Solution can cause skin irritation and serious (irreversible) eye damage.

Substance	CAS No	IMAP Hazard Ranking	Environmental Behaviour	Key Determinants and Potential Hazard Outcomes
Magnesium silicate hydrate (talc)	14807-96-6	1	Relatively inert and non-reactive.	Mild skin and eye irritant
Magnesium chloride	7786-30-3	0	Magnesium chloride in solution dissociates to magnesium and chloride ions. Magnesium is an essential mineral in all life	Non-hazardous to human health
Ceramic materials and wares	66402-68-4	3	Insoluble in water, persistent, non bioaccumulative.	Serious eye irritation (irreversible eye damage).
Sodium Bromate	7789-38-0	4	Readily dissociates / dilutes in water.	Probable human carcinogen,
Sodium thiosulphate	7772-98-7	0	Dilutes in water. Likely to be biodegradable, unlikely to bioaccumulate.	Non-hazardous to human health.
Non crystalline silica	7631-86-9	0	Insoluble in water. Unlikely to bioaccumulate.	Non-hazardous substance, nuisance dust when inhalable.
Potassium hydroxide	1310-58-3	3	Readily dissociates / dilutes in water.	Severe skin burns and eye damage (irreversible effects). If aerosols/mist occur, they will cause direct local effects on respiratory tracts
Surrogate for Sodium tetraborate (Borax)	1303-96-4 (surrogate for 1330-43-4)	4	Readily dissociates to boric acid / dilutes in water. Waterborne boron may also be adsorbed by soils and sediments and may persist.	Skin, eye and respiratory irritant effects. Reproductive toxicity potential.

Substance	CAS No	IMAP Hazard Ranking	Environmental Behaviour	Key Determinants and Potential Hazard Outcomes
Silica gel	112926-00-8	0	Low solubility. Would settle into soils and sediments and become indistinguishable from those materials.	Non-hazardous to human health. Hazard limited to dust generation.
Hydrogen Peroxide (impurity)	7722-84-1	3	Readily dissociates / dilutes in water.	Severe burns and eye damage (corrosive – irreversible effects). Potential to cause respiratory irritation. Severe health effects if swallowed or inhaled.
Zirconium dichloride oxide	7699-43-6	3	Readily dissociates / dilutes in water.	Causes severe skin burn and eye damage (corrosive).

6.5 Uncertainty Analysis and Concluding Comments

The evaluation of the hazards presented in Table 44 is based on the available data obtained from the selected sources presented in Section 6.3. As a consequence it is limited to the quantity and quality of information available in those sources. A measure of the data completeness for the toxicological and hazard parameters used has been estimated using a percentage of the parameters for which data were available. An assessment of the quality of the available data is beyond the scope of this report. In the absence of verifying the data by going to the primary literature sources, the selection of data for use in the assessment has been confined to established, robust and reputable sources such as WHO and US EPA where available. As new toxicological data are generated and becomes available in the published literature, the information presented in this hazard evaluation and the associated conclusions may be subject to change. Specific areas where such information is being generated include the areas of endocrine disruptors and nanotoxicity. The latter has at this stage not been a focus of these current evaluations due to the paucity of available peer-reviewed information but may be required as new information becomes available.

The hazard evaluation for human health suggests that the dominant concerns are related to occupational hazards such as carcinogenicity, silicosis, skin, eye and respiratory irritancy or corrosivity and sensitisation. In some cases physical hazards of flammability and explosion prevail and are identified in this report. While extensive dilution of the hydraulic stimulation chemicals is anticipated such that exposure concentrations will be much reduced compared to concentrations injected into the well, and in flowback fluid, there are a number of environmental hazards that are suggested from this human health evaluation. These include the potential for:

- Residual elevation of organic moieties. e.g. some salts have an organic part that will be present following dissociation that may increase in environmental waters.
- Changes in pH of environmental waters due to alkaline or acidic components.
- Elevations of certain metal concentrations in environmental waters.
- Some additives to exert endocrine disruption effects.
- Certain inorganic substances to generate atmospheric particulates that may impact nearby communities.

Volatile components to comprise nuisance or irritant effects should atmospheric concentrations be elevated in close proximity to communities. These environmental hazards may be assessed further, and/or managed as required. Acrylonitrile has been identified as a specific concern due to it classification as a probable human carcinogen and the possibility that aqueous degradation in some cases may be limited necessitating further examination of site-specific degradation potential. It is noted, however, that the evaluation of exposure pathways has indicated that the potential for surface water and groundwater, to which humans could be exposed, to be impacted by hydraulic stimulation fluid chemicals is considered to be low.

7.0 RISK CHARACTERISATION

Risk characterisation is the final step in a risk assessment process. It traditionally involves the incorporation of the exposure assessment and toxicological dose-response data. In this qualitative risk assessment the process has embodied a hazard assessment and discussion of potential exposure pathways as part of a qualitative assessment of risk.

7.1 Discussion of Hazard Assessment

A hazard assessment of the chemicals used in the hydraulic stimulation process by Santos contractor Schlumberger have been assessed through the evaluation of PBT for aquatic toxicity, various data sources for terrestrial toxicity, and human health toxicity including physical hazards such as fire and explosion. The review of hazards is qualitative in that it has provided a relative ranking of chemicals.

It should be noted that the selection of a substance as a COPC does not indicate an unacceptable risk; rather it indicates that potential exposures to these chemicals should be evaluated in greater detail to assess whether they might present an unacceptable risk. Further assessment usually entails evaluation of likely environmental concentrations and refinement of the exposure assessment.

The hazard assessment incorporates the assessment of toxicity and is based on the assumption that the pure substance is present; this is not true of either the stimulation fluid or the resultant concentration in the environment. The concentration of chemicals in the stimulation fluid during a release into the environment is expected to be less than the starting concentration calculated in the mass balance. The concentrations are expected to be reduced due to chemical processes during the stimulation process that result in transformation of the chemicals to simpler end products. In addition chemicals will be subject to degradation, dispersion and adsorption all of which will result in attenuation of chemical concentrations with distance from the radius of stimulation.

7.1.1 Aquatic and Terrestrial Assessment

Of the fifty-two individual hydraulic stimulation chemicals assessed, forty-four were classified for aquatic hazard. Five of the fifty-two chemicals: sodium hydroxide, hydrochloric acid, magnesium chloride, potassium hydroxide and magnesium nitrate, were not scored for persistence as these chemicals readily dissociate in the environment. Two chemicals (guar gum and sodium carboxymethylhydroxypropyl guar) were not assessed due to insufficient data but are qualitatively discussed. An additional four chemicals were not assessed due to being equivalent to sand and/or chemically inert.

Of the forty-four chemicals classified, the following aquatic hazard classifications were assigned:

- twenty-two were classified low hazard;
- fourteen were classified moderate hazard; and
- eight were classified high hazard.

The eight chemicals classified as a high aquatic hazard were considered to be COPC, these were:

- Dicoco dimethyl quarternary ammonium chloride;
- Alkyl (C12-C16) dimethylbenzyl ammonium chloride;
- Sodium tetraborate;
- Nitrogen, liquid form;
- Boric acid;
- Magnesium silicate hydrate (talc);

- Hydrogen peroxide (impurity); and
- Zirconium dichloride oxide.

Of the high aquatic hazard chemicals identified, the following further interpretations are provided:

- Nitrogen, liquid form. Nitrogen is only a liquid at low temperature and pressure, conditions which will not prevail in the hydraulic stimulation fluid or at the drill pad. At atmospheric temperature and pressure nitrogen is a gas. The extent that nitrogen will have reacted with other constituents in the hydraulic stimulation mixture before volatilisation, is not known.
- Boric acid, magnesium silicate hydrate (talc), hydrogen peroxide, zirconium dichloride oxide and sodium tetraborate are considered as high hazards in this assessment based primarily on persistence. Review and interpretation of the aquatic toxicity data suggest these five chemicals present a low to moderate aquatic toxicity hazard.
- Dicoco dimethyl quarternary ammonium chloride is considered a high hazard based primarily on its toxicity. The toxicity data available for this chemical are limited (only acute fish and invertebrate data available) however review and interpretation of the persistence and bioaccumulation data suggest this chemical presents a low to moderate aquatic hazard.
- Alkyl (C12-C16) dimethylbenzyl ammonium chloride is considered a high hazard based on its high persistence and aquatic toxicity. As with dicoco dimethyl quarternary ammonium chloride the toxicity data available for this chemical is limited with only acute fish and plant data available.

It is noted that only one (liquid nitrogen) of the eight high aquatic hazard chemicals is expected to be in concentrations greater than 0.1% in a stimulation fluid mixture (as indicated by the fluid descriptions) and five of the high aquatic hazard chemicals are expected to be at concentrations less than 0.01%.

Given the management controls in place to prevent releases to the environment, potential aquatic hazards from individual hydraulic stimulation chemicals, are considered unlikely to be realised.

Of the fifty-two hydraulic stimulation chemicals, seven chemicals were not assessed due to insufficient data and six were not assessed because they were considered to be essentially sand, leaving 39 chemicals for assessment of terrestrial toxicity.

The following organic chemicals were assessed to have the potential to pose a higher hazard in the terrestrial environment relative to the other chemicals assessed based on persistence and potential to biomagnify:

- Cetylethylmorpholinium ethyl sulphate;
- Tetramethylammonium chloride;
- Surrogate for Octadecanoic acid, calcium salt;
- Decyldimethyl amine (impurity);
- Declydimethyl amine oxide;
- Surrogate for Vinylidene chloride/methacrylate; and
- Disodium ethylene diamine tetra acetate.

Six of the seven chemicals shown above are expected to be in concentrations less than 0.1% in a stimulation fluid mixture (as indicated by the fluid descriptions), with only one chemical (tetramethylammonium chloride) expected at concentrations up to 1%.

Tetramethylammonium chloride, decyldimethyl amine oxide and disodium ethylene diamine tetra acetate have low volatility but they are not likely to persist in the terrestrial environment as illustrated by a moderate to rapid half-life and low potential to bioaccumulate.

Surrogate for octadecanoic acid, calcium salt and decyldimethyl amine (impurity) both have a high potential to biomagnify but due to a moderate half-life and low to moderate volatility they are not likely to persist in the terrestrial environment.

Surrogate for vinylidene chloride/methacrylate (1,1 DCE) has the potential to persist in the terrestrial environment due to a slow half-life however it has low potential to biomagnify and low volatility.

Given the management controls in place to prevent releases to the environment, potential hazards from individual hydraulic fracturing chemicals to terrestrial ecosystems are not expected to be realised.

7.1.2 Human Health Assessment

The hazard evaluation for human health undertaken on the fifty-two chemicals in accordance with the IMAP Framework hazard ranking methodology indicated thirty-five of fifty-two chemicals assessed under this methodology to be a Hazard Rank of 3 or 4. Of the Hazard Rank 4 chemicals, all but one chemical (crystalline silica) are expected to be at concentrations less than 0.1% in a fluid mix (based on the fluid disclosure information provided by Schlumberger). Crystalline silica is not expected at a concentration above 1%.

The hazard evaluation for human health suggests that the dominant concerns are related to occupational hazards such as carcinogenicity, silicosis, skin, eye and respiratory irritancy or corrosivity and sensitisation. In some cases physical hazards of flammability and explosion prevail and are identified in this report. While extensive dilution of the hydraulic stimulation chemicals is anticipated such that potential exposure concentrations will be much reduced compared to concentrations injected into the well and in flowback fluid, there are a number of hazards that are suggested from this human health evaluation, as previously discussed in section 6.5.

7.2 Discussion of Exposure Assessment

Potential exposure pathways were evaluated for on-site (i.e. within the lease) and those relevant for off-site (i.e. anything beyond the well lease boundary). Potentially complete exposure pathways were evaluated for workers, trespassers, native fauna and flora and livestock. The environment immediately surrounding the well lease (i.e. off-site) throughout the study area may vary from lease to lease but was considered to potentially include homesteads (adult and child residents), water supply bores, creeks or waterholes, livestock and native flora and fauna.

The on-site assessment indicated that the majority of potential exposure pathways were unlikely or incomplete, given the application of operational controls by Santos.

One potentially complete exposure pathway was identified, which is direct contact to the flowback water in the Flare Pit for small fauna (i.e. rodents, lizards and birds). All reasonable measures will be implemented to discourage entry of small native fauna into the well lease area during hydraulic stimulation operations.

Potential off-site exposure pathways were evaluated for homesteads, livestock, native flora and fauna and aquatic ecosystems. Three possible sources were identified: hydraulic stimulation fluids, sediments from Flare Pit and flowback water. The exposure assessment concluded:

- Based on understanding of the Eromanga and Cooper Basin geology and hydrogeology, and Santos' well integrity testing procedures and operational monitoring, exposure to residual stimulation chemicals through subsurface pathways is considered unlikely and incomplete; and

- At the surface, a spill or leak of flowback water from the Flare Pit was considered possible, however the implementation of operational controls, including use of liners in Flare Pits, removal of fluid and sediment using vacuum techniques and engineering and operational controls (grading of well leases, stormwater controls and maintenance of a minimum of 300 mm freeboard within the Flare Pits) is considered sufficient to limit the potential for uncontrolled releases of flowback water to the environment. A further margin of safety is provided by Santos' evaluation of 'environmentally sensitive areas' when establishing well leases, which includes the establishment of buffers between petroleum (and stimulation) activities and features of potential environmental concern. Subsequently, the potential off-site exposure scenarios are considered unlikely and incomplete.

7.3 Qualitative Risk Assessment of Fluids

A preliminary characterisation of typical stimulation fluids, comprising a limited suite of chemical analyses was undertaken. Flow back fluids were not characterised.

The initial chemical suite and assessment was to assist in further identification of potential hazards to humans and the environment using reported concentrations of stimulation fluid constituents, prior to stimulation being undertaken.

7.3.1 Methodology for Qualitative Risk Assessment

7.3.1.1 Field Work and Sampling Approach

The objective of the sampling was to provide a preliminary comparison against DEHP guidelines, prior to stimulation being undertaken. The approach is not a definitive representation of chemical or physical parameters, as this would ideally require a broad suite of analytes, larger number of samples over a longer time frame.

Schlumberger indicated that the following sampling procedure was adopted:

- On 17 July and 12 August, 2013, a Schlumberger laboratory technician collected four stimulation fluids samples at their office in Chinchilla, Queensland.
- Each fluid sample was placed in two sample bottles prepared by the analytical laboratory. The sample bottle was filled to the top to minimise loss of volatile chemicals, and oxidation of the sample.
- Samples collected on 17 July were labelled *YF120w/L07/* and *YF140 HDT*, and samples collected on 12 August were labelled ThermaFRAC 40 Additives, ThermaFRAC 40 Polymer and Slickwater. These samples could not be mixed as mixing caused the fluid to coagulate, which was not practical for the laboratory to test without significant dilution.
- Disposable gloves were used during sampling.
- The fluid sample was placed in a chilled, insulated container and delivered to the laboratory.

The general sample collection, storage and transport procedures indicated by Schlumberger appear to be consistent with good industry practice. However the following QA/QC limitations were noted:

- No blind duplicate samples were noted in the laboratory analytical reports.
- No rinsate blank samples were noted in the laboratory analytical reports. Typical frequency is one rinsate blank per sample batch submitted to the laboratory.
- No trip blank or trip spike samples were noted in the laboratory analytical reports. Typical frequency is one trip spike and one trip blank per analytical batch.
- No reagent blank samples were noted in the laboratory analytical reports. For any product sample prepared as a dilution, a sample of the diluting fluid (reagent blank) should also be submitted for analysis to assess for the presence of impurities.

- Chain of custody (CoC) and sample receipt notice (SRN) documentation were not provided for review along with the laboratory analytical reports as evidence of proper procedure.

7.3.1.2 Laboratory Quality Control

Typical laboratory quality control measures include laboratory duplicate samples, method blanks, laboratory control spikes, matrix spikes, and surrogate spikes. Each of these measures assesses a separate aspect of the laboratory procedures for analytical bias due to the laboratory methods, equipment, or sample properties. Of these, only evidence of surrogate spikes was reported on the laboratory reports. The absence of other laboratory control data may be due to small sample batches, which are insufficient to warrant the full standard suite of laboratory QC samples.

ALS typically supplies quality control summary reports along with its laboratory reports, which may include additional information in this regard. However, if provided, these were not passed on to Golder for review.

7.3.1.3 Assessment of QA/QC

With regard to potential future product sampling and analysis, it is recommended that samples are either submitted in larger batches, or a minimum level of laboratory QA/QC is specified on the CoC for each batch such that a broader suite of laboratory QC measures can be assessed.

While the limited information provided by Schlumberger in regard to sample preparation, storage and transport to the laboratory is generally consistent with good industry practice, there were omissions to the standard QA/QC protocols without which it is not possible to validate the integrity of the laboratory data for its suitability for interpretive use.

7.3.1.4 Analytical Approach

ALS Environmental (ALS) was engaged to perform chemical analyses. ALS is registered by the National Association of Testing Authorities (NATA) for the analyses performed. Analysis of the fluid samples included a limited range of parameters.

- Polycyclic aromatic hydrocarbons (PAH) – 5 samples.
- Benzene, toluene, ethylbenzene, xylenes (BTEX) – 4 samples.

The laboratory certificates are also presented in APPENDIX G.

7.3.2 Fluid Risk Assessment

The purpose of the stimulation fluid assessment was a preliminary, qualitative comparison against DEHP guidelines. The BTEX results for the fluids are summarised in Table 45. Make-up water and flowback fluids were not assessed.

Table 45: Summary of BTEX Analytical Results for Fluids (µg/L)

Analyte	DEHP Criteria	YF120w/L07	YF140 HDT[1,2]	ThermaFRAC additives	ThermaFRAC polymer	Slickwater
Benzene	1	-	<0.12	<0.05	<0.05	<0.05
Toluene	180	-	<0.5	3.7	<0.5	<0.5
Ethylbenzene	80	-	<0.12	0.07	<0.05	<0.05
o-Xylene	350	-	<0.12	<0.05	<0.05	<0.05
m & p-Xylene	275[3]	-	<0.25	<0.05	<0.05	<0.05

Notes:

1) The laboratory reported that sample YF140 HTD has been heated to reduce viscosity of the gel. As such volatile analytes may have been lost through evaporation.
2) YF140 HTD required dilution prior to extraction due to matrix interferences. LOR values have been adjusted accordingly
3) Combined criteria of 75 µg/L for m-xylene and 200 µg/L for p-xylene

The reported BTEX and PAH concentrations were below the laboratory LOR and DEHP regulated criteria (for BTEX) for hydraulic stimulation fluid additives in Queensland with the exception of the ThermaFRAC 40 samples.

- There were two samples analysed for ThermaFRAC, with sample IDs annotated with “additives” and “polymer”.
  - The “additives” sample reported PAH concentrations below the LOR, however reported detectable concentrations of toluene and ethylbenzene (below the prescribed concentrations in Table 1) and styrene (for which there is no specific prescribed concentration in relation to stimulation fluids, refer to Table 2). The reported styrene concentration (0.25 µg/L) was below the health-based (30 µg/L) and aesthetic (4 µg/L) values in the NHMRC & NRMMC (2011) *Australian Drinking Water Guidelines*; no ecological trigger value is available for styrene in the ANZECC & ARMCANZ (2000) *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*.
  - The “polymer” sample reported BTEX concentrations below the LOR, however reported detectable concentrations of three PAHs (benzo(ghi)perylene (0.2 µg/L); naphthalene (0.7 µg/L), phenanthrene (0.3 µg/L); refer to Table 2). With regard to Australian water quality criteria, both naphthalene and phenanthrene were below the ANZECC & ARMCANZ (2000) trigger values. No ecological criterion is available for benzo(ghi)perylene, and no Australian health-based criteria are available for the three chemicals.

The information provided by Schlumberger in relation to BTEX and PAH analysis of its disclosed stimulation fluids has limitations in both its representation of all of the disclosed fluids and specific additives, and also in the limited QA/QC data available with which to validate the analytical results. These limitations would be required to be reported in conjunction with discussion of the analytical results.

7.4 Overall Evaluation of Risk

Considering the hazard and exposure assessment and operational controls discussed, the overall risk to human health and environment associated with the chemicals involved in hydraulic stimulation are expected to be low. These operational controls include:

- OH&S procedures implemented during hydraulic stimulation operations to prevent workers from direct contact and inhalation exposure to chemicals during spills and when handling flowback water or sediments.
- Assigning buffers during establishment of well leases between petroleum operations and potential “environmentally sensitive areas” identified though database review and site-specific ecological assessment where warranted.
- Establishment of buffers prior to stimulation activities, between the stimulation initiation point and private water bores identified though water bore baseline assessment.
- Implementation of spill containment procedures during operations to prevent migration of and exposure to chemicals.
- Removal of sediments and fluids contained within drained Flare Pits to prevent exposure to contaminants in windborne dust.
- Installation and maintenance of fences around the Flare Pits to prevent access by trespassers and installation of signs to indicate well leases are a work zones to be accessed by authorised personnel.

- Installation and maintenance of fences around Flare Pits to prevent access by livestock and large native fauna.
- Santos operational procedures regarding well integrity verification and fracture design to stay within the target formation.
- Lining of Flare Pits as a minimum standard, and evaluation of improved containment methods in 2013, to prevent seepage of flowback water into the underlying aquifer.
- Engineering and operational controls (grading of well leases, stormwater controls and maintenance of a minimum of 300 mm freeboard within the Flare Pits) to limit the potential for uncontrolled surface releases of flowback water to the environment.

7.5 Other Considerations

7.5.1 Noise and Vibration

The activities associated with hydraulic stimulation have the potential to generate noise or vibration that could potentially impact nearby receptors. However, given the remote nature of Cooper Basin stimulation activities the presence of nearby receptors is considered unlikely. In addition, whilst the proposed activities will take place on a continuous basis, they will be undertaken sequentially for short periods of time at different sites over a wide area. As a result individual sensitive receivers are only likely to be exposed to the effects of noise and vibration from these activities for a few weeks at a time. On this basis, risk associated with noise and vibration to offsite receptors has not been considered further in this report.

Potential for onsite noise and vibration exposure to workers exist during hydraulic stimulation activities. Santos and stimulation service provider's equipment are subject to noise emission testing by a professional third party. Prevention of exposure to workers is managed through Santos OH&S procedures.

8.0 CONCLUSIONS

8.1 Environmental Setting

Santos operates conventional gas and oil fields across petroleum tenements within an approximately 30,000 km^2 portion of Southwest Queensland. These tenements and the land surrounding the Santos tenement boundaries comprise the Santos SWQ *study area*.

The terrain in the study area is generally characterised by low undulating topography (hills and ridges) between the drainage channel systems of the Cooper Creek. The area is sparsely developed, and generally comprises rural communities and homesteads that are largely engaged in farming and livestock.

It is within the stratigraphy that comprises the Eromanga Basin and the underlying Cooper Basin that oil and gas reservoirs are located which contain the proposed target formations for hydraulic stimulation. A detailed description of key geological and hydrogeological features is provided in Volume One, including geological models for the study area, target hydrocarbon-bearing sandstone formations (oil in the Eromanga Basin formations at depths ranging from 700 to 1,200 mbgl, and gas in the Cooper Basin formations at depths of 1,500 to greater than 2,000 mbgl), their hydraulic characteristics, adjacent aquifers and aquitards, structural features including faults and fracture characteristics (and their potential to behave as barriers or conduits), regional and local seismicity characteristics, aquifer environmental values and the location of groundwater users.

In terms of the environmental setting, Volume One of the SWQ HSRA has provided specific information which addresses the requirements anticipated of the EA conditions regarding hydraulic stimulation that will apply to existing and new areas.

Based on understanding of the environmental setting, this qualitative risk assessment considered the key environmental values as follows:

Groundwater environmental values:

- Town water supply;
- Stock and domestic water supply;
- Sandstone aquifers of the GAB; and
- GDEs.

Surface water environmental values:

- Protection of aquatic ecosystems;
- Recreation and aesthetics: primary recreation with direct contact, and visual appreciation with no contact; and
- Cultural and spiritual values.

Terrestrial environmental values:

- Protection of flora and fauna, particularly small mammals, reptiles and birds with a greater the potential to come into contact with flowback water in Flare Pits.

The report has considered each in terms of the risk to aquatic ecosystems, terrestrial ecosystems and human health.

8.2 Hydraulic Stimulation Process Description Summary

With regard to the process of hydraulic stimulation, information addressing the anticipated EA approval conditions (with reference to the model conditions) is located within Volume One of the SWQ HSRA, including:

- Practices and procedures to ensure that the stimulation activity(ies) is designed to be contained within the target gas producing formation.
- Provide details of where, when and how often stimulation is to be undertaken on the tenures covered by this environmental authority.
- A description of the well mechanical integrity testing program.
- Process control and assessment techniques to be applied for determining extent of stimulation activity(ies) (e.g. microseismic measurements, modelling etc).
- A process description of the stimulation activity to be applied, including equipment and a comparison to best international practice.

8.3 Toxicological Evaluation

The toxicity of the chemicals used in the hydraulic stimulation process by Schlumberger has been assessed for persistence, bioaccumulation and aquatic toxicity (PBT), terrestrial toxicity and human health toxicity including the physical hazards of fire and explosion. The review of toxicity is qualitative and has provided a ranking of chemicals considered to represent a high, moderate or low hazard in respect to the ecological or human health end points with qualification as appropriate.

A preliminary quantitative assessment has also been undertaken, with Schlumberger collecting a total of two fluid samples of stimulation fluids for chemical analysis. The two samples were tested for PAHs and BTEX. The concentrations of BTEX were reported below the DEHP BTEX standard.

8.4 Evaluation of Exposure Pathways

Potential exposure pathways were evaluated for on-site (i.e. within the well lease), and those relevant for off-site (i.e. anything beyond the well lease boundary). The on-site assessment indicated that the majority of possible exposures were unlikely or incomplete. One complete exposure pathway was identified, which is direct contact to the flowback water in the Flare Pit for small fauna (i.e. lizards and birds). All reasonable measures will be conducted to discourage entry of small native fauna into the well lease area during hydraulic stimulation operations. Improvement of flowback water containment will further reduce the potential for this exposure scenario to occur.

For the off-site exposure assessment, it was assumed that potential off-site receptors could include homesteads (adult and child residents), water supply bores, creeks and waterholes, livestock and native flora and fauna. Three possible chemical sources were identified: injected hydraulic stimulation fluids, sediments from Flare Pit and flowback water. The exposure assessment concluded:

- Subsurface exposure to stimulation fluids is controlled by Santos' well integrity testing procedures and operational monitoring, and this pathway (whereby stimulation fluids could escape into the formation and contaminate adjacent aquifers that are used for domestic or stock water supply) is considered unlikely or incomplete.
- Based on an understanding of the Eromanga and Cooper Basin geology and hydrogeology, and the nature and extent of groundwater supply development, exposure to residual stimulation chemicals through subsurface pathways is considered unlikely and incomplete.
- At the surface, a spill or leak of flowback water from the Flare Pit was considered as a possible exposure scenario, however the implementation of operational controls, including use of liners in Flare Pits, removal of fluid and sediment using vacuum techniques and engineering and operational controls

(grading of well leases, stormwater controls and maintenance of a minimum of 300 mm freeboard within the Flare Pits) is considered sufficient to limit the potential for uncontrolled releases of flowback water to the environment. A further margin of safety is provided by Santos' evaluation of 'environmentally sensitive areas' when establishing well leases, which includes the establishment of buffers between petroleum (and stimulation) activities and features of potential environmental concern. Subsequently, the potential off-site exposure scenarios are considered unlikely and incomplete.

8.5 Overall Risk Evaluation

Considering the hazard, exposure assessment and qualitative assessment of fluids, flowback water at surface presents inherent possible, albeit unlikely, risk. However, with Santos operational controls and management, the overall or residual risk to human health and environment associated with the chemicals involved in hydraulic stimulation are expected to be low. The management measures implemented through operational controls include:

- OH&S procedures implemented during hydraulic stimulation operations to prevent workers from direct contact with chemicals during spills and when handling flowback water or sediments.
- Santos operational procedures regarding well integrity verification and fracture design to stay within the target formation.
- Assigning buffers during establishment of well leases between petroleum operations and potential "environmentally sensitive areas" identified though database review and site-specific ecological assessment where warranted.
- Establishment of buffers prior to stimulation activities, between the stimulation initiation point and private water bores identified though water bore baseline assessment.
- Implementation of spill containment procedures during operations to prevent migration of and exposure to chemicals.
- Vacuum removal of sediments and fluids contained within Flare Pits, to prevent exposure to contaminants in fluids and windborne dust.
- Installation and maintenance of fences around the Flare Pits to prevent access by trespassers, and installation of signs to indicate that well leases are work zones to be accessed by authorised personnel.
- Installation and maintenance of fences around the Flare Pits to prevent access to the by livestock and large native fauna.
- Lining of Flare Pits and improvement of fluid storage and containment methods, to prevent seepage of flowback water into the underlying aquifer.
- Engineering and operational controls (grading of well leases, stormwater controls and maintenance of a minimum of 300 mm freeboard within the Flare Pits) to limit the potential for uncontrolled surface releases of flowback water to the environment.

The adequacy and appropriateness of these exposure controls will be routinely evaluated by Santos and modifications and revisions made, where necessary, to achieve continuous improvement.

9.0 REFERENCES

Australian and New Zealand Environment Conservation Council (ANZECC) and Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ) (2000). Australian and New Zealand Guidelines for Fresh and Marine Water Quality for protection of aquatic ecosystems and stock watering.

Bunn, S.E., Thoms, M.C., Stephen, K.H., Capon, S.J., 2006. Flow variability in dryland rivers: boom, bust and the bits in between. River Research and Applications, 22, 179–186.

CCME (2008) Canadian Council of Ministers of the Environment, National Classification System for Contaminated Sites (NCSCS) Guidance Document, Winnipeg.

Cendon, D.I., Larsen, J.R., Jones, B.G., Nanson, G.C., Rickleman, D., Hankin, S.I., Pueyo, J.J., Maroulis, J., 2010. Freshwater recharge into a shallow saline groundwater system, Cooper Creek floodplain, Queensland, Australia. Journal of Hydrology, 392, 150-163.

ChemIDplus (2012). United States National Library of Medicine. Accessed at: http://chem.sis.nlm.nih.gov/chemidplus/rn/.

Christensen, F.M., de Bruijn J.H.M., Hansen, B.G., Munn, S.J., Sokull-Kluttgen, B. and Pedersen, F. (2003). Assessment Tools under the New European Union Chemicals Policy. GMI 41, Springleaf Publishing, 2003.

Clean Production Organisation (2009). The Green Screen for Safer Chemicals Version 1.0. White paper. Available @ http//: http://www.cleanproduction.org/Greenscreen.php (accessed 30 May 2011).

Costelloe, J.F., Shields, A., Grayson, R.B., McMahon, T.A., 2007. Determining loss characteristics of arid zone river waterbodies. River Research and Applications, 23, 715–731.

Department of Environment and Heritage Protection (DEHP) (2010). Regional Ecosystems, updated April 2010. Accessed at: http://www.ehp.qld.gov.au/ecosystems/.

Dunn A.M. (2009) A relative risk ranking of selected substances on Canada's National Pollutant Release Inventory. HERA 15: 579-603.

ECETOC (2005). European Centre for Ecotoxicology and Toxicology of Chemicals Risk Assessment of PBT Chemicals Technical Report No.98, Accessed at: http://www.ecetoc.org/technical-reports.

ECHA (2012). European Chemical Agency. Accessed at: http://echa.europa.eu/.

ECOSAR (2012). Ecological Structure Activity Relationships ECOSAR™ software version 1.11 dated July 2012. Accessed at: http://www.epa.gov/oppt/newchems/tools/21ecosar.htm.

enHealth (2010) Australian Exposure Factor Guidance REVIEW DRAFT enHealth Council.

Environment Canada (2003) Existing Substances Branch Guidance Manual for the Categorization of Organic and Inorganic Substances on Canada's Domestic Substances List (DSL).

EPHC (2009a). Environment Protection and Heritage Council Environmental Risk Assessment Guidance Manual for Industrial Chemicals, February 2009. Accessed at: http://www.ephc.gov.au/sites/default/files/CMgt_NChEM__ERAGM_for_Industrial_Chemicals_200902.pdf.

EPHC (2009b). Environment Protection and Heritage Council Environmental Risk Assessment Guidance Manual for Agricultural and Veterinary Chemicals February 2009. Accessed at: http://www.scew.gov.au/publications/pubs/chemicals/cmgt_nchem__eragm_for_agricultural_and_veterinary_chemicals_200902.pdf.

EPISUITE (2012). United States Environmental Protection Agency Exposure Tools and Assessment EPISUITE v4.1. Accessed at: http://www.epa.gov/oppt/exposure/pubs/episuitedl.htm.

enHealth (2004). Environmental Health Risk Assessment, Guidelines for Assessing Human Health Risks from Environmental Hazards, Department of Health and Ageing and enHealth Council, June 2004.

European Commission (2003). European Chemicals Bureau Technical Guidance Document on Risk Assessment in support of Commission Directive 93/67/EEC on Risk Assessment for New Notified Substances. Accessed at: http://ihcp.jrc.ec.europa.eu/our_activities/public-health/risk_assessment_of_Biocides/doc/tgd/tgdpart2_2ed.pdf.

European Commission (2012). Toxicity and Assessment of Chemical Mixtures. Accessed at: http://ec.europa.eu/health/scientific_committees/environmental_risks/docs/scher_o_155.pdf.

European Union (2006) Registration, Evaluation and Authorisation of Chemicals–REACH (European Chemicals Agency – an agency of the European Union).

Franke, C., Studinger, G., Berger,G., Bohling, D., Bruckmann, U., Cohors-Fresenborg, D. and Johncke, U. (1994), The Assessment of Bioaccumulation. Chemosphere 29: 1501-1514.

Gibson, E., Strudwick, D and P. Walker (1997). Draft National Framework for Ecological Risk Assessment of Contaminated Sites, Victorian Environment Protection Authority (VIC EPA).

Hamilton, S.K., Bunn, S.E., Thoms, M.C., Marshall, J.C., 2005. Persistence of aquatic refugia between flow pulses in a dryland river system (Cooper Creek, Australia). Limnology and Oceanography, 50, 743–754.

HSDB (2012). Hazardous Substances Data Bank. Accessed at: http://toxnet.nlm.nih.gov/.

Hulzebos, E.M., Ademab., D.M.M., Dirven-van Breemena, E.M., Henzenb, L. and Van Gestela, C.A.M. (1991). QSARs in Phytotoxicity. The Science of the Total Environment. Volumes 109-110, December 1991, Pages 493-497.

The International Agency for Research on Cancer (IARC) (2012) monographs on Carcinogens, Volume 100 available at http://monographs.iarc.fr.

INCHEM (2012). OECD Screening Information DataSet (SIDS) High Production Volume Chemicals. Accessed at: http://www.inchem.org/documents/sids/sids/Naco.pdf.

IUCLID (2012) European Commission - European Chemicals Bureau IUCLID Dataset. Accessed at: http://esis.jrc.ec.europa.eu.

Japan Ministry of Environment (1998) Endocrine Disrupting Chemicals Database, Table of Chemicals Suspected of Having Endocrine Disrupting Effects.

Kortenkamp, A., Backhaus, T., and Faust, M. (2009). State of the Art Report on Mixture Toxicity (Final) prepared for the European Commission Directorate General for Environment, Study Contract Number 070307/2007/485103/ETU/D.1, dated 22 December 2009.

Langley, A (1993) Refining Exposure Assessment. In: Langley, A.J. and Van Alphen, M. (eds). The health risk assessment and management of contaminated sites. Proceedings of the Second National Workshop on the Health Risk Assessment and Management of Contaminated Sites. South Australian Health Commission, Adelaide, pp. 89-117.

Logue J.M, McKone T.E, Sherman M.H and Singer B.C. (2011) Hazard assessment of chemical air contaminants measured in residences. Indoor Air 21: 92-109.

Nanson, G.C., Price, D.M., Jones, B.G., Maroulis, J.C., Coleman, M., Bowman, H., Cohen, T.J., Pietsch, T.J., Larsen, J.R., 2008. Alluvial evidence for major climate and flow regime changes during the middle and late Quaternary in eastern central Australia. Geomorphology, 101, 109–129.

NEPC (1999). National Environment Protection (Assessment of Site Contamination) Measure. National Environment Protection Council Service Corporation. Adelaide, SA.

NEPC (2013). National Environment Protection (Assessment of Site Contamination) Amendment Measure. National Environment Protection Council Service Corporation. Adelaide, SA, April 2013.

NHMRC (2011). National Health and Medical Research Council (NHMRC). Australian Drinking Water Guidelines.

NICNAS (2013) Inventory Multi-tiered Assessment and Prioritisation (IMAP) Framework. National Industrial Chemicals Notification and Assessment Scheme. Department of Health and Aging, Canberra.

OECD (2001) Harmonised integrated classification system for human health and environmental hazards of chemical substances and mixtures. OECD Series on Testing and Assessment, number 33. Organisation for Economic Co-operation and Development, Paris France.

OECD (2009), Guideline for the Testing of Chemicals, Acute Inhalation Toxicity No. 403.

OECD (2010). Online Glossary of Statistical Terms. Accessed at: http://stats.oecd.org/glossary/detail.asp?ID=203.

Pennington, DW and Bare JC (2001) Comparison of Chemical Screening and Ranking Approaches: The Waste Minimisation Prioritization Tool versus Toxic Equivalency Potentials. Risk Analysis 21 (5): 897-912.

Pittinger CA, Brennan TH, Badger DA, Hakkinen PJ and Fehrenbacher MC (2003). Aligning Chemical Assessment Tools Across the Hazard-Risk Continuum. Risk Analysis 23 (3): 529-535.

QSAR Toolbox (2013). OECD QSAR Toolbox 3.1.0.21. Accessed at: www.oecd.org/env/exitingchemicals/qsar.

Swann, R.l., Laskowski, D.A. and McCall, P.J. (1983) A rapid method for the estimation of the environmental parameters octanol/water partition coefficient, soil sorption constant, water to air ratio, and water solubility. Residue Reviews 85: 17-28.

State of California, Environmental Protection Agency (2006), Office of Environmental Health Hazard Assessment. Chemicals Known to the State to Cause Cancer or Reproductive Toxicity.

UNECE (2009) Globally Harmonised System (GHS) of Classification and Labelling of Chemicals. Accessed at: http://www.unece.org/trans/danger/publi/adr/adr2009/09contentse.html.

UNECE (2011) Globally Harmonized System of Classification and Labelling of Chemicals (GHS). Fourth revised edition. United Nations Economic Cooperation for Europe (UNECE), New York and Geneva.

US Dept of Food and Drug Admin (2000) Guidance for Industry and Other Stakeholder Toxicological Principles for the Safety Assessment of Food Ingredients (Redbook 2000, revised July 2007).

US Department of Health and Human Services, Public Health Service, National Toxicology Program (US NTP). 2005. Report on Carcinogens, Eleventh Edition.

US Department of Labour Occupational Safety and Health Administration (OSHA) List of OSHA carcinogens. https://www.osha.gov/SLTC/carcinogens/ (accessed January 2014).

USEPA (2005). United States Environmental Protection Agency. Inert Ingredient Tolerance Reassessment – Hydroxypropyl Guar Gum (CAS Reg. No. 39421-75-5). Action Memorandum. Dated January 27, 2005.

USEPA (2005a), Design for Environment Program. (USEPA DfE) 2005. Environmental Profiles of Chemical Flame-Retardant Alternatives for Low-Density Polyurethane Foam.

USEPA (2012) ECOTOXicology Database Version 4.0. Accessed at: http://cfpub.epa.gov/ecotox/.

Van Gestel, C.A.M (1992). The influence of soil characteristics on the toxicity of chemicals for earthworms: a review in H. Becker (ed.) Ecotoxicology of Earthworms, Intercept, Andover, UK, pp 44-54.

WHO (2005). World Health Organisation (WHO). Petroleum Products in Drinking Water. Background Document for Development of WHO Guidelines for Drinking Water Quality.

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APPENDIX A

Regulatory Consent Conditions

Environmental Protection Act 1994

Level 1 Environmental Authority

Chapter 5A petroleum activity

Permit[1] Number: PEN1000XXXXX

DRAFT Coal Seam Gas Model Conditions

FOR REFERENCE AND DISCUSSION PURPOSES ONLY

Under section 310M of the *Environmental Protection Act 1994* this permit is issued to:

Principal Holder:
[*Insert Registered Company Name*]
[*Insert Registered Company Address*]
[*Insert ACN*]

Joint Holder(s):
[*Insert Joint Holder Name 1*]
[*Insert Joint Holder Name 2*]
[*Insert Joint Holder Name 3*]

in respect to carrying out a level 1 chapter 5A activity(ies) as per Section 23 of the *Environmental Protection Regulation 2008* on the relevant resource authorities listed below:

Project Name	Relevant Resource Authority(ies)

This environmental authority takes effect from [*insert date of effect*].

The anniversary date of this environmental authority is [*insert date of environmental authority*].

This environmental authority is subject to the attached schedule of conditions.

.....

Date

[*Insert Delegate Name*]
Delegate of Administering Authority
Department of Environment and Heritage Protection

[1] Permit includes licences, approvals, permits, authorisations, certificates, sanctions or equivalent/similar as required by legislation administered by the Department of Environment and Heritage Protection.

Additional advice about the approval

1. This approval is for the carrying out the following level 1 chapter 5A activity(ies):

Schedule 5 of the *Environmental Protection Regulation 2008*
2. A petroleum activity authorised under the *Petroleum (Submerged Lands) Act 1982*
3. A petroleum activity that is likely to have a significant impact on a Category A or B environmentally sensitive area
4. Extending an existing pipeline by more than 150 km under a petroleum authority
5. Constructing a new pipeline of more than 150 km under a petroleum authority
6. A petroleum activity carried out on a site containing a high hazard dam or a significant hazard dam
7. A petroleum activity involving injection of a waste fluid into a natural underground reservoir or aquifer
8. A petroleum activity, other than a petroleum activity mentioned in items 1 to 7, that includes 1 or more chapter 4 petroleum activities for which an aggregate environmental score is stated, namely: [*Insert each ERA number and full description including threshold for the purposes of determining the aggregate environmental score and the correct annual fee relevant to the application*] For example: ERA 8 – Chemical storage 10 cubic metres to 500 cubic metres of chemical or dangerous goods class 3 or class 1 or class 2 combustible liquids under AS1940. ERA 15 – Fuel burning operation using equipment capable of burning at least 500 kg per hour of fuel. ERA 60(1)(D) – Waste disposal facility (any combination of regulated waste, general waste and limited regulated waste – and < 5 tonne untreated clinical waste if in a scheduled area) >200,000t / year. ERA 63(2)(A) – Sewage treatment 21 to 100 EP.

2. This approval pursuant to the *Environmental Protection Act 1994* does not remove the need to obtain any additional approval for this activity which might be required by other State and / or Commonwealth legislation. Other legislation administered by the Department of Environment and Heritage Protection for which a permit may be required includes but is not limited to the:

- *Aboriginal Cultural Heritage Act 2003*
- *Queensland Heritage Act 1992*
- Contaminated land provisions of the *Environmental Protection Act 1994*
- *Forestry Act 1959*
- *Nature Conservation Act 1992*
- *Water Act 2000*
- *Water Supply (Safety and Reliability) Act 2008*

<<To be deleted>> Under the provisions of the Strategic Cropping Land Act 2011, an environmental authority application (included an amendment application) can not be issued until a protection decision or compliance certificate has been decided.

Applicants are advised to check with all relevant statutory authorities and comply with all relevant legislation.

3. This environmental authority does not authorise environmental harm unless a condition contained in this environmental authority explicitly authorises that harm. Where there is no condition, the lack of a condition shall not be construed as authorising harm.
4. This approval, issued under the *Environmental Protection Act 1994*, for the carrying out of a level 1 petroleum activity(ies) is not an authority to impact on water levels or pressure heads in groundwater aquifers in or surrounding coal seams. There are obligations to minimise or mitigate any such impact under other Queensland Government and Australian Government legislation.
5. Terms defined in Schedule M of this environmental authority are **bolded** in this document. Where a term is not defined in this environmental authority, the definition in the *Environmental Protection Act 1994*, its regulations and Environmental Protection Policies, then the *Acts Interpretation Act 1954* then the Macquarie Dictionary then the *Petroleum and Gas (Production and Safety) Act 2004* or its regulations must be used in that order.
6. This environmental authority does not authorise the taking of protected animals or the tampering with an animal breeding place as defined under the *Nature Conservation Act 1992* and its regulations.
7. The Duty to Notify is a requirement contained in the *Environmental Protection Act 1994* which applies to all persons. The duty to notify arises where a person carries out activities and becomes aware of the act of another person arising from or connected to those activities which causes or threatens serious or material environmental harm. If a person carries out a carrying out a chapter 5A activity, such as coal seam gas activities, the law requires that person to notify the administering authority where:

   - the activity negatively affects (or is reasonably likely to negatively affect) the water quality of an aquifer; or
   - the activity has caused the unauthorised connection of two or more aquifers.

   For more information about the Duty to Notify, refer to section 320A of the *Environmental Protection Act 1994* and/or the guideline, *The Duty to Notify of Environmental Harm* (EM467), published by the Department of Environment and Heritage Protection.
8. This environmental authority consists of the following schedules

SCHEDULE J ACTIVITIES WELL CONSTRUCTION, MAINTAINANCE AND HYDRAULIC FRACTURING

Drilling Activities

(J1) **Oil based drilling muds** must not be used in the carrying out of the petroleum activity(ies).

(J2) **Synthetic oil-based drilling muds** must not be used in the carrying out of the petroleum activity(ies).

(J3) Drilling activities must not result in the connection of the target gas producing formation and another aquifer.

(J4) Practices and procedures must be in place to detect, as soon as practicable, any fractures that have or may result in the connection of a target formation and another aquifer as a result of drilling activities.

Hydraulic Fracturing Activities

(J5a) **Hydraulic fracturing** activities are not permitted.

Where a risk assessment is not submitted as part of the Environmental Management Plan accompanying the environmental authority application, hydraulic fracturing will not be authorised and condition (J5a) applies, otherwise delete condition (J5a).

(J5b) Polycyclic aromatic hydrocarbons or products that contain polycyclic aromatic hydrocarbons must not be used in **hydraulic fracturing** fluids in concentrations above the **reporting limit**.

(J6) **Hydraulic fracturing** activities must not negatively affect water quality, other than that within the **stimulation impact zone** of the target gas producing formation.

(J7) **Hydraulic fracturing** activities must not cause the connection of the target gas producing formation and another aquifer.

(J8) The holder of this authority must ensure the internal and external mechanical integrity of the well system prior to and during **hydraulic fracturing** such that there is:

(a) no significant leakage in the casing, tubing, or packer; and

(b) there is no significant fluid movement into another aquifer through vertical channels adjacent to the well **bore** hole.

(J9) Practices and procedures must be in place to detect, as soon as practicable, any fractures that cause the connection of a target gas producing formation and another aquifer.

<<To be deleted>> Detection measures will need to be determined through the risk assessment and could include microseismic monitoring, tracer analysis and water quality signature analysis. Such measures will be required to be outlined in the Environmental Management Plan accompanying the application.

Stimulation Risk Assessment

(J10) Prior to undertaking **hydraulic fracturing** activities, a risk assessment must be developed to ensure that **hydraulic fracturing** activities are managed to prevent environmental harm.

(J11) The stimulation risk assessment must assessment must address issues at a relevant geospatial scale such that changes to features and attributes are adequately described and must include, but not necessarily be limited to:

(a) a process description of the **hydraulic fracturing** activity to be applied, including equipment and a comparison to best international practice;

(b) provide details of where, when and how often **hydraulic fracturing** is to be undertaken on the tenures covered by this environmental authority;

(c) a geological model of the field to be stimulated including geological names, descriptions and depths of the target gas producing formation(s);

(d) naturally occurring geological faults;

(e) seismic history of the region (e.g earth tremors, earthquakes);

(f) proximity of overlying and underlying aquifers;

(g) description of the depths that aquifers with environmental values occur, both above and below the target gas producing formation.

(h) identification and proximity of **landholders' active groundwater bores** in the area where **hydraulic fracturing** activities are to be carried out;

(i) the environmental values of groundwater in the area;

(j) an assessment of the appropriate **limits of reporting** for all indicators relevant to **hydraulic fracturing** monitoring in order to accurately assess the risks to environmental values of groundwater;

(k) description of overlying and underlying formations in respect of porosity, permeability, hydraulic conductivity, faulting and fracture propensity;

(l) consideration of barriers or known direct connections between the target gas producing formation and the overlying and underlying aquifers;

(m) a description of the well mechanical integrity testing program;

(n) process control and assessment techniques to be applied for determining extent of **hydraulic fracturing** activities (e.g. microseismic measurements, modelling etc);

(o) practices and procedures to ensure that the **hydraulic fracturing** activities are designed to be contained within the target gas producing formation;

(p) groundwater **transmissivity,** flow rate, hydraulic conductivity and direction(s) of flow;

(q) a description of the chemicals used in **hydraulic fracturing** activities (including estimated total mass, estimated composition, chemical abstract service numbers and properties), their mixtures and the resultant compounds that are formed after **hydraulic fracturing**;

(r) a mass balance estimating the concentrations and absolute masses of chemicals that will be reacted, returned to the surface or left in the target gas producing formation subsequent to **hydraulic fracturing**;

(s) an environmental hazard assessment of the chemicals used including their mixtures and the resultant chemicals that are formed after **hydraulic fracturing** including:

  (i) toxicological and ecotoxicological information of chemicals used;

  (ii) information on the persistence and bioaccumulation potential of the chemicals used;

  (iii) identification of the **hydraulic fracturing** fluid chemicals of potential concern derived from the risk assessment;

(t) an environmental hazard assessment of use, formation of, and detection of polycyclic aromatic hydrocarbons in **hydraulic fracturing** activities;

(u) identification and an environmental hazard assessment of using radioactive tracer beads in **hydraulic fracturing** activities;

(v) an environmental hazard assessment of leaving chemicals used in **stimulation fluids** in the target gas producing formation for extended periods subsequent to **hydraulic fracturing**;

(w) human health exposure pathways to operators and the regional population;

(x) risk characterisation of environmental impacts based on the environmental hazard assessment;

(y) potential impacts to landholder bores as a result of **hydraulic fracturing** activities;

(z) an assessment of cumulative impacts, spatially and temporally of the **hydraulic fracturing** activities to be carried out on the tenures covered by this environmental authority; and

(aa) potential environmental or health impacts which may result from **hydraulic fracturing** activities including but not limited to water quality, air quality (including suppression of dust and other airborne contaminants), noise and vibration.

<<To be deleted>> Conditions (J10) and (J11) can be deleted from the environmental authority in the event the applicant has submitted a Stimulation Risk Assessment with the application and to the satisfaction of the administering authority. In this event, amend condition (J12) to include the Stimulation Risk Assessment's reference details and date.

(J12) The stimulation risk assessment must be carried out for every well to be stimulated prior to **hydraulic fracturing** activities being carried out at that well.

<<To be deleted>> Condition (J12) provides flexibility to the applicant to develop risk assessments for each well or develop one overarching stimulation risk assessment providing that one document covers all relevant and site specific matters for each of the wells.

Water Quality Baseline Monitoring

(J13) Prior to undertaking any **hydraulic fracturing** activity, a baseline **bore** assessment must be undertaken of the water quality of:

(a) all **landholders' active groundwater bores** (subject to access being permitted by the landholder) that are spatially located within a two (2) kilometre horizontal radius from the location of the **hydraulic fracturing** initiation point within the target gas producing formation; and

(b) all **landholders' active groundwater bores** (subject to access being permitted by the landholder) in any aquifer that is within 200 metres above or below the target gas producing formation and is spatially located with a two (2) kilometre radius from the location of the **hydraulic fracturing** initiation point; and

(d) any other **bore** that could potentially be adversely impacted by the **hydraulic fracturing** activity(ies) in accordance with the findings of the risk assessment required by conditions (J10) and (J11).

(J14) Prior to undertaking **hydraulic fracturing** activities at a well, there must be sufficient water quality data to accurately represent the water quality in the well to be stimulated. The data must include as a minimum the results of analyses for the parameters in condition (J15)).

<<To be deleted>> Condition (J14) allows for flexibility regarding pre-hydraulic fracturing monitoring of water quality in a well. In the event that there is not sufficient water in a well prior to hydraulic fracturing, coal seam gas companies may use monitoring data from another unstimulated well or bore which is in the vicinity and which accurately represents the water quality in the well to be stimulated.

(J15) Baseline bore and well assessments must include relevant **analytes** and physico-chemical parameters to be monitored in order to establish baseline water quality and must include, but not necessarily be limited to:

(a) pH;

(b) electrical conductivity [μS/m];

(c) turbidity [NTU];

(d) total dissolved solids [mg/L];

(e) temperature [ºC];

(f) dissolved oxygen [mg/L]

(g) dissolved gases (methane, chlorine, carbon dioxide, hydrogen sulfide) [mg/L];

(h) alkalinity (bicarbonate, carbonate, hydroxide and total as $CaCO_3$) [mg/L];

(i) sodium adsorption ratio (SAR);

(j) anions (bicarbonate, carbonate, hydroxide, chloride, sulphate) [mg/L];

(k) cations (aluminium, calcium, magnesium, potassium, sodium) [mg/L];

(l) dissolved and total metals and metalloids (including but not necessarily being limited to: aluminium, arsenic, barium, borate (boron), cadmium, total chromium, copper, iron, fluoride, lead, manganese, mercury, nickel, selenium, silver, strontium, tin and zinc) [μg/L];

(m) total petroleum hydrocarbons [μg/L];

(n) **BTEX** (as benzene, toluene, ethylbenzene, ortho-xylene, para- and meta-xylene, and total xylene) [μg/L];

(o) polycyclic aromatic hydrocarbons (including but not necessarily being limited to: naphthalene, phenanthrene, benzo[a]pyrene) [μg/L];

(q) sodium hypochlorite [mg/L];

(r) sodium hydroxide [mg/L];

(s) formaldehyde [mg/L];

(t) ethanol [mg/L]; and

(u) gross alpha + gross beta or radionuclides by gamma spectroscopy [Bq/L].

Stimulation Impact Monitoring Program

(J16) A Stimulation Impact Monitoring Program must be developed prior to the carrying out of **hydraulic fracturing** activities which must be able to detect adverse impacts to water quality from **hydraulic fracturing** activities and must consider the findings of the risk assessment required by conditions (J10) and (J11) that relate to **hydraulic fracturing** activities and must include, as a minimum, monitoring of:

(a) the **stimulation fluids** to be used in **hydraulic fracturing** activities at sufficient frequency and which sufficiently represents the quantity and quality of the fluids used; and

(b) flow back waters from **hydraulic fracturing** activities at sufficient frequency and which sufficiently represents the quality of that flow back water; and

(c) flow back waters from **hydraulic fracturing** activities at sufficient frequency and accuracy to demonstrate that 150 % of the volume used in **hydraulic fracturing** activities has been extracted from the stimulated well; and

(d) all **bores** in accordance with condition (J13).

(J17) The Stimulation Impact Monitoring Program must provide for monitoring of:

(a) **analytes** and physico-chemical parameters relevant to baseline bore and well assessments to enable data referencing and comparison including, but not necessarily being limited to the **analytes** and physico-chemical parameters in condition (J16); and

(b) any other **analyte** or physico-chemical parameters that will enable detection of adverse water quality impacts and the inter-connection with a non-target aquifer as a result of **hydraulic fracturing** activities including chemical compounds that are actually or potentially formed by chemical reactions with each other or coal seam materials during **hydraulic fracturing** activities.

(J18) The Stimulation Impact Monitoring Program must provide for monitoring of the **bores** in condition (J16)(d) at the following minimum frequency:

(a) monthly for the first six (6) **months** subsequent to **hydraulic fracturing** activities being undertaken; then

(b) annually for the first five (5) **years** subsequent to **hydraulic fracturing** activities being undertaken or until **analytes** and physico-chemical parameters listed in condition (J15)(b), (J15)(n) – (J15)(u) are not detected in concentrations above baseline bore monitoring data on two (2) consecutive monitoring occasions.

<<To be deleted>> Monthly monitoring required by condition (J18)(a) may need to be extended beyond six (6) months depending on the outcomes of the risk assessment and the transmissivity of groundwater in the area.

(J19) The results of the Stimulation Impact Monitoring Program must be made available to any potentially affected landholder upon request by that landholder.

<<To be deleted>> There may be variations to the Stimulation Impact Monitoring in the event that a risk assessment for hydraulic fracturing activities is submitted to the administering authority with the application which includes sufficient data to demonstrate the quality and quantity of the stimulation fluids to be used in hydraulic fracturing activities. To reduce the suite of impact monitoring parameters in condition (J15), monitoring results of these parameters as sampled from on site hydraulic fracturing activities must be included. To vary the requirements of conditions (J16) – ***Error! Reference source not found.****, the risk assessment must include, for example:*

- *comprehensive characterisation data from replicate sampling of batch samples of stimulation additive mixtures intended to be used in hydraulic fracturing; and*
- *monitoring results of stimulation fluid blends as sampled at low pressure pumps associated with hydraulic fracturing activities;*
- *monitoring results of flow back waters;*
- *relevant current MSDS's for all additives to be used in stimulation fluids;*
- *whole effluent or direct toxicity assessments of additives and/or stimulation fluids;*
- *an assessment of all monitoring data and toxicity assessments against known water quality guidelines, including US EPA Drinking Water guidelines.*

APPENDIX B

Limitations

The document ("Report") to which this page is attached and which this page forms a part of, has been issued by Golder Associates Pty Ltd ("Golder") subject to the important limitations and other qualifications set out below.

This Report constitutes or is part of services ("Services") provided by Golder to its client ("Client") under and subject to a contract between Golder and its Client ("Contract"). The contents of this page are not intended to and do not alter Golder's obligations (including any limits on those obligations) to its Client under the Contract.

This Report is provided for use solely by Golder's Client and persons acting on the Client's behalf, such as its professional advisers. Golder is responsible only to its Client for this Report. Golder has no responsibility to any other person who relies or makes decisions based upon this Report or who makes any other use of this Report. Golder accepts no responsibility for any loss or damage suffered by any person other than its Client as a result of any reliance upon any part of this Report, decisions made based upon this Report or any other use of it.

This Report has been prepared in the context of the circumstances and purposes referred to in, or derived from, the Contract and Golder accepts no responsibility for use of the Report, in whole or in part, in any other context or circumstance or for any other purpose.

The scope of Golder's Services and the period of time they relate to are determined by the Contract and are subject to restrictions and limitations set out in the Contract. If a service or other work is not expressly referred to in this Report, do not assume that it has been provided or performed. If a matter is not addressed in this Report, do not assume that any determination has been made by Golder in regards to it.

At any location relevant to the Services conditions may exist which were not detected by Golder, in particular due to the specific scope of the investigation Golder has been engaged to undertake. Conditions can only be verified at the exact location of any tests undertaken. Variations in conditions may occur between tested locations and there may be conditions which have not been revealed by the investigation and which have not therefore been taken into account in this Report.

Golder accepts no responsibility for and makes no representation as to the accuracy or completeness of the information provided to it by or on behalf of the Client or sourced from any third party. Golder has assumed that such information is correct unless otherwise stated and no responsibility is accepted by Golder for incomplete or inaccurate data supplied by its Client or any other person for whom Golder is not responsible. Golder has not taken account of matters that may have existed when the Report was prepared but which were only later disclosed to Golder.

Having regard to the matters referred to in the previous paragraphs on this page in particular, carrying out the Services has allowed Golder to form no more than an opinion as to the actual conditions at any relevant location. That opinion is necessarily constrained by the extent of the information collected by Golder or otherwise made available to Golder. Further, the passage of time may affect the accuracy, applicability or usefulness of the opinions, assessments or other information in this Report. This Report is based upon the information and other circumstances that existed and were known to Golder when the Services were performed and this Report was prepared. Golder has not considered the effect of any possible future developments including physical changes to any relevant location or changes to any laws or regulations relevant to such location.

Where permitted by the Contract, Golder may have retained subconsultants affiliated with Golder to provide some or all of the Services. However, it is Golder which remains solely responsible for the Services and there is no legal recourse against any of Golder's affiliated companies or the employees, officers or directors of any of them.

By date, or revision, the Report supersedes any prior report or other document issued by Golder dealing with any matter that is addressed in the Report.

Any uncertainty as to the extent to which this Report can be used or relied upon in any respect should be referred to Golder for clarification

APPENDIX C

Safety Data Sheets

Schlumberger

SAFETY DATA SHEET

(Australia)

According to the criteria of NOHSC:2011(2003)

Version: 1 *Revision date: 16 March 2012*

1. IDENTIFICATION OF THE SUBSTANCE/PREPARATION AND THE COMPANY/UNDERTAKING

Product Name: **Surfactant F112**

Product Code: **F112**

Company Identification: Schlumberger Oilfield Australia Pty Ltd
ABN: 74 002 459 225
ACN: 002 459 225
256 St. Georges Terrace, Perth WA 6000

Emergency Telephone Number: 1-800-039-008 (24hr)

Use of the Substance/Preparation: For industrial use only. Surfactant in oilfield applications.

2. HAZARDS IDENTIFICATION

Indication of danger Xi - Irritant.

Most important hazards R-phrase(s): Risk of serious damage to eyes.

Health hazards: May cause skin irritation.

S-phrase(s): S26 - In case of contact with eyes, rinse immediately with plenty of water and seek medical advice. S39 - Wear eye/face protection.

Environmental hazard: Harmful to aquatic organisms, may cause long-term adverse effects in the aquatic environment.

Main physical hazards: None known.

3. COMPOSITION/INFORMATION ON INGREDIENTS

Component	CAS-No	EC-No.	Weight % - Range	Classification (67/548)
Polyethylene glycol monohexyl ether	31726-34-8	500-077-5	7-13	Xi;R38,R41

For the full text of the R phrases mentioned in this Section, see Section 16

4. FIRST AID MEASURES

Inhalation: Move to fresh air. Consult a physician if necessary.

Skin contact: Wash off immediately with plenty of water for at least 15 minutes. Seek medical attention if irritation occurs.

Eye contact: Immediately flush eyes with water for .? minutes while holding eyelids open. Seek medical attention at once.

Ingestion: Do NOT induce vomiting. Call a physician or poison control centre immediately. Never give anything by mouth to an unconscious person. If vomiting occurs spontaneously, minimize the risk of aspiration by properly positioning the affected person.

5. FIRE-FIGHTING MEASURES

Suitable extinguishing media: Water Fog, Alcohol Foam, CO2, Dry Chemical.

Extinguishing media which must not be used for safety reasons: None known.

Special protective equipment for firefighters: Wear protective fire fighting clothing and avoid breathing vapors. Use self-contained breathing apparatus in closed areas.

Special exposure hazards arising from the substance or preparation itself, its combustion products, or released gases: When heated strongly or burned, oxides of carbon, nitrogen oxides, ammonia and harmful organic chemical fumes are released.

6. ACCIDENTAL RELEASE MEASURES

Personal precautions: Do not get on skin or clothing. Wash thoroughly after handling.

Environmental precautions: Keep out of waterways.

Methods for cleaning up: Dam up. After cleaning, flush away traces with water.

7. HANDLING AND STORAGE

Handling:

Technical measures/Precautions: Ensure adequate ventilation.
Safe handling advice: Avoid contact with skin and eyes. Wear suitable protective equipment.

Storage:

Technical measures/Storage conditions: Store in well ventilated area out of direct sunlight. Keep container tightly closed.

Packaging requirements: High density polyethylene (HDPE) drum or can.

Incompatible products: Strong bases, Oxidizing agents

8. EXPOSURE CONTROLS / PERSONAL PROTECTION

Engineering measures to reduce exposure: Ensure adequate ventilation

Respiratory protection: No personal respiratory protective equipment normally required.

Hand protection: Impervious gloves made of: Neoprene PVC

Eye protection: Tightly fitting safety goggles.

Skin and body protection: Clean, body-covering clothing.

Environmental exposure controls

Exposure limit(s)

Component	Australia - Occupational Exposure Standards - TWAs	Australia - Occupational Exposure Standards - STELs
Polyethylene glycol monohexyl ether	None	None

9. PHYSICAL AND CHEMICAL PROPERTIES

General Information

Form: Liquid
Odour: Alcohols
Colour: Clear Yellow

Important Health, Safety and Environmental Information

pH: 9-11
Boiling point/range: ~100 °C
Flash point: Does not flash.
Explosive properties:
Explosion data - sensitivity to mechanical impact: No information available.
Explosion data - sensitivity to static discharge: No information available
Flammability Limits in Air:
lower: Not applicable
upper: Not applicable
Oxidizing properties: None known
Relative density: ~ 1.0 (@ 20°C)
Solubility:
Water solubility: Soluble
Fat solubility: No information available.
Partition coefficient (n-octanol/water): See also section 12
Viscosity: 5-50 kPa.s (@ 16 °C)
Vapour density: No information available.
Vapour pressure: No information available.
Evaporation rate: No information available.

Other information

Melting point/range: 5 °C

10. STABILITY AND REACTIVITY

Stability: Stable under recommended storage conditions.

Conditions to avoid: Heat.

Materials to avoid: Strong bases, Oxidizing agents

Hazardous decomposition products: When heated strongly or burned, oxides of carbon, nitrogen oxides, ammonia and harmful organic chemical fumes are released.

Hazardous polymerization: Hazardous polymerization does not occur.

11. TOXICOLOGICAL INFORMATION

Local effects

Skin: May cause skin irritation.

Eyes: Risk of serious damage to eyes.

Inhalation: No effect expected. Prolonged or repeated contact may cause mild irritation.

Ingestion: Accidental ingestion of small amounts is not expected to cause adverse effects. Swallowing large amounts may be harmful.

Sensitization - skin: Not known to cause allergic reaction.

Chronic Health Hazard

Carcinogenic effects: None known.

Mutagenic effects: Not known to cause heritable genetic damage.

Teratogenic effects: Not known to cause birth defects or have a deleterious effect on a developing fetus.

Reproductive toxicity: Not known to adversely affect reproductive functions and organs.

12. ECOLOGICAL INFORMATION

Ecotoxicity

COMPONENT INFORMATION

Polyethylene glycol monohexyl ether

Bioaccumulation: No information available

Persistence and degradability: No information available

13. DISPOSAL CONSIDERATIONS

Waste from residues / unused products: Dispose of as special waste in compliance with local and national regulations

Contaminated packaging: Empty containers should be transported/delivered using a registered waste carrier for local recycling or waste disposal

14. TRANSPORT INFORMATION

UN number: None
Shipping name: Not regulated.

ADR/RID
Class: Not regulated

IMDG/IMO
Class or Div.: Not regulated

ICAO/IATA
Class or Div.: Not regulated

15. REGULATORY INFORMATION

In accordance with the criteria of NOHSC

Indication of danger
- Xi - Irritant

R-phrase(s):
- R41 - Risk of serious damage to eyes.

S-phrase(s):
- S26 - In case of contact with eyes, rinse immediately with plenty of water and seek medical advice.
- S39 - Wear eye/face protection.

International Inventories

Australia (AICS): All the constituents of this material are listed on the Australian Inventory of Chemical Substances (AICS).

16. OTHER INFORMATION

Prepared by: Chemical Regulatory Compliance

The information and recommendations contained herein are based upon tests believed to be reliable. However, Schlumberger does not guarantee their accuracy or completeness NOR SHALL ANY OF THIS INFORMATION CONSTITUTE A WARRANTY, WHETHER EXPRESSED OR IMPLIED, AS TO THE SAFETY OF THE GOODS, THE MERCHANTABILITY OF THE GOODS, OR THE FITNESS OF THE GOODS FOR A PARTICULAR PURPOSE. Adjustment to conform to actual conditions of usage may be required. Schlumberger assumes no responsibility for results obtained or for incidental or consequential damages, including lost profits arising from the use of these data. No warranty against infringement of any patent, copyright or trademark is made or implied.

End of Safety Data Sheet

Schlumberger

SAFETY DATA SHEET

(Australia)

According to the criteria of NOHSC:2011(2003)

Version: 1 *Revision date: 11 April 2011*

1. IDENTIFICATION OF THE SUBSTANCE/PREPARATION AND THE COMPANY/UNDERTAKING

Product Name: **Hydrochloric Acid 32% Unihibited H32**

Product Code: **H032**

Company Identification: Schlumberger Oilfield Australia Pty Ltd
ABN: 74 002 459 225
ACN: 002 459 225
256 St. Georges Terrace, Perth WA 6000

Emergency Telephone Number: 1-800-039-008 (24hr)

Use of the Substance/Preparation: Used as an acidizing additive in oilfield applications.

2. HAZARDS IDENTIFICATION

Indication of danger: C - Corrosive.

Most important hazards
R-phrase(s): Causes burns. Irritating to respiratory system.
Health hazards: Causes severe eye burns. Causes severe skin burns. Causes burns to respiratory tract. Causes burns to mouth, throat and stomach.

S-phrase(s): S26 - In case of contact with eyes, rinse immediately with plenty of water and seek medical advice. S45 - In case of accident or if you feel unwell, seek medical advice immediately (show the label where possible).

Safety Combination Phrases: S36/37/39 - Wear suitable protective clothing, gloves and eye/face protection.

Environmental hazard: None known.

Main physical hazards: Corrosive to metals.

3. COMPOSITION/INFORMATION ON INGREDIENTS

Component	CAS-No	EC-No.	Weight % - Range	Classification
Hydrochloric acid	7647-01-0	231-595-7	32	C;R34-37

For the full text of the R phrases mentioned in this Section, see Section 16

4. FIRST AID MEASURES

Inhalation: Move to fresh air. Seek medical attention at once. If breathing has stopped, begin artificial respiration.

Skin contact:	Take off contaminated clothing and shoes immediately. After contact with skin, wash immediately with plenty of soap and water for at least 15 minutes. Seek medical attention at once.
Eye contact:	Immediately flush eyes with water for 30 minutes while holding eyelids open. Seek medical attention at once.
Ingestion:	Do NOT induce vomiting. Drink large quantities of milk (preferred) or water. Give milk of magnesia. Seek medical attention at once.

5. FIRE-FIGHTING MEASURES

Suitable extinguishing media:	The product itself does not burn. Use extinguishing media appropriate for surrounding material.
Extinguishing media which must not be used for safety reasons:	None known.
Special protective equipment for firefighters:	Wear protective fire fighting clothing and avoid breathing vapors. Wear self-contained breathing apparatus and protective suit.
Special exposure hazards arising from the substance or preparation itself, its combustion products, or released gases:	Gives off hydrogen by reaction with metals.

6. ACCIDENTAL RELEASE MEASURES

Personal precautions:	Avoid contact with eyes. Do not get on skin or clothing. Wash thoroughly after handling. Wear suitable protective equipment. See also section 8.
Environmental precautions:	Prevent further leakage or spillage. Keep out of waterways.
Methods for cleaning up:	Dam up. Neutralize with lime milk or soda and flush with plenty of water. Put into suitable containers for disposal. See also section 13.

7. HANDLING AND STORAGE

Handling:

Technical measures/Precautions:	Ensure adequate ventilation.
Safe handling advice:	Keep airborne concentrations below exposure limits. Use personal protective equipment. See also section 8.

Storage:

Technical measures/Storage conditions:	Keep container tightly closed. Store in well ventilated area out of direct sunlight.
Packaging requirements:	High density polyethylene (HDPE) drum or can.

Incompatible products: Strong bases, Metals, Oxidizing agents

8. EXPOSURE CONTROLS / PERSONAL PROTECTION

Engineering measures to reduce exposure: Ensure adequate ventilation, Keep airborne concentrations below exposure limits

Respiratory protection: Use NIOSH approved respirator with organic vapor/acid gas protection (color coded yellow).

Hand protection: Impervious gloves made of: Neoprene Butyl Nitrile

Eye protection: Chemical splash goggles and face shield.

Skin and body protection: Chemical resistant suit. Chemical resistant boots.

Environmental exposure controls

Exposure limit(s)

Component	Australia - Occupational Exposure Standards - TWAs	Australia - Occupational Exposure Standards - STELs
Hydrochloric acid	None	None

9. PHYSICAL AND CHEMICAL PROPERTIES

General Information

Form: Liquid (fumes)
Odour: Pungent
Colour: Colorless, - , Light yellow

Important Health, Safety and Environmental Information

pH: < 2
Boiling point/range: 55 °C
Flash point: Not combustible
Explosive properties:
Explosion data - sensitivity to mechanical impact: None
Explosion data - sensitivity to static discharge: None
Flammability Limits in Air:
lower: Not applicable
upper: Not applicable
Oxidizing properties: None
Relative density: 1.2 (@ 16°C)
Solubility:
Water solubility: Soluble
Fat solubility: No information available.
Partition coefficient (n-octanol/water): Not applicable.
Viscosity: 1.7 mPa.s (@ 20 °C)
Vapour density: 1.3 (air = 1)
Vapour pressure: 18.9 kPa (@ 25°C)

Evaporation rate:	No data available.
Other information	
Melting point/range:	-35 °C

10. STABILITY AND REACTIVITY

Stability:	Stable under recommended storage conditions.
Conditions to avoid:	Heat.
Materials to avoid:	Bases, Metals, Oxidizing agents
Hazardous decomposition products:	Chlorine, chlorine oxides, hydrogen chloride. May release hydrogen gas (explosive) on contact with metals.
Hazardous polymerization:	Hazardous polymerization does not occur.

11. TOXICOLOGICAL INFORMATION

Local effects

Skin:	Corrosive; rapidly causes pain, burns, redness, swelling and damage to tissue.
Eyes:	Corrosive. Rapidly causes pain, burns, corneal injury. May cause permanent damage and blindness.
Inhalation:	Corrosive. Short exposure can injure lungs, throat, and mucous membranes. Causes pain, burns, choking, and coughing.
Ingestion:	Corrosive. Causes pain and severe burns to mouth, throat and stomach.
Sensitization - skin:	Not known to cause allergic reaction.
Sensitization - lung:	Not known to cause allergic reaction

Chronic Health Hazard

Carcinogenic effects:	None known.
Mutagenic effects:	Not known to cause heritable genetic damage.
Teratogenic effects:	Not known to cause birth defects or have a deleterious effect on a developing fetus.
Reproductive toxicity:	Not known to adversely affect reproductive functions and organs.
Target organ effects:	Eyes. Skin. Respiratory system.

Component	**LD50 / LC50**
Hydrochloric acid	- = 3124 ppm (Inhalation LC50; Rat) 1 h = 700 mg/kg (Oral LD50; Rat) > 5010 mg/kg (Dermal LD50; Rabbit)

12. ECOLOGICAL INFORMATION

Ecotoxicity

COMPONENT INFORMATION

Hydrochloric acid

Bioaccumulation:	Not applicable
Persistence and degradability:	The methods for determining biodegradability are not applicable to inorganic substances
Freshwater Fish Species Data	LC50 96 h (Gambusia affinis) = 282 mg/L

13. DISPOSAL CONSIDERATIONS

Waste from residues / unused products:	Dispose of as special waste in compliance with local and national regulations
Contaminated packaging:	Empty containers should be transported/delivered using a registered waste carrier for local recycling or waste disposal

14. TRANSPORT INFORMATION

UN number:	UN 1789
Shipping name:	HYDROCHLORIC ACID SOLUTION (32%)

ADR/RID

Class:	8
Classification Code:	C1
Packing Group:	II
ADR/RID-Labels	8
Hazard ID	80

IMDG/IMO

Class or Div.:	8
Packing Group:	II
EmS:	F-A, S-B

ICAO/IATA

Class or Div.:	8	
Packing group:	II	
Packing instruction (passenger aircraft):	851	**Max Net Qty/Pkg:** 1 L
Packing instruction (cargo aircraft):	855	**Max Net Qty/Pkg:** 30 L

15. REGULATORY INFORMATION

In accordance with the criteria of NOHSC

contains: Hydrochloric acid .

Indication of danger:
- C - Corrosive

C

R-phrase(s):
- R34 - Causes burns.
- R37 - Irritating to respiratory system.

S-phrase(s):
- S26 - In case of contact with eyes, rinse immediately with plenty of water and seek medical advice.
- S45 - In case of accident or if you feel unwell, seek medical advice immediately (show the label where possible).
- S36/37/39 - Wear suitable protective clothing, gloves and eye/face protection.

International Inventories

Australia (AICS): All the constituents of this material are listed on the Australian Inventory of Chemical Substances (AICS).

16. OTHER INFORMATION

Text of R phrases mentioned in Section 3
- R37 - Irritating to respiratory system.
- R34 - Causes burns.

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End of Safety Data Sheet

Schlumberger

Safety Data Sheet

(Australia)

According to the criteria of NOHSC:2011(2003)

Version: 1 *Revision date: 07/Jan/2013*

1. IDENTIFICATION OF THE SUBSTANCE/PREPARATION AND THE COMPANY/UNDERTAKING

Product name: **High-Temperature Gel Stabilizer J353L**

Product code: **J353L**

Company Identification:
Schlumberger Oilfield Australia Pty Ltd
ABN: 74 002 459 225
ACN: 002 459 225
256 St. Georges Terrace, Perth WA 6000

Emergency telephone number: 1-800-039-008 (24hr)

Use of the Substance/Preparation: Used as a fracturing additive in oilfield applications.

2. Hazards Identification

Indication of danger The product is non-dangerous in accordance with Directive 1999/45/EC.

Most Important Hazards
Health hazards: Mild eye irritation.

Environmental hazard: None known.

Special precautions: Liberates poisonous sulfur dioxide gas on contact with acid

3. Composition/information on Ingredients

component	CAS-No	EC-No.	Weight % - Range	Classification (67/548)
Sodium thiosulphate	7772-98-7	231-867-5	10 - 30	-

4. First Aid Measures

Inhalation: Move to fresh air.

Skin contact: Rinse with water.

Eye contact: Rinse with water.

Ingestion: Rinse mouth. Never give anything by mouth to an unconscious person.

5. Fire-fighting Measures

Suitable extinguishing media:	The product itself does not burn. Use extinguishing media appropriate for surrounding material.
Extinguishing media which must not be used for safety reasons:	None known.
Special protective equipment for firefighters:	Wear protective fire fighting clothing and avoid breathing vapors. Use self-contained breathing apparatus in closed areas.
Special exposure hazards arising from the substance or preparation itself, its combustion products, or released gases:	Thermal decomposition can lead to release of irritating gases and vapours.

6. Accidental Release Measures

Personal Precautions:	No special precautions required.
Environmental Precautions:	Large spills released to the environment may disturb the natural chemical balance of soil/fresh water. Prevent further leakage or spillage.
Methods for cleaning up:	Dam up. Put into suitable containers for disposal. After cleaning, flush away traces with water.

7. Handling and Storage

Handling:

Technical measures/Precautions:	DO NOT use metal containers.
Safe handling advice:	Keep away from direct sunlight. See also section 8.

Storage:

Technical measures/Storage conditions:	Keep away from direct sunlight.
Packaging requirements:	High density polyethylene (HDPE) drum or can.
Incompatible products:	Oxidizing agents

8. EXPOSURE CONTROLS / PERSONAL PROTECTION

All chemical Personal Protective Equipment (PPE) should be selected based on an assessment of both the chemical hazard present and the risk of exposure to those hazards. The PPE recommendations below are based on an assessment of the chemical hazards associated with this product. Where this product is used in a mixture with other products or fluids, additional hazards may be created and as such further assessment of risk may be required. The risk of exposure and need of respiratory protection will vary from workplace to workplace and should be assessed by the user in each situation.

Engineering measures to reduce exposure: No special technical protective measures required

Respiratory protection: No information available.

Hand protection: Rubber gloves

Eye protection: It is good practice to wear goggles when handling any chemical.

Skin and body protection: No special precautions required. Remove and wash contaminated clothing before re-use.

Environmental exposure controls

Exposure limit(s)

component	Australia - Occupational Exposure Standards - TWAs	Australia - Occupational Exposure Standards - STELs
Sodium thiosulphate	none	none

9. Physical and Chemical Properties

General information

Form: Liquid
Odour: None
Colour: light yellow

Important health, safety and environmental information

pH: 7 - 9
Boiling point/range: No data available
Flash Point: Does not flash.
Explosive properties:
Explosion data - sensitivity to mechanical impact: None
Explosion data - sensitivity to static discharge: None
Flammability Limits in Air:
lower: Not applicable
upper: Not applicable
Oxidizing properties: None
Relative density: 1.3 (@ 17°C)
Bulk density: Not applicable
Solubility:
Water solubility: Soluble
Fat solubility: Insoluble

Partition coefficient (n-octanol/water):	Not applicable
Viscosity:	No data available
Vapor density:	No data available
Vapor pressure:	No data available
Evaporation Rate:	No data available

Other information

Melting point/range:	No data available

10. Stability and Reactivity

Stability:	Stable under recommended storage conditions.
Conditions to Avoid:	None known.
Materials to avoid:	Oxidizing agents
Hazardous decomposition products:	Sulfur oxides.
Hazardous polymerization:	Hazardous polymerisation does not occur.

11. Toxicological Information

Local effects

skin:	No effect expected. Prolonged or repeated exposure may cause mild irritation.
Eyes:	May be mildly irritating.
Inhalation:	May be mildly irritating.
Ingestion:	No effect expected.
Sensitization - skin:	Not known to cause allergic reaction.
Sensitization - lung:	Not known to cause allergic reaction

Chronic Health Hazard:

Carcinogenic effects:	None known.
Mutagenic effects:	Not known to cause heritable genetic damage.
Teratogenic effects:	Not known to cause birth defects or have a deleterious effect on a developing fetus.
Reproductive toxicity:	Not known to adversely affect reproductive functions and organs.
Target Organ Effects:	None known.

12. Ecological Information

Ecotoxicity

Aquatic toxicity: This product has no known eco-toxicological effects. See component information below.

Component Information

Sodium thiosulphate

Bioaccumulation: not applicable

Persistence and degradability: not applicable

Freshwater Fish Species Data 24000 mg/L LC50 (Gambusia affinis) = 96 h

13. Disposal Considerations

Waste from residues / unused products: In accordance with local and national regulations

Contaminated packaging: Empty containers should be transported/delivered using a registered waste carrier for local recycling or waste disposal

14. Transport Information

UN number: Not classified as dangerous in the meaning of transport regulations

Shipping name: Not regulated

ADR/RID

Class: Not regulated

IMDG/IMO

Class or Div.: Not regulated

ICAO/IATA

Class or Div.: Not regulated

15. Regulatory Information

In accordance with the criteria of NOHSC

Indication of danger

• The product is non-dangerous in accordance with Directive 1999/45/EC

R-phrase(s):

• none

S-phrase(s):
• Exercise reasonable care and cleanliness

International Inventories

Australia (AICS):	All the constituents of this material are listed on the Australian Inventory of Chemical Substances (AICS).

16. Other Information

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End of Safety Data Sheet

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Safety Data Sheet

(Australia)

According to the criteria of NOHSC:2011(2003)

Version: 1 *Revision date: 05/Oct/2012*

1. IDENTIFICATION OF THE SUBSTANCE/PREPARATION AND THE COMPANY/UNDERTAKING

Product name: **Stabilizer J450**

Product code: **J450**

Company Identification:
Schlumberger Oilfield Australia Pty Ltd
ABN: 74 002 459 225
ACN: 002 459 225
256 St. Georges Terrace, Perth WA 6000

Emergency Telephone Number: 1-800-039-008 (24hr)

Use of the Substance/Preparation: Used as a fracturing additive in oilfield applications.

2. Hazards Identification

Indication of danger The product is non-dangerous in accordance with Directive 1999/45/EC.

Most Important Hazards
Health hazards: May be mildly irritating to eyes. May cause sensitization by skin contact.

Environmental hazard: None known.

Main physical hazards: Combustible material.

3. Composition/information on Ingredients

component	CAS-No	EC-No.	Weight % - Range	Classification (67/548)
2,2`,2"-nitrilotriethanol	102-71-6	203-049-8	60 - 100	-

For the full text of the R phrases mentioned in this Section, see Section 16

4. First aid measures

INHALATION: Move to fresh air. Consult a doctor if necessary.

Skin contact: Wash off immediately with soap and plenty of water. Seek medical attention if irritation occurs.

Eye contact:	Immediately flush eyes with water for 15 minutes while holding eyelids open. Seek medical attention.
Ingestion:	Rinse mouth. Consult a doctor if necessary.

5. Fire-fighting measures

Suitable extinguishing media:	Water Fog, Alcohol Foam, CO2, Dry Chemical.
Extinguishing media which must not be used for safety reasons:	None known.
Special protective equipment for firefighters:	Wear protective fire fighting clothing and avoid breathing vapors. Use self-contained breathing apparatus in closed areas.
Special exposure hazards arising from the substance or preparation itself, its combustion products, or released gases:	Combustible material. When heated strongly or burned, oxides of carbon, nitrogen oxides, ammonia and harmful organic chemical fumes are released.

6. Accidental release measures

Personal Precautions:	Do not get on skin or clothing. Wash thoroughly after handling. See also section 8. Wear suitable protective equipment.
Environmental Precautions:	Prevent further leakage or spillage. Keep out of waterways.
Methods for cleaning up:	Dam up. Soak up with inert absorbent material. Shovel into suitable container for disposal. See also section 13.

7. Handling and Storage

Handling:

Technical measures/Precautions:	Ensure adequate ventilation. Keep away from heat, sparks, and flame.
Safe handling advice:	Keep airborne concentrations below exposure limits. Wear suitable protective equipment. See also section 8.

Storage:

Technical measures/Storage conditions:	Do not store in contact with aluminum. Keep containers tightly closed in a dry, cool and well-ventilated place.
Packaging requirements:	Steel or high density polyethylene (HDPE) container.

Incompatible products: Aluminium, Strong acids, Oxidizing agents

8. EXPOSURE CONTROLS / PERSONAL PROTECTION

All chemical Personal Protective Equipment (PPE) should be selected based on an assessment of both the chemical hazard present and the risk of exposure to those hazards. The PPE recommendations below are based on an assessment of the chemical hazards associated with this product. Where this product is used in a mixture with other products or fluids, additional hazards may be created and as such further assessment of risk may be required. The risk of exposure and need of respiratory protection will vary from workplace to workplace and should be assessed by the user in each situation.

Engineering measures to reduce exposure: Control the source, Ensure adequate ventilation, Keep airborne concentrations below exposure limits

Respiratory protection: No personal respiratory protective equipment normally required. In case of insufficient ventilation, wear suitable respiratory equipment.

Hand protection: (Bad file name)

Eye protection: Tightly fitting safety goggles.

Skin and body protection: Clean, body-covering clothing.

Environmental exposure controls

Exposure limit(s)

component	Australia - Occupational Exposure Standards - TWAs	Australia - Occupational Exposure Standards - STELs
2,2`,2"-nitrilotriethanol	5 mg/m^3	none

9. Physical and Chemical Properties

General information

Form: Liquid
Odour: amine-like
Colour: colourless

Important health, safety and environmental information

pH: ~ 11
Boiling point/range: 121 °C
Flash Point: 196 °C
Method: Tag Closed Cup
Explosive properties:
Explosion data - sensitivity to mechanical impact: none
Explosion data - sensitivity to static discharge: none
Flammability Limits in Air:
lower: none

upper:	none
Oxidizing properties:	None known
Relative density:	1.1 (@ 20°C)
Bulk density:	not applicable
Solubility:	
Water solubility:	Soluble
Fat solubility:	No information available
Partition coefficient (n-octanol/water):	See also section 12
Viscosity:	140 mPa.s (@ 20 °C)
Vapor density:	1.1 (air = 1)
Vapor pressure:	< 0.001 kPa (@ 20°C)
Evaporation Rate:	no data available

OTHER INFORMATION

Melting point/range: -9 °C

10. Stability and Reactivity

Stability: Stable under recommended storage conditions.

Conditions to Avoid: Keep away from heat and sources of ignition.

Materials to avoid: Aluminium, Oxidizing agents, Strong acids

Hazardous decomposition products: When heated strongly or burned, oxides of carbon, nitrogen oxides, ammonia and harmful organic chemical fumes are released.

Hazardous polymerization: Hazardous polymerisation does not occur.

11. Toxicological Information

Local effects

skin: May be mildly irritating. Prolonged or repeated exposure may damage skin.

EYES: May be mildly irritating.

INHALATION: No effect expected. Prolonged or repeated contact may cause mild irritation.

Ingestion: No effect expected.

Sensitization - skin: May cause sensitization by skin contact.

Sensitization - lung: Not known to cause allergic reaction

Chronic Health Hazard:

Carcinogenic effects: None known.

Mutagenic effects: Animal experiments showed mutagenic effects in cultured bacterial cells.

Teratogenic effects: Not known to cause birth defects or have a deleterious effect on a developing fetus.

Reproductive toxicity: Not known to adversely affect reproductive functions and organs.

Target Organ Effects: liver. kidney.

component	LD50 / LC50
2,2`,2"-nitrilotriethanol	- = 4190 mg/kg (Oral LD50; Rat) > 2000 mg/kg (Dermal LD50; Rabbit) > 16 mL/kg (Dermal LD50; Rat) mg/kg (oral-rat)

12. Ecological Information

ecotoxicity

Aquatic toxicity: See component information below.

Component Information

2,2`,2"-nitrilotriethanol

Bioaccumulation: log Pow = -1.4

Persistence and degradability: 57 % (OECD 301B)

Freshwater Fish Species Data 169 mg/L EC50 (Desmodesmus subspicatus) = 96 h 216 mg/L EC50 (Desmodesmus subspicatus) = 72 h

Fish toxicity: 96h LC50= >1000 mg/l (Scophthalamus maximus juvenile)

Freshwater Fish Species Data 10600 - 13000 mg/L LC50 (Pimephales promelas) = 96 h 1000 mg/L LC50 (Pimephales promelas) = 96 h 450 - 1000 mg/L LC50 (Lepomis macrochirus) = 96 h

Water Flea Data 1386 mg/L EC50 (Daphnia magna) = 24 h

13. Disposal Considerations

Waste from residues / unused products: In accordance with local and national regulations

Contaminated packaging: Empty containers should be transported/delivered using a registered waste carrier for local recycling or waste disposal

14. Transport Information

UN number: none

Shipping name: Not regulated

ADR/RID

Class: Not regulated

IMDG/IMO

Class or Div.: Not regulated

ICAO/IATA

Class or Div.: Not regulated

15. regulatory information

In accordance with the criteria of NOHSC

Indication of danger
• The product is non-dangerous in accordance with Directive 1999/45/EC

R-phrase(s):
• none

S-phrase(s):
• Exercise reasonable care and cleanliness

International Inventories

Australia (AICS): All the constituents of this material are listed on the Australian Inventory of Chemical Substances (AICS).

16. other information

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End of Safety Data Sheet

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Safety Data Sheet

(Australia)

According to the criteria of NOHSC:2011(2003)

Version: 1 *Revision date: 07/Jan/2013*

1. IDENTIFICATION OF THE SUBSTANCE/PREPARATION AND THE COMPANY/UNDERTAKING

Product name: **YF100HTD Crosslinker Delay Agent J480**

Product code: **J480**

Company Identification:
Schlumberger Oilfield Australia Pty Ltd
ABN: 74 002 459 225
ACN: 002 459 225
256 St. Georges Terrace, Perth WA 6000

Emergency telephone number: 1-800-039-008 (24hr)

Use of the Substance/Preparation: Used as a fracturing additive in oilfield applications.

2. Hazards Identification

Indication of danger The product is non-dangerous in accordance with Directive 1999/45/EC.

Most Important Hazards
Health hazards: May be mildly irritating to eyes.

Environmental hazard: None known.

Main physical hazards: Dust.

3. Composition/information on Ingredients

component	CAS-No	EC-No.	Weight % - Range	Classification (67/548)
Aliphatic acid salt		Listed	60 - 100	-

4. First Aid Measures

Inhalation: Move to fresh air.

Skin contact: Rinse with water.

Eye contact: Consult a doctor if necessary. Flush eyes with water as a precaution.

Ingestion: Consult a doctor if necessary. Rinse mouth.

5. Fire-fighting Measures

Suitable extinguishing media:	Use extinguishing media appropriate for surrounding material.
Extinguishing media which must not be used for safety reasons:	None known.
Special protective equipment for firefighters:	Wear protective fire fighting clothing and avoid breathing vapors. Use self-contained breathing apparatus in closed areas.
Special exposure hazards arising from the substance or preparation itself, its combustion products, or released gases:	Thermal decomposition can lead to release of irritating gases and vapours.

6. Accidental Release Measures

Personal Precautions:	Wear suitable protective equipment.
Environmental Precautions:	Prevent further leakage or spillage. Should not be released into the environment.
Methods for cleaning up:	Shovel into suitable container for disposal. After cleaning, flush away traces with water.

7. Handling and Storage

Handling:

Technical measures/Precautions: **Safe handling advice:**	Avoid dust formation. Provide appropriate exhaust ventilation at places where dust is formed.

Storage:

Technical measures/Storage conditions:	Store in well ventilated area out of direct sunlight. Keep containers tightly closed in a dry, cool and well-ventilated place.
Packaging requirements:	Paper bag (minimum 3 ply), or other industrial container designed for powders and granulated materials.
Incompatible products:	Oxidizing agents

8. EXPOSURE CONTROLS / PERSONAL PROTECTION

All chemical Personal Protective Equipment (PPE) should be selected based on an assessment of both the chemical hazard present and the risk of exposure to those hazards. The PPE recommendations below are based on an assessment of the chemical hazards associated with this product. Where this product is used in a mixture with other products or fluids, additional hazards may be created and as such further assessment of risk may be required. The risk of exposure and need of respiratory protection will vary from workplace to workplace and should be assessed by the user in each situation.

Engineering measures to reduce exposure: Ensure adequate ventilation

Respiratory protection: No personal respiratory protective equipment normally required.

Hand protection: Rubber gloves

Eye protection: Tightly fitting safety goggles.

Skin and body protection: Clean, body-covering clothing.

Environmental exposure controls

Exposure limit(s)

component	Australia - Occupational Exposure Standards - TWAs	Australia - Occupational Exposure Standards - STELs
Aliphatic acid salt	none	none

9. Physical and Chemical Properties

General information

Form: powder
Odour: None
Colour: white - yellow

Important health, safety and environmental information

pH: 6.5 - 8
pH concentration: 10 g/l
Boiling point/range: Not applicable
Flash Point: Not applicable
Explosive properties:
Explosion data - sensitivity to mechanical impact: None
Explosion data - sensitivity to static discharge: None
Flammability Limits in Air:
lower: No information available
upper: No information available
Oxidizing properties: None
Relative density: 1.2 (@ 20°C)
Bulk density: 650 kg/m^3
Solubility:

Water solubility:	590 g/l (@ 25°C)
Fat solubility:	No information available
Partition coefficient (n-octanol/water):	Does not bioaccumulate.
Viscosity:	Not applicable
Vapor density:	Not applicable
Vapor pressure:	Not applicable
Evaporation Rate:	Not applicable

Other information

Melting point/range: Decomposes @175 °C

10. Stability and Reactivity

Stability: Stable under recommended storage conditions.

Conditions to Avoid: Avoid dust formation.

Materials to avoid: Oxidizing agents

Hazardous decomposition products: When heated strongly or burned, oxides of carbon and harmful organic chemical fumes are released.

Hazardous polymerization: Hazardous polymerisation does not occur.

11. Toxicological Information

Local effects

skin: No effect expected.

Eyes: May be mildly irritating.

Inhalation: No effect expected.

Ingestion: No effect expected.

Sensitization - skin: Not known to cause allergic reaction.

Sensitization - lung: Not known to cause allergic reaction

Chronic Health Hazard:

Carcinogenic effects: None known.

Mutagenic effects: Not known to cause heritable genetic damage.

Teratogenic effects: Not known to cause birth defects or have a deleterious effect on a developing fetus.

Reproductive toxicity: Not known to adversely affect reproductive functions and organs.

Target Organ Effects: None known.

12. Ecological Information

Ecotoxicity

Component Information

Aliphatic acid salt

Bioaccumulation:	log Pow = <0
Persistence and degradability:	READILY BIODEGRADABLE
Algae toxicity:	72h EC50=>1000 mg/l (Skeletonema costatum)
Crustacean toxicity:	48h LC50= 1000 mg/l (Acartia tonsa)
Fish toxicity:	96h LC50= 3000 mg/l (Scophthalamus maximus juvenile)

13. Disposal Considerations

Waste from residues / unused products: Dispose of as special waste in compliance with local and national regulations

Contaminated packaging: Dispose of in accordance with local regulations

14. Transport Information

UN number: Not classified as dangerous in the meaning of transport regulations
Shipping name: Not regulated

ADR/RID
Class: Not regulated

IMDG/IMO
Class or Div.: Not regulated

ICAO/IATA
Class or Div.: Not regulated

15. Regulatory Information

In accordance with the criteria of NOHSC

Indication of danger
• The product is non-dangerous in accordance with Directive 1999/45/EC

R-phrase(s):
• none

S-phrase(s):
• Exercise reasonable care and cleanliness

International Inventories

Australia (AICS): All the constituents of this material are listed on the Australian Inventory of Chemical Substances (AICS).

16. Other Information

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End of Safety Data Sheet

Schlumberger

SAFETY DATA SHEET
Breaker J481

SECTION 1: IDENTIFICATION OF THE SUBSTANCE/MIXTURE AND OF THE COMPANY/UNDERTAKING

1.1. Product identifier

Product name Breaker J481

Product No. J481

1.2. Relevant identified uses of the substance or mixture and uses advised against

Identified uses Fracturing additive.

Uses advised against No specific uses advised against are identified.

1.3. Details of the supplier of the safety data sheet

Supplier
Schlumberger Oilfield Australia Pty Ltd
ABN: 74 002 459 225
ACN: 002 459 225
256 St. Georges Terrace, Perth
WA 6000

Manufacturer
Schlumberger
Woodlands Drive,
Kirkhill Industrial Estate,
Dyce. Aberdeen. AB21 0GW
Scotland.UK
Tel: +44(0)-1224 246690
Fax: +44(0)1224 246699
Email:SDS@slb.com

1.4. Emergency telephone number

USA: +1 281 595 3518 (24h)

SECTION 2: HAZARDS IDENTIFICATION

2.1. Classification of the substance or mixture

Classification (EC 1272/2008)

Physical and Chemical Hazards	Ox. Sol. 1 - H271
Human health	Acute Tox. 4 - H302;Skin Irrit. 2 - H315;Eye Irrit. 2 - H319
Environment	Not classified.

Classification (67/548/EEC) Xn;R22. Xi;R36/38. O;R9.

The Full Text for all R-Phrases and Hazard Statements are Displayed in Section 16.

2.2. Label elements

Contains SODIUM BROMATE

Label In Accordance With (EC) No. 1272/2008

Signal Word Danger

Hazard Statements

H271	May cause fire or explosion; strong oxidiser.
H302	Harmful if swallowed.
H315	Causes skin irritation.
H319	Causes serious eye irritation.

Precautionary Statements

P280	Wear protective gloves/protective clothing/eye protection/face protection.
P305+351+338	IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing.
P314	Get medical advice/attention if you feel unwell.
P405	Store locked up.

Supplementary Precautionary Statements

P210	Keep away from heat/sparks/open flames/hot surfaces. - No smoking.
P220	Keep away from combustible materials.
P221	Take any precaution to avoid mixing with combustibles.
P270	Do not eat, drink or smoke when using this product.
P283	Wear fire/flame resistant/retardant clothing.
P264	Wash contaminated skin thoroughly after handling.
P321	Specific treatment (see medical advice on this label).
P370+378	In case of fire: Use foam, carbon dioxide, dry powder or water fog for extinction.
P301+312	IF SWALLOWED: Call a POISON CENTER or doctor/physician if you feel unwell.
P302+352	IF ON SKIN: Wash with plenty of soap and water.
P306+360	IF ON CLOTHING: rinse immediately contaminated clothing and skin with plenty of water before removing clothes.
P313	Get medical advice/attention.
P330	Rinse mouth.
P332+313	If skin irritation occurs: Get medical advice/attention.
P337	If eye irritation persists:
P362	Take off contaminated clothing and wash before reuse.
P371+380+375	In case of major fire and large quantities: Evacuate area. Fight fire remotely du to the risk of explosion.
P501	Dispose of contents/container to …

2.3. Other hazards

Not Classified as PBT/vPvB by current EU criteria.

SECTION 3: COMPOSITION/INFORMATION ON INGREDIENTS

3.1. Substances

SODIUM BROMATE **60-100%**

CAS-No.: 7789-38-0 **EC No.: 232-160-4**

Classification (EC 1272/2008)	Classification (67/548/EEC)
Ox. Liq. 1 - H271	Xn;R22.
Acute Tox. 4 - H302	Xi;R36/38.
Skin Irrit. 2 - H315	O;R9.
Eye Irrit. 2 - H319	

The Full Text for all R-Phrases and Hazard Statements are Displayed in Section 16.

Composition Comments

The data shown is in accordance with the latest EC Directives.

SECTION 4: FIRST AID MEASURES

4.1. Description of first aid measures

Inhalation

Move the exposed person to fresh air at once. If respiratory problems, artificial respiration/oxygen. Get medical attention.

Ingestion

Rinse mouth thoroughly. Get medical attention.

Skin contact

Remove contaminated clothing immediately and wash skin with soap and water. Get medical attention promptly if symptoms occur after washing.

Eye contact

Make sure to remove any contact lenses from the eyes before rinsing. Promptly wash eyes with plenty of water while lifting the eye lids. Continue to rinse for at least 15 minutes. Get medical attention if any discomfort continues.

4.2. Most important symptoms and effects, both acute and delayed

Inhalation.

High concentrations of dust may irritate throat and respiratory system and cause coughing. May cause methemoglobinemia (blue skin)

Ingestion

May irritate and cause stomach pain, vomiting and diarrhoea. May cause drowsiness or dizziness.

Skin contact

Prolonged skin contact may cause redness and irritation.

Eye contact

Irritating and may cause redness and pain. Visual disturbances including blurred vision

4.3. Indication of any immediate medical attention and special treatment needed

Get medical attention.

SECTION 5: FIREFIGHTING MEASURES

5.1. Extinguishing media

Extinguishing media

Use fire-extinguishing media appropriate for surrounding materials.

5.2. Special hazards arising from the substance or mixture

Hazardous combustion products

When heated, vapours/gases hazardous to health may be formed. Bromine. Hypobromite (BrO) Hydrogen bromide (HBr).

Unusual Fire & Explosion Hazards

High concentrations of dust may form explosive mixture with air.

Specific hazards

50 Oxidising (fire-intensifying) substance.

5.3. Advice for firefighters

Special Fire Fighting Procedures

Containers close to fire should be removed immediately or cooled with water.

Protective equipment for fire-fighters

Self contained breathing apparatus and full protective clothing must be worn in case of fire.

SECTION 6: ACCIDENTAL RELEASE MEASURES

6.1. Personal precautions, protective equipment and emergency procedures

Wear protective clothing as described in Section 8 of this safety data sheet.

6.2. Environmental precautions

Do not allow to enter drains, sewers or watercourses. Avoid release to the environment.

6.3. Methods and material for containment and cleaning up

Avoid generation and spreading of dust. Shovel into dry containers. Cover and move the containers. Flush the area with water.

6.4. Reference to other sections

Wear protective clothing as described in Section 8 of this safety data sheet.

SECTION 7: HANDLING AND STORAGE

7.1. Precautions for safe handling

Avoid inhalation of dust and contact with skin and eyes. Avoid handling which leads to dust formation.

7.2. Conditions for safe storage, including any incompatibilities

Store in tightly closed original container in a dry, cool and well-ventilated place. Oxidising material - Keep away from flammable and combustible materials.

7.3. Specific end use(s)

Fracturing additive.

SECTION 8: EXPOSURE CONTROLS/PERSONAL PROTECTION

8.1. Control parameters

Ingredient Comments

No exposure limits noted for ingredient(s).

8.2. Exposure controls

Protective equipment

Process conditions

All chemical Personal Protective Equipment (PPE) should be selected based on an assessment of both the chemical hazard present and the risk of exposure to those hazards. The PPE recommendations below are based on an assessment of the chemical hazards associated with this product. Where this product is used in a mixture with other products or fluids, additional hazards may be created and as such further assessment of risk may be required. The risk of exposure and need of respiratory protection will vary from workplace to workplace and should be assessed by the user in each situation.

Engineering measures

Provide adequate general and local exhaust ventilation.

Respiratory equipment

In case of inadequate ventilation or risk of inhalation of dust, use suitable respiratory equipment with particle filter (type P2).

Hand protection

Protective gloves must be used if there is a risk of direct contact or splash. Butyl rubber gloves are recommended. PVC gloves are recommended.

Eye protection

Use approved safety goggles or face shield.

Other Protection

Wear appropriate clothing to prevent any possibility of skin contact. Provide eyewash station.

SECTION 9: PHYSICAL AND CHEMICAL PROPERTIES

9.1. Information on basic physical and chemical properties

Appearance	Granular
Colour	White.
Odour	No characteristic odour.
Solubility	Soluble in water.
Melting point (°C)	340°C
Relative density	3.3 @20°C
Bulk Density	2060 kg/m3
pH-Value, Diluted Solution	6 -7 (10%)
Solubility Value (G/100G H2O@20°C)	360g/L
Decomposition temperature (°C)	< 380°C

9.2. Other information

SECTION 10: STABILITY AND REACTIVITY

10.1. Reactivity

Reacts strongly with strong acids, bases, organic chemicals and certain metal combinations. Oxidising material - Keep away from flammable and combustible materials.

10.2. Chemical stability

Stable under normal temperature conditions and recommended use.

10.3. Possibility of hazardous reactions

Hazardous Polymerisation

Will not polymerise.

10.4. Conditions to avoid

Avoid heat.

10.5. Incompatible materials

Materials To Avoid

Avoid contact with: Flammable/combustible material. Acids. Aluminium. Copper. Strong reducing agents.

10.6. Hazardous decomposition products

When heated, vapours/gases hazardous to health may be formed. Bromine. Hypobromite (BrO) Hydrogen bromide (HBr). High concentrations of dust may form explosive mixture with air. 50 Oxidising (fire-intensifying) substance.

SECTION 11: TOXICOLOGICAL INFORMATION

11.1. Information on toxicological effects

Acute toxicity:

Acute Toxicity (Oral LD50)

300 mg/kg Rat

Acute Toxicity (Dermal LD50)

250 mg/kg Rabbit

Aspiration hazard:

Not anticipated to present an aspiration hazard based on chemical structure.

Inhalation

Dust in high concentrations may irritate the respiratory system.

Ingestion

Harmful if swallowed.

Skin contact

Irritating to skin.

Eye contact

May cause severe irritation to eyes.

Route of entry

Inhalation. Ingestion. Skin and/or eye contact.

Target Organs

Respiratory system, lungs Kidneys Blood Gastro-intestinal tract

SECTION 12: ECOLOGICAL INFORMATION

12.1. Toxicity

Acute Fish Toxicity

Not considered toxic to fish.

EC 50, 48 Hrs, Daphnia, mg/l 380mg/L

12.2. Persistence and degradability

Degradability

There are no data on the degradability of this product.

12.3. Bioaccumulative potential

Bioaccumulative potential

No data available on bioaccumulation.

12.4. Mobility in soil

Mobility:

The product is soluble in water.

12.5. Results of PBT and vPvB assessment

Not Classified as PBT/vPvB by current EU criteria.

12.6. Other adverse effects

None known.

SECTION 13: DISPOSAL CONSIDERATIONS

13.1. Waste treatment methods

Waste is classified as hazardous waste. Disposal to licensed waste disposal site in accordance with the local Waste Disposal Authority.

Waste Class

EWC-code: 06 13 99 EWC-code: 16 03 03

SECTION 14: TRANSPORT INFORMATION

General	The product is not covered by international regulation on the transport of dangerous goods (IMDG, IATA, ADR/RID).

14.1. UN number

Not applicable.

UN No. (ADR/RID/ADN)	1494
UN No. (IMDG)	1494
UN No. (ICAO)	1494

14.2. UN proper shipping name

Proper Shipping Name	SODIUM BROMATE

14.3. Transport hazard class(es)

ADR/RID/ADN Class	5.1
ADR/RID/ADN Class	Class 5.1: Oxidising substances.
IMDG Class	5.1
ICAO Class/Division	5.1

Transport Labels

14.4. Packing group

ADR/RID/ADN Packing group	II
IMDG Packing group	II
ICAO Packing group	II

14.5. Environmental hazards

Environmentally Hazardous Substance/Marine Pollutant

No.

14.6. Special precautions for user

EMS	F-H, S-Q
Emergency Action Code	1Y
Hazard No. (ADR)	50
Tunnel Restriction Code	(E)

14.7. Transport in bulk according to Annex II of MARPOL73/78 and the IBC Code

General (Chemtags) The product is not covered by international regulation on the transport of dangerous goods (IMDG, IATA, ADR/RID). Not applicable.

SECTION 15: REGULATORY INFORMATION

15.1. Safety, health and environmental regulations/legislation specific for the substance or mixture

Uk Regulatory References

Chemicals (Hazard Information & Packaging) Regulations. Control of Substances Hazardous to Health Regulations 2002 (as amended) Workplace Exposure Limits EH40.

EU Legislation

Regulation (EC) No 1907/2006 of the European Parliament and of the Council of 18 December 2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH), establishing a European Chemicals Agency, amending Directive 1999/45/EC and repealing Council Regulation (EEC) No 793/93 and Commission Regulation (EC) No 1488/94 as well as Council Directive 76/769/EEC and Commission Directives 91/155/EEC, 93/67/EEC, 93/105/EC and 2000/21/EC, including amendments.

Water hazard classification

WGK 3

15.2. Chemical Safety Assessment

International Chemical Inventories

Contact REACH@slb.com for REACH information. Complies with the following national/regional chemical inventory requirements: Australia (AICS), Canada (DSL / NDSL), China (IECSC), Europe (EINECS / ELINCS), Japan (METI / ENCS), Korea (TCCL / ECL), New Zealand (NZIoC), Phillipines (PICCS), United States (TSCA).

SECTION 16: OTHER INFORMATION

Information Sources

Product information provided by the commercial vendor(s). Material Safety Data Sheet, Misc. manufacturers. LOLI. European Chemicals Bureau - ESIS (European Chemical Substances Information).

Revision Comments

Compiled or revised by Nicola Anderson.

Issued By	Bill Cameron
Revision Date	03-Jul-2012
Revision	0

Risk Phrases In Full

R9	Explosive when mixed with combustible material.
R22	Harmful if swallowed.
R36/38	Irritating to eyes and skin.

Hazard Statements In Full

H319	Causes serious eye irritation.
H315	Causes skin irritation.
H302	Harmful if swallowed.
H271	May cause fire or explosion; strong oxidiser.

Schlumberger

Safety Data Sheet

(Australia)

According to the criteria of NOHSC:2011(2003)

Version: 1 *Revision date: 07/Jan/2013*

1. IDENTIFICATION OF THE SUBSTANCE/PREPARATION AND THE COMPANY/UNDERTAKING

Product name: **EB-Clean* J490 HT Encapsulated Breaker**

Product code: **J490**

Company Identification:
Schlumberger Oilfield Australia Pty Ltd
ABN: 74 002 459 225
ACN: 002 459 225
256 St. Georges Terrace, Perth WA 6000

Emergency telephone number: 1-800-039-008 (24hr)

Use of the Substance/Preparation: Used as a fracturing additive in oilfield applications.

2. Hazards Identification

Indication of danger Xn - Harmful. O - Oxidizing.

Most Important Hazards
R-phrase(s): Explosive when mixed with combustible material HARMFUL IF SWALLOWED

Risk Combination Phrases Irritating to eyes and skin

Health hazards: MAY CAUSE RESPIRATORY TRACT IRRITATION.

S-phrase(s): S22 - Do not breathe dust
Safety Combination Phrases: S24/25 - Avoid contact with skin and eyes

Environmental hazard: None known.

Main physical hazards: Oxidizer. Explosive with dry ammonium salts.

3. Composition/information on Ingredients

component	CAS-No	EC-No.	Weight % - Range	Classification (67/548)
Sodium bromate	7789-38-0	232-160-4	60 - 100	O;R9 Xi;R36/38 Xn;R22

4. First Aid Measures

Inhalation:	Move to fresh air. Seek medical attention if irritation occurs.
Skin contact:	Take off contaminated clothing and shoes immediately. After contact with skin, wash immediately with plenty of soap and water for at least 15 minutes. Seek medical attention.
Eye contact:	Immediately flush eyes with water for 15 minutes while holding eyelids open. Seek medical attention.
Ingestion:	Rinse mouth. Call a physician immediately. Do not induce vomiting without medical advice.

5. Fire-fighting Measures

Suitable extinguishing media:	Deluge with water. Other methods not effective.
Extinguishing media which must not be used for safety reasons:	None known.
Special protective equipment for firefighters:	Wear protective fire fighting clothing and avoid breathing vapors. Use self-contained breathing apparatus in closed areas.
Special exposure hazards arising from the substance or preparation itself, its combustion products, or released gases:	Thermal decomposition can lead to release of irritating gases and vapours.

6. Accidental Release Measures

Personal Precautions:	Avoid dust formation. Avoid contact with the skin and the eyes. Use personal protective equipment. See also section 8.
Environmental Precautions:	No special environmental precautions required.
Methods for cleaning up:	Sweep up and shovel into suitable containers for disposal. After cleaning, flush away traces with water. See also section 13.

7. Handling and Storage

Handling:

Technical measures/Precautions:	Ensure adequate ventilation. Provide appropriate exhaust ventilation at places where dust is formed.

Safe handling advice: Keep airborne concentrations below exposure limits. Do not breathe dust. Avoid contact with skin and eyes. Use personal protective equipment. See also section 8.

Storage:

Technical measures/Storage conditions: Keep material dry. Do not store, transport with or allow to contact combustible materials, corrosives, reducing agents or dry ammonium salts. Store in well ventilated area out of direct sunlight.

Packaging requirements: No information available.

Incompatible products: Dry ammonium salts, Acids, Combustible material, Reducing agents, Organics, Aluminium, Copper

8. EXPOSURE CONTROLS / PERSONAL PROTECTION

All chemical Personal Protective Equipment (PPE) should be selected based on an assessment of both the chemical hazard present and the risk of exposure to those hazards. The PPE recommendations below are based on an assessment of the chemical hazards associated with this product. Where this product is used in a mixture with other products or fluids, additional hazards may be created and as such further assessment of risk may be required. The risk of exposure and need of respiratory protection will vary from workplace to workplace and should be assessed by the user in each situation.

Engineering measures to reduce exposure: Ensure adequate ventilation, Keep airborne concentrations below exposure limits

Respiratory protection: Half mask with a particle filter P2 (BS EN 143).

Hand protection: Impervious gloves made of: Butyl , PVC

Eye protection: Tightly fitting safety goggles.

Skin and body protection: Clean, body-covering clothing.

Environmental exposure controls

Exposure limit(s)

component	Australia - Occupational Exposure Standards - TWAs	Australia - Occupational Exposure Standards - STELs
Sodium bromate	none	none

9. Physical and Chemical Properties

General information

Form: granules Resin-coated inorganic material

Odour:	None
Colour:	white

Important health, safety and environmental information

pH:	not applicable
Boiling point/range:	Decomposes
Flash Point:	Does not flash.
Explosive properties:	
Explosion data - sensitivity to mechanical impact:	None known
Explosion data - sensitivity to static discharge:	None known
Flammability Limits in Air:	
lower:	Not applicable
upper:	Not applicable
Oxidizing properties:	Oxidizer
Relative density:	No information available
Bulk density:	1790 kg/m^3
Solubility:	
Water solubility:	Soluble
Fat solubility:	No information available
Partition coefficient (n-octanol/water):	No information available
Viscosity:	Not applicable
Vapor density:	Not applicable
Vapor pressure:	Not applicable
Evaporation Rate:	Not applicable

Other information

Melting point/range:	No data available

10. Stability and Reactivity

Stability: Stable under recommended storage conditions.

Conditions to Avoid: Decomposes with heat.

Materials to avoid: Dry ammonium salts, Acids, Reducing agents, Organics, Aluminium, Copper, Combustible material

Hazardous decomposition products: Bromine, bromine oxides and hydrogen bromide. When heated strongly or burned, oxides of carbon and harmful organic chemical fumes are released. Hydrogen chloride.

Hazardous polymerization: Hazardous polymerisation does not occur.

11. Toxicological Information

Local effects

skin: Irritant; may cause pain, redness, dermatitis.

Eyes: Severe eye irritation. Causes pain and redness. Prolonged or repeated contact may cause mild burn.

Inhalation: Irritant; may cause pain and coughing.

Ingestion: Harmful if swallowed; large amounts may cause illness.

Sensitization - skin: Not known to cause allergic reaction.

Chronic Health Hazard:

Carcinogenic effects: None known.

Mutagenic effects: Not known to cause heritable genetic damage.

Teratogenic effects: Not known to cause birth defects or have a deleterious effect on a developing fetus.

Reproductive toxicity: Not known to adversely affect reproductive functions and organs.

Target Organ Effects: blood. kidney. Lungs. See component information below.

component	LD50 / LC50
Sodium bromate	- = 400 mg/kg (oral-rat) mg/kg (oral-rat)

12. Ecological Information

Ecotoxicity

Aquatic toxicity: This product has no known eco-toxicological effects. See component information below.

Component Information

Sodium bromate

Bioaccumulation: not applicable
Persistence and degradability: not applicable
Crustacean toxicity: 48h LC50= 380 mg/l (Acartia tonsa)

13. Disposal Considerations

Waste from residues / unused products: Dispose of as special waste in compliance with local and national regulations

Contaminated packaging: Empty containers should be transported/delivered using a registered waste carrier for local recycling or waste disposal

14. Transport Information

UN number: UN 1494
Shipping name: SODIUM BROMATE MIXTURE

ADR/RID

Class:		5.1
Classification Code:	O2	
Packing Group:	II	
ADR/RID-Labels	5.1	
Hazard ID	50	

IMDG/IMO

Class or Div.:		5.1
Label(s):	5.1	
Packing Group:	II	
EmS:	F-H, S-Q	

ICAO/IATA

Class or Div.:		5.1
Label(s)	5.1	
Packing group:	II	

15. Regulatory Information

In accordance with the criteria of NOHSC

Contains: Sodium bromate.

Indication of danger
- Xn - Harmful
- O - Oxidizing

R-phrase(s):
- R 9 - Explosive when mixed with combustible material
- R22 - Harmful if swallowed
- R36/38 - Irritating to eyes and skin

S-phrase(s):
- S22 - Do not breathe dust
- S24/25 - Avoid contact with skin and eyes

International Inventories

Australia (AICS):	All the constituents of this material are listed on the Australian Inventory of Chemical Substances (AICS).

16. Other Information

Text of R phrases mentioned in Section 3
- R 9 - Explosive when mixed with combustible material
- R22 - Harmful if swallowed
- R36/38 - Irritating to eyes and skin

Section(s) revised: 1

Prepared by: Chemical Regulatory Compliance

End of Safety Data Sheet

Schlumberger

MATERIAL SAFETY DATA SHEET

(USA)

(Complies with USA OSHA 29 CFR 1910.1200 and ANSI Z 400.1)

Version: 2 *Revision date:* 17 April 2010

1. IDENTIFICATION OF THE SUBSTANCE/PREPARATION AND THE COMPANY/UNDERTAKING

Product code: **J579**

Product name: **Proppant Transport Additive J579**

Company identification:

Schlumberger Technology Corporation
110 Schlumberger Drive
Sugar Land, Texas 77478, USA
Telephone: 1-281-285-7873

Emergency telephone number: **USA: +1-281-595-3518 (24hr)**

2. HAZARDS IDENTIFICATION

EMERGENCY OVERVIEW

Main physical hazards: No classified physical hazards.

Main health hazards: No classifiable hazards known. May cause mechanical irritation. Inhalation of dust may cause shortness of breath, tightness of the chest, a sore throat and cough.

Main environmental hazards: None known.

Other Information: Dust.

Precautions: Keep away from heat, sparks, and flame. Avoid dust formation. Incompatible with oxidizing agents.

HMIS classification:

Form: Fibers **Color:** Off-white **Odor:** None

Principle routes of exposure:
Skin contact.

3. COMPOSITION/INFORMATION ON INGREDIENTS

Component	CAS-No	Weight % - Range
Synthetic organic polymer	Proprietary	60-100

4. FIRST AID MEASURES

General advice: Consult a physician if necessary.

Eye contact: Rinse with water. Seek medical attention if irritation occurs.

Skin contact: Wash off with soap and water.

Ingestion: Rinse mouth. Never give anything by mouth to an unconscious person.

Inhalation: Move to fresh air.

5. FIRE-FIGHTING MEASURES

Fire hazard: Combustible material.
Flash point: Not applicable.
Autoignition temperature: No data available.
Flammability limits in air:
Lower: Not applicable
Upper: Not applicable
Oxidizing properties: None.

Suitable extinguishing media:
Compatible with all types.

Extinguishing media which must not be used for safety reasons:
None known.

Special exposure hazards arising from the substance or preparation itself, its combustion products, or released gases:
Thermal decomposition can lead to release of irritating gases and vapors.

Special protective equipment for firefighters:
Use extinguishing measures that are appropriate to local circumstances and the surrounding environment.

NFPA rating:

Health:	**1**
Flammability:	**1**
Instability:	**0**
Special:	**None**

6. ACCIDENTAL RELEASE MEASURES

Main physical hazards: No classified physical hazards.
Other Information: Dust.
Personal precautions: Wear suitable protective equipment.
Methods for cleaning up: Sweep up and shovel into suitable containers for disposal.
Environmental precautions: Keep out of waterways.

7. HANDLING AND STORAGE

Handling:
Precautions: Keep away from heat, sparks, and flame. Avoid dust formation. Incompatible with oxidizing agents.
Safe handling advice: Wear suitable protective equipment.
Technical measures/ storage conditions: No special storage conditions required.
Packaging requirements: Polyethylene bag or drum with polyethylene liner.
Incompatible products: Oxidizing agents.

8. EXPOSURE CONTROLS / PERSONAL PROTECTION

Engineering measures to reduce exposure: Control the source.
Hygiene measures: Exercise reasonable care and cleanliness.

Respiratory protection: If dust or mist is generated use NIOSH approved respirator with dust and mist protection (3M 8210).
Eye protection: It is good practice to wear goggles when handling any chemical.
Hand protection: Cotton gloves.
Skin and body protection: No special precautions required.

Occupational Exposure Limits

	ACGIH - TLVs			OSHA - PELs		
Component	**TWA / Ceiling**	**STEL**	**ACGIH - Skin**	**TWA / C**	**STEL**	**Final PELs - Skin**
Synthetic organic polymer	-	-	-	-	-	-

Particles Not Otherwise Regulated/Specified [PNOR or PNOS] (insoluble or poorly soluble):
- OSHA PEL's for Inert or Nuisance Dust are covered by PNOR limits: respirable fraction: 5 mg/m³; total dust 15 mg/m³.
ACGIH PNOS Recommendations: airborne concentrations should be kept below 3 mg/m³, respirable particulate, and 10 mg/m³, inhalable particles.

9. PHYSICAL AND CHEMICAL PROPERTIES

Chemical characterization: Synthetic polymer.
Fire hazard: Combustible material.
Form: Fibers
Color: Off-white
Odor: None
Odor threshold: No information available.
pH: Not applicable.
Boiling point/range: Not applicable.
Flash point: Not applicable.
Flammability limits in air:
Lower: Not applicable
Upper: Not applicable
Bulk density: Not applicable.
Melting point/range: Decomposes
Decomposition temperature: > 242 °C / 468 °F
Solubility:
Water solubility: Insoluble
Fat solubility: Insoluble.
Partition coefficient (n-octanol/water): Not applicable.
Relative density: 1.2 (@ 25°C)
Vapor pressure: Not applicable.
Vapor density: Not applicable.
Viscosity: Not applicable.
Evaporation rate: Not applicable.
% Volatile (VOC): None.

10. STABILITY AND REACTIVITY

Stability:
Stable.

Conditions to avoid:
Keep away from heat, sparks, and flame.

Incompatibility with other substances:
None known.

Hazardous decomposition products:
When heated strongly or burned, oxides of carbon and harmful organic chemical fumes are released.

Hazardous polymerization:
Hazardous polymerization does not occur.

Other Information:
Dust.

11. TOXICOLOGICAL INFORMATION

PRODUCT TOXICOLOGICAL INFORMATION

Acute Health Hazard

Eye contact: May cause mechanical irritation.
Skin contact: May cause mechanical irritation.
Ingestion: This is an unlikely route of exposure. May cause mechanical irritation.
Inhalation: Inhalation of dust may cause shortness of breath, tightness of the chest, a sore throat and cough.
Sensitization - lung: Not known to cause allergic reaction.
Sensitization - skin: Not known to cause allergic reaction.
Toxicologically synergistic products: None known.

Chronic Health Hazard

Carcinogenic effects: None known.
Mutagenic effects: None known.
Teratogenic effects: None known.
Reproductive toxicity: None known.
Target organ effects: None known.

COMPONENT TOXICOLOGICAL INFORMATION

Component	Target Organ Effects	LD50 / LC50
Synthetic organic polymer	-	-

Component	IARC Group 1 or 2:	ACGIH - Carcinogens:	OSHA Listed Carcinogens	NTP:
Synthetic organic polymer	-	-	-	-

12. ECOLOGICAL INFORMATION

PRODUCT INFORMATION

Main environmental hazards: None known.

COMPONENT INFORMATION

Synthetic organic polymer

Bioaccumulation:	Not likely to bioaccumulate because of high molecular w eight
Persistence / degradability:	Partially biodegradable.
Crustacean toxicity:	48h LC50= >195 mg/l (Acartia tonsa)

13. DISPOSAL CONSIDERATIONS

Waste from residues / unused products:
Dispose of by sanitary landfilling or other acceptable method in accordance with local regulations.

Contaminated packaging:
Dispose of in accordance with local regulations. Send empty bags to sanitary landfill. Render other types of containers unuseable by puncturing or crushing and sanitary landfill unless prohibited by local regulations.

EPA RCRA Hazardous Waste Code:
None

14. TRANSPORT INFORMATION

DOT:

CERCLA RQ:	None
Hazard class:	Not regulated.
Proper shipping name:	Not regulated
Label(s):	None required.

IMDG/IMO

Shipping name:	Not regulated.
UN number:	None

ICAO/IATA

Shipping name:	Not regulated.
UN number:	None

TDG (Canada):

Shipping name:	Not regulated.
PIN:	None

Note 1:
For the applicable placard selection refer to the appropriate transport regulations; the selection may vary depending on the cargo size and categories of other hazardous materials in the cargo.

15. REGULATORY INFORMATION

International Chemical Inventories

USA, Toxic Substances Control Act inventory (TSCA):	This product complies with TSCA requirements.
IMPORTS, USA:	No import volume restrictions.
Canada, Domestic Substance List (DSL):	This product complies with DSL requirements.
IMPORTS, Canada:	No import volume restrictions.

U.S.A. Regulations

OSHA Hazard Communication Standard:
(Complies with USA OSHA 29 CFR 1910.1200 and ANSI Z 400.1)

EPA RCRA Hazardous Waste Code:
None

EPA, Sections 311 and 312 - Material Safety Data Sheet Requirements (40 CFR 370):

Immediate (Acute) Health Hazard:	None
Delayed (Chronic) Health Hazard:	None
Fire Hazard:	None
Sudden Release or Pressure Hazard:	None
Reactive Hazard:	None

EPA, Sections 313 - List of Toxic Chemicals (40 CFR 372):
This product contains the following substance(s), which appear(s) on the List of Toxic Chemicals:

Additional Regulatory Information

Synthetic organic polymer

EPA, CERCLA Section 102a/103 Hazardous Substances (40 CFR 302.4): None
CERCLA/SARA - Hazardous Substances and their RQs: None
EPA, SARA TITLE III Section 304, Extremely Hazardous Substances (40 CFR 355.40): None
California Proposition 65: None

International Hazard Class

WHMIS Hazard Class:
Non-controlled product.

16. OTHER INFORMATION

Current references:

1. Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices. *American Conference of Governmental Industrial Hygienists, Cincinnati OH.*
2. IARC Monograms on the Evaluation of the Carcinogenic Risk of Chemicals to Man. *World Health Organization, International Agency for Research on Cancer. Geneva, Switzerland.*
3. Annual Report on Carcinogens. National Toxicology Program. *U.S. Department of Heath and Human Services, Public Health Service.*
4. NIOSH Registry of Toxic Effects of Chemical Substances (RTECS). *National Institute for Occupational safety and Health. Cincinnati, OH.*
5. LOLI Database.

Explanation of terms:
ACGIH: American Conference of Governmental Industrial Hygienist
ACGIH-TL: Threshold Limit Value
DSL: Domestic Substance List
HMIRC: Hazardous Materials Information Review Commission
IARC: International Agency for Research on Cancer
NTP: National Toxicology Program
NIOSH: National Institute of Occupational Safety & Health
NIOSH-REL: Recommended Exposure Limit
OSHA: Occupational Safety & Health Administration
OSHA-PEL: Permissible Exposure Limit
TSCA: Toxic Substance Control Act (Inventory)

Occupational Exposure Limits indicators: TWA - Time Weighted Average; STEL - Short Term Limit; C - Ceiling Limit;units: [mg/m^3]

ACGIH Notations:
"Skin" refers to the potential significant contribution to the overall exposure by the cutaneous route, including mucous membranes and the eyes, either by contact with vapors or by direct skin contact with the substance.
"A" notation indicates carcinogenicity as follows:
ACGIH classification: A1 - Confirmed Human Carcinogen; A2 - Suspected Human Carcinogen; A3 - Confirmed Animal Carcinogen with Unknown Relevance to Humans; A4 - Not Classifiable as a Human Carcinogen; A5 - Not suspected as a Human Carcinogen.
"SEN" refers to the potential for an agent to product sensitization as confirmed by human and animal data.

Section(s) revised: 8

Prepared by: Chemical Regulatory Compliance (CRC)

Revision date: 17 April 2010

End of the Material Safety Data Sheet

Schlumberger

SAFETY DATA SHEET

(Australia)

According to the criteria of NOHSC:2011(2003)

Version: 1 *Revision date: 18 March 2011*

1. IDENTIFICATION OF THE SUBSTANCE/PREPARATION AND THE COMPANY/UNDERTAKING

Product Name: **Water Gelling Agent J580**

Product Code: **J580**

Company Identification: Schlumberger Oilfield Australia Pty Ltd
ABN: 74 002 459 225
ACN: 002 459 225
256 St. Georges Terrace, Perth WA 6000

Emergency Telephone Number: 1-800-039-008 (24hr)

Use of the Substance/Preparation: Used as a gelling agent in oilfield applications.

2. HAZARDS IDENTIFICATION

Most important hazards

Health hazards: May be mildly irritating to eyes.

Environmental hazard: None.

Main physical hazards: Slick when wet. Dust.

3. COMPOSITION/INFORMATION ON INGREDIENTS

Component	CAS-No	EC-No.	Weight % - Range	Classification
Carbohydrate polymer		Listed	60-100	-

For the full text of the R phrases mentioned in this Section, see Section 16

4. FIRST AID MEASURES

Inhalation: Move to fresh air. If not breathing, give artificial respiration. Call a physician immediately.

Skin contact: Rinse with water.

Eye contact: Rinse immediately with plenty of water, also under the eyelids. Consult a physician if necessary.

Ingestion: Rinse mouth. Consult a physician if necessary. Never give anything by mouth to an unconscious person.

5. FIRE-FIGHTING MEASURES

Suitable extinguishing media: Water Fog, Alcohol Foam, CO2, Dry Chemical.

Extinguishing media which must not be used for safety reasons: None known.

Special protective equipment for firefighters: Wear protective fire fighting clothing and avoid breathing vapors. Use self-contained breathing apparatus in closed areas.

Special exposure hazards arising from the substance or preparation itself, its combustion products, or released gases: Slick when wet.

6. ACCIDENTAL RELEASE MEASURES

Personal precautions: Do not breathe dust.

Environmental precautions: Prevent product from entering drains. Should not be released into the environment.

Methods for cleaning up: Sweep up and shovel into suitable containers for disposal. Avoid dust formation. After cleaning, flush away traces with water.

7. HANDLING AND STORAGE

Handling:

Technical measures/Precautions: Avoid dust formation.

Safe handling advice: Ensure adequate ventilation. Dust may form explosive mixture in air.

Storage:

Technical measures/Storage conditions: Keep material dry.

Packaging requirements: Bag with moisture barrier.

Incompatible products: Oxidizing agents

8. EXPOSURE CONTROLS / PERSONAL PROTECTION

Engineering measures to reduce exposure: Ensure adequate ventilation

Respiratory protection: No personal respiratory protective equipment normally required.

Hand protection: Rubber gloves.

Eye protection: Safety glasses with side-shields.

Skin and body protection: Clean, body-covering clothing.

Environmental exposure controls

Exposure limit(s)

Component	Australia - Occupational Exposure Standards - TWAs	Australia - Occupational Exposure Standards - STELs
Carbohydrate polymer	None	None

9. PHYSICAL AND CHEMICAL PROPERTIES

General Information

Form: Powder
Odour: mild
Colour: Light yellow

Important Health, Safety and Environmental Information

pH: 5.5 - 7.5
pH concentration: 10 g/l
Boiling point/range: Not applicable.
Flash point: Not applicable.
Explosive properties:
Explosion data - sensitivity to mechanical impact: None
Explosion data - sensitivity to static discharge: None known
Flammability Limits in Air:
lower: not determined.
upper: not determined.
Oxidizing properties: None
Relative density: 0.7 (@ 25°C)
Bulk density: > 430 kg/m^3
Solubility:
Water solubility: Gels on contact with water.
Fat solubility: Insoluble.
Partition coefficient (n-octanol/water): Does not bioaccumulate.
Viscosity: Not applicable.
Vapour density: Not applicable.
Vapour pressure: Not applicable.
Evaporation rate: Not applicable.

Other information

Melting point/range: Decomposes

10. STABILITY AND REACTIVITY

Stability: Stable at normal conditions.

Conditions to avoid:	Avoid dust formation.
Materials to avoid:	Oxidizing agents
Hazardous decomposition products:	When heated strongly or burned, oxides of carbon and harmful organic chemical fumes are released.
Hazardous polymerization:	Hazardous polymerization does not occur.

11. TOXICOLOGICAL INFORMATION

Local effects

Skin:	No effect expected.
Eyes:	May cause slight irritation.
Inhalation:	Inhalation of dust may cause shortness of breath, tightness of the chest, a sore throat and cough.
Ingestion:	This is an unlikely route of exposure. No effect expected.
Sensitization - skin:	Not known to cause allergic reaction.
Sensitization - lung:	Not known to cause allergic reaction

Chronic Health Hazard

Carcinogenic effects:	None known.
Mutagenic effects:	Not known to cause heritable genetic damage.
Teratogenic effects:	Not known to cause birth defects or have a deleterious effect on a developing fetus.
Reproductive toxicity:	Not known to adversely affect reproductive functions and organs.
Target organ effects:	None known.

Component	**LD50 / LC50**
Carbohydrate polymer	- = 6770 mg/kg (Oral LD50; Rat)

12. ECOLOGICAL INFORMATION

Ecotoxicity

COMPONENT INFORMATION

Carbohydrate polymer

Bioaccumulation:	Does not bioaccumulate
Persistence and degradability:	Readily biodegradable
Other information:	Listed on PLONOR list of OSPAR

13. DISPOSAL CONSIDERATIONS

Waste from residues / unused products: Dispose of as special waste in compliance with local and national regulations

Contaminated packaging: Empty containers should be transported/delivered using a registered waste carrier for local recycling or waste disposal
Send empty bags to sanitary landfill. Render other types of containers unuseable by puncturing or crushing and sanitary landfill unless prohibited by local regulations

14. TRANSPORT INFORMATION

UN number: None
Shipping name: Not regulated.

ADR/RID
Class: Not regulated

IMDG/IMO
Class or Div.: Not regulated

ICAO/IATA
Class or Div.: Not regulated

15. REGULATORY INFORMATION

In accordance with the criteria of NOHSC

Indication of danger:
None

R-phrase(s):
None

S-phrase(s):
Exercise reasonable care and cleanliness

International Inventories

Australia (AICS): All the constituents of this material are listed on the Australian Inventory of Chemical Substances (AICS).

16. OTHER INFORMATION

Prepared by: Chemical Regulatory Compliance

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End of Safety Data Sheet

Schlumberger

SAFETY DATA SHEET

(Australia)

According to the criteria of NOHSC:2011(2003)

Version: 1 *Revision date: 06 May 2011*

1. IDENTIFICATION OF THE SUBSTANCE/PREPARATION AND THE COMPANY/UNDERTAKING

Product Name: **Crosslinker L10**

Product Code: **L010**

Company Identification: Schlumberger Oilfield Australia Pty Ltd
ABN: 74 002 459 225
ACN: 002 459 225
256 St. Georges Terrace, Perth WA 6000

Emergency Telephone Number: 1-800-039-008 (24hr)

Use of the Substance/Preparation: Crosslinker in oilfield applications.

2. HAZARDS IDENTIFICATION

Indication of danger: T - Toxic.

Most important hazards R-phrase(s): May cause harm to the unborn child. May impair fertility.

Health hazards: May be mildly irritating to eyes. May be mildly irritating if inhaled.

S-phrase(s): S45 - In case of accident or if you feel unwell, seek medical advice immediately (show the label where possible). S53 - Avoid exposure - obtain special instructions before use.

Environmental hazard: None known.

Main physical hazards: Dust.

3. COMPOSITION/INFORMATION ON INGREDIENTS

Component	CAS-No	EC-No.	Weight % - Range	Classification
Boric acid	10043-35-3	233-139-2	60 - 100	Repr.Cat2;R60-61

For the full text of the R phrases mentioned in this Section, see Section 16

4. FIRST AID MEASURES

Inhalation: Move to fresh air.

Skin contact: Wash off immediately with soap and plenty of water removing all contaminated clothes and shoes. Seek medical attention if irritation occurs.

Eye contact: Flush eyes with water as a precaution. Seek medical attention if irritation occurs.

Ingestion: Rinse mouth. Drink large quantities of milk (preferred) or water. Seek medical attention.

5. FIRE-FIGHTING MEASURES

Suitable extinguishing media: The product itself does not burn. Use extinguishing media appropriate for surrounding material.

Extinguishing media which must not be used for safety reasons: None known.

Special protective equipment for firefighters: No special protective measures against fire required.

Special exposure hazards arising from the substance or preparation itself, its combustion products, or released gases: None known.

6. ACCIDENTAL RELEASE MEASURES

Personal precautions: Wear suitable protective equipment. Do not breathe dust.

Environmental precautions: Should not be released into the environment.

Methods for cleaning up: Shovel into suitable container for disposal. After cleaning, flush away traces with water.

7. HANDLING AND STORAGE

Handling:

Technical measures/Precautions: Ensure adequate ventilation.
Safe handling advice: Avoid dust formation. Avoid contact with skin and eyes.

Storage:

Technical measures/Storage conditions: Keep material dry. Keep containers tightly closed in a dry, cool and well-ventilated place.

Packaging requirements: Paper bag (minimum 3 ply), or other industrial container designed for powders and granulated materials.

Incompatible products: Strong bases

8. EXPOSURE CONTROLS / PERSONAL PROTECTION

Engineering measures to reduce exposure: Ensure adequate ventilation

Respiratory protection: No personal respiratory protective equipment normally required. In case of insufficient ventilation, wear suitable respiratory equipment. Suitable mask with particle filter P3 (European Norm 143).

Hand protection: Impervious gloves made of: Butyl PVC

Eye protection: Tightly fitting safety goggles.

Skin and body protection: Clean, body-covering clothing.

Environmental exposure controls

Exposure limit(s)

Component	Australia - Occupational Exposure Standards - TWAs	Australia - Occupational Exposure Standards - STELs
Boric acid	None	None

9. PHYSICAL AND CHEMICAL PROPERTIES

General Information

Form: Granules
Odour: None
Colour: White

Important Health, Safety and Environmental Information

pH: 5.1
pH concentration: 10 g/l
Boiling point/range: Decomposes
Flash point: Does not flash.
Explosive properties:
Explosion data - sensitivity to mechanical impact: None
Explosion data - sensitivity to static discharge: None known
Flammability Limits in Air:
lower: Not applicable
upper: Not applicable
Oxidizing properties: None
Relative density: 1.4 (@ 20°C)
Bulk density: 500 kg/m^3
Solubility:
Water solubility: 46 g/l (@ 20°C)
Fat solubility: Insoluble.
Partition coefficient (n-octanol/water): Not applicable.
Viscosity: Not applicable.
Vapour density: Not applicable.
Vapour pressure: Not applicable.
Evaporation rate: Not applicable.

Other information

Melting point/range: >171 °C

10. STABILITY AND REACTIVITY

Stability: Stable under recommended storage conditions.

Conditions to avoid: None known.

Materials to avoid: Strong bases

Hazardous decomposition products: none.

Hazardous polymerization: Hazardous polymerization does not occur.

11. TOXICOLOGICAL INFORMATION

Local effects

Skin: No effect expected.

Eyes: May be mildly irritating. May cause mechanical irritation.

Inhalation: No effect expected. Prolonged or repeated contact may cause mild irritation.

Ingestion: Swallowing large amounts may be harmful.

Sensitization - skin: Not known to cause allergic reaction.

Chronic Health Hazard

Carcinogenic effects: A component of this product is listed in EC Annex I as a carcinogen category 2.

Mutagenic effects: Not known to cause heritable genetic damage.

Teratogenic effects: May cause harm to the unborn child..

Reproductive toxicity: Possible risk of harm to the unborn child.. Possible risk of impaired fertility.

Component	**LD50 / LC50**
Boric acid	- = 2660 mg/kg (Oral LD50; Rat) > 2000 mg/kg (Dermal LD50; Rabbit) > 0.16 mg/L (Inhalation LC50; Rat) 4 h 2 mg/m³ mg/kg (oral-rat)

12. ECOLOGICAL INFORMATION

Ecotoxicity

COMPONENT INFORMATION

Boric acid

Bioaccumulation: Not applicable

Persistence and degradability: Not applicable

Algae toxicity: 72h EC50= 220 mg/l (Skeletonema costatum)

Freshwater Fish Species Data	LC50 72 h (Carassius auratus) = 1020 mg/L
Water Flea Data	EC50 48 h (water flea) = 115.0 mg/L EC50 48 h (Daphnia magna) = 658 - 875 mg/L

13. DISPOSAL CONSIDERATIONS

Waste from residues / unused products: Dispose of as special waste in compliance with local and national regulations

Contaminated packaging: Dispose of in accordance with local regulations

14. TRANSPORT INFORMATION

UN number: None
Shipping name: Not regulated.

ADR/RID
Class: Not regulated

IMDG/IMO
Class or Div.: Not regulated

ICAO/IATA
Class or Div.: Not regulated

15. REGULATORY INFORMATION

In accordance with the criteria of NOHSC

contains: Boric acid.

Indication of danger:
- T - Toxic

R-phrase(s):
- R60 - May impair fertility.
- R61 - May cause harm to the unborn child.

S-phrase(s):
- S45 - In case of accident or if you feel unwell, seek medical advice immediately (show the label where possible).
- S53 - Avoid exposure - obtain special instructions before use.

International Inventories

Australia (AICS): All the constituents of this material are listed on the Australian Inventory of Chemical Substances (AICS).

16. OTHER INFORMATION

Text of R phrases mentioned in Section 3

- R61 - May cause harm to the unborn child.
- R60 - May impair fertility.

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End of Safety Data Sheet

Schlumberger

SAFETY DATA SHEET

(Australia)

According to the criteria of NOHSC:2011(2003)

Version: 2 *Revision date: 30 April 2012*

1. IDENTIFICATION OF THE SUBSTANCE/PREPARATION AND THE COMPANY/UNDERTAKING

Product Name: **L071 Temporary Clay Stabilizer**

Product Code: **L071**

Company Identification: Schlumberger Oilfield Australia Pty Ltd
ABN: 74 002 459 225
ACN: 002 459 225
256 St. Georges Terrace, Perth WA 6000

Emergency Telephone Number: 1-800-039-008 (24hr)

Use of the Substance/Preparation: For industrial use only. Additive in oilfield applications.

2. HAZARDS IDENTIFICATION

Indication of danger The product is non-dangerous in accordance with Directive 1999/45/EC.

Most important hazards
Health hazards: May be mildly irritating to eyes. May be mildly irritating to skin.

Environmental hazard: None known.

Main physical hazards: None known.

3. COMPOSITION/INFORMATION ON INGREDIENTS

Component	CAS-No	EC-No.	Weight % - Range	Classification (67/548)
Cholinium chloride	67-48-1	200-655-4	70-75	-

For the full text of the R phrases mentioned in this Section, see Section 16

4. FIRST AID MEASURES

Inhalation: Move to fresh air. Consult a physician if necessary.

Skin contact: Wash off immediately with soap and plenty of water. Consult a physician if necessary.

Eye contact: Immediately flush eye(s) with plenty of water. Seek medical attention if irritation occurs.

Ingestion: Do not induce vomiting without medical advice. Seek medical attention.

5. FIRE-FIGHTING MEASURES

Suitable extinguishing media:	Use extinguishing media appropriate for surrounding material.
Extinguishing media which must not be used for safety reasons:	None known.
Special protective equipment for firefighters:	Use self-contained breathing apparatus in closed areas. Wear protective fire fighting clothing and avoid breathing vapors.
Special exposure hazards arising from the substance or preparation itself, its combustion products, or released gases:	When heated strongly or burned, oxides of carbon, nitrogen oxides, ammonia and harmful organic chemical fumes are released. Chlorine, chlorine oxides, hydrogen chloride.

6. ACCIDENTAL RELEASE MEASURES

Personal precautions:	Avoid contact with the skin and the eyes. Use personal protective equipment.
Environmental precautions:	None known.
Methods for cleaning up:	Dam up. Put into suitable containers for disposal.

7. HANDLING AND STORAGE

Handling:

Technical measures/Precautions:	No special precautions required.
Safe handling advice:	Avoid contact with skin and eyes. Use personal protective equipment.

Storage:

Technical measures/Storage conditions:	Keep containers tightly closed in a dry, cool and well-ventilated place.
Packaging requirements:	High density polyethylene (HDPE) drum or can.
Incompatible products:	Strong acids, Strong bases, Oxidizing agents

8. EXPOSURE CONTROLS / PERSONAL PROTECTION

All chemical Personal Protective Equipment (PPE) should be selected based on an assessment of both the chemical hazard present and the risk of exposure to those hazards. The PPE recommendations below are based on an assessment of the chemical hazards associated with this product. Where this product is used in a mixture with other products or fluids, additional hazards may be created and as such further assessment of risk may be required. The risk of exposure and need of respiratory protection will vary from workplace to workplace and should be assessed by the user in each situation.

Engineering measures to reduce exposure: Ensure adequate ventilation

Respiratory protection: No personal respiratory protective equipment normally required.

Hand protection: Impervious gloves made of: Rubber PVC disposable gloves

Eye protection: Tightly fitting safety goggles.

Skin and body protection: Clean, body-covering clothing.

Environmental exposure controls

Exposure limit(s)

Component	Australia - Occupational Exposure Standards - TWAs	Australia - Occupational Exposure Standards - STELs
Cholinium chloride	None	None

9. PHYSICAL AND CHEMICAL PROPERTIES

General Information

Form: Liquid
Odour: amine-like
Colour: Amber - blue

Important Health, Safety and Environmental Information

pH: 6.5 - 8.5
Boiling point/range: No data available.
Flash point: Does not flash.
Explosive properties:
Explosion data - sensitivity to mechanical impact: None
Explosion data - sensitivity to static discharge: None
Flammability Limits in Air:
lower: Not applicable
upper: Not applicable
Oxidizing properties: None known
Relative density: 1.1
Solubility:
Water solubility: Soluble
Fat solubility: No information available.
Partition coefficient (n-octanol/water): No information available.
Viscosity: No information available.

Vapour density:	No information available.
Vapour pressure:	No information available.
Evaporation rate:	No information available.

Other information

Melting point/range:	< 0 °C

10. STABILITY AND REACTIVITY

Stability:	Stable under recommended storage conditions.
Conditions to avoid:	None known.
Materials to avoid:	Strong acids and strong bases, Oxidizing agents
Hazardous decomposition products:	When heated strongly or burned, oxides of carbon, nitrogen oxides, ammonia and harmful organic chemical fumes are released. Chlorine, chlorine oxides, hydrogen chloride.
Hazardous polymerization:	Hazardous polymerization does not occur.

11. TOXICOLOGICAL INFORMATION

Local effects

Skin:	May be mildly irritating.
Eyes:	May be mildly irritating.
Inhalation:	This is an unlikely route of exposure.
Ingestion:	May be mildly irritating.
Sensitization - skin:	Not known to cause allergic reaction.

Chronic Health Hazard

Carcinogenic effects:	None known.
Mutagenic effects:	Not known to cause heritable genetic damage.
Teratogenic effects:	Not known to cause birth defects or have a deleterious effect on a developing fetus.
Reproductive toxicity:	Not known to adversely affect reproductive functions and organs.

12. ECOLOGICAL INFORMATION

Ecotoxicity

COMPONENT INFORMATION

Cholinium chloride

Bioaccumulation:	No information available
Persistence and degradability:	No information available
Freshwater Fish Species Data	500 mg/L EC50 (Desmodesmus subspicatus) = 72 h
Freshwater Fish Species Data	10000 mg/L LC50 (Leuciscus idus) = 96 h
Water Flea Data	500 mg/L EC50 (Daphnia magna Straus) = 48 h 320 mg/L EC50 (Daphnia magna) = 48 h

13. DISPOSAL CONSIDERATIONS

Waste from residues / unused products: Dispose of as special waste in compliance with local and national regulations

Contaminated packaging: Empty containers should be transported/delivered using a registered waste carrier for local recycling or waste disposal

14. TRANSPORT INFORMATION

UN number: None
Shipping name: Not regulated.

ADR/RID
Class: Not regulated

IMDG/IMO
Class or Div.: Not regulated

ICAO/IATA
Class or Div.: Not regulated

15. REGULATORY INFORMATION

In accordance with the criteria of NOHSC

Indication of danger
- The product is non-dangerous in accordance with Directive 1999/45/EC

R-phrase(s):
None

S-phrase(s):
Exercise reasonable care and cleanliness

International Inventories

Australia (AICS): All the constituents of this material are listed on the Australian Inventory of Chemical Substances (AICS).

16. OTHER INFORMATION

Reason for revision:
9. PHYSICAL AND CHEMICAL PROPERTIES

Prepared by: Chemical Regulatory Compliance

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End of Safety Data Sheet

Schlumberger

Safety Data Sheet

(Australia)

According to the criteria of NOHSC:2011(2003)

Version: 1 *Revision date: 05/Feb/2013*

1. IDENTIFICATION OF THE SUBSTANCE/PREPARATION AND THE COMPANY/UNDERTAKING

Product name: **CAUSTIC SODA M2**

Product code: **M002**

Company Identification:
Schlumberger Oilfield Australia Pty Ltd
ABN: 74 002 459 225
ACN: 002 459 225
256 St. Georges Terrace, Perth WA 6000

Emergency telephone number: 1-800-039-008 (24hr)

Use of the Substance/Preparation: Used as a fracturing additive in oilfield applications.

2. Hazards Identification

Indication of danger C - Corrosive.

Most Important Hazards
Health hazards: Causes burns to mouth, throat and stomach. Causes severe eye burns. Causes burns to respiratory tract. Causes severe skin burns.

S-phrase(s): S26 - In case of contact with eyes, rinse immediately with plenty of water and seek medical advice S45 - In case of accident or if you feel unwell, seek medical advice immediately (show the label where possible)

Safety Combination Phrases: S37/39 - Wear suitable gloves and eye/face protection

Environmental hazard: None known.

Main physical hazards: Corrosive to Metals. Water reactive.

3. Composition/information on Ingredients

component	CAS-No	EC-No.	Weight % - Range	Classification (67/548)
Sodium hydroxide	1310-73-2	215-185-5	60-100	C;R35

4. First aid measures

Inhalation: Move to fresh air. Call a physician immediately. If not breathing, give artificial respiration.

Skin contact:	Take off contaminated clothing and shoes immediately. Rinse immediately with plenty of water for at least 30 minutes. Obtain medical attention.
Eye contact:	Immediately flush eyes with water for 30 minutes while holding eyelids open. Seek medical attention at once.
Ingestion:	Do NOT induce vomiting. Immediately give large quantities of water to drink. Call a physician immediately.

5. Fire-fighting measures

Suitable extinguishing media:	The product itself does not burn. Use extinguishing media appropriate for surrounding material.
Extinguishing media which must not be used for safety reasons:	None known.
Special protective equipment for firefighters:	Wear protective fire fighting clothing and avoid breathing vapors. Use self-contained breathing apparatus in closed areas.
Special exposure hazards arising from the substance or preparation itself, its combustion products, or released gases:	None known.

6. Accidental release measures

Personal Precautions:	Use personal protective equipment. See also section 8.
Environmental Precautions:	Do not allow material to contaminate ground water system.
Methods for cleaning up:	Shovel into suitable container for disposal. After cleaning, flush away traces with water.

7. Handling and Storage

Handling:

Technical measures/Precautions:	No special precautions required.
Safe handling advice:	Keep airborne concentrations below exposure limits.

Storage:

Technical measures/Storage conditions:	Keep material dry. Keep containers tightly closed in a dry, cool and well-ventilated place.

Packaging requirements: Paper bag (minimum 3 ply), or other industrial container designed for powders and granulated materials.

Incompatible products: Aluminium, Water

8. EXPOSURE CONTROLS / PERSONAL PROTECTION

All chemical Personal Protective Equipment (PPE) should be selected based on an assessment of both the chemical hazard present and the risk of exposure to those hazards. The PPE recommendations below are based on an assessment of the chemical hazards associated with this product. Where this product is used in a mixture with other products or fluids, additional hazards may be created and as such further assessment of risk may be required. The risk of exposure and need of respiratory protection will vary from workplace to workplace and should be assessed by the user in each situation.

Engineering measures to reduce exposure: Ensure adequate ventilation

Respiratory protection: No personal respiratory protective equipment normally required. In case of insufficient ventilation, wear suitable respiratory equipment. Half mask with a particle filter P2 (BS EN 143).

Hand protection: Impervious gloves made of: Neoprene Rubber gloves

Eye protection: Chemical splash goggles and face shield.

Skin and body protection: Chemical resistant suit. Chemical resistant boots.

Environmental exposure controls

Exposure limit(s)

component	Australia - Occupational Exposure Standards - TWAs	Australia - Occupational Exposure Standards - STELs
Sodium hydroxide	none	none

9. PHYSICAL AND CHEMICAL PROPERTIES

General information

Physical State: flakes
Odour: None
Colour: white

Important health, safety and environmental information

pH: 13
pH Regulating agent 10 g/l
Boiling point/range: Not applicable
Flash Point: Not applicable
Explosive properties:

Explosion data - sensitivity to mechanical impact	Not applicable
Explosion data - sensitivity to static discharge	Not applicable
Flammability Limits in Air:	
lower:	Not applicable
upper:	Not applicable
Oxidizing properties:	None
Relative density:	2.1 (@ 20°C)
Bulk density:	No information available
Solubility:	
Water solubility:	Soluble
Fat solubility:	No information available
Partition coefficient (n-octanol/water):	Not applicable
Viscosity:	Not applicable
Vapor density:	> 1 (air = 1)
Vapor pressure:	0.13 kPa (@ 739°C)
Evaporation Rate:	No data available

Other information

Melting point/range: 318 °C

10. STABILITY AND REACTIVITY

Stability: Stable under recommended storage conditions.

Conditions to Avoid: Keep material dry.

Materials to avoid: Water, Metals, Acids

Hazardous decomposition products: None known.

Hazardous polymerization: Hazardous polymerisation does not occur.

11. TOXICOLOGICAL INFORMATION

Local effects

Skin: Corrosive; rapidly causes pain, burns, redness, swelling and damage to tissue.

Eyes: Corrosive. Rapidly causes pain, burns, corneal injury. May cause permanent damage and blindness.

Inhalation: Corrosive. Short exposure can injure lungs, throat, and mucous membranes. Causes pain, burns, choking, and coughing.

Ingestion: Corrosive. Causes pain and severe burns to mouth, throat and stomach.

Sensitization - skin: Not known to cause allergic reaction.

Chronic Health Hazard:

Carcinogenic effects: None known.

Mutagenic effects: Not known to cause heritable genetic damage.

Teratogenic effects: Not known to cause birth defects or have a deleterious effect on a developing fetus.

Reproductive toxicity: Not known to adversely affect reproductive functions and organs.

component	LD50 / LC50
Sodium hydroxide	- = 1350 mg/kg (Dermal LD50; Rabbit)

12. ECOLOGICAL INFORMATION

Ecotoxicity

Component Information

Sodium hydroxide

Bioaccumulation: not applicable
Persistence and degradability: not applicable
Freshwater Fish Species Data 45.4 mg/L LC50 (Oncorhynchus mykiss) = 96 h

13. DISPOSAL CONSIDERATIONS

Waste from residues / unused products: In accordance with local and national regulations

Contaminated packaging: Send empty bags to sanitary landfill. Render other types of containers unuseable by puncturing or crushing and sanitary landfill unless prohibited by local regulations

14. TRANSPORT INFORMATION

UN number: UN 1823
Shipping name: SODIUM HYDROXIDE, SOLID

ADR/RID

Class: 8
Classification Code: C6
14.7 II
ADR/RID-Labels 8
Hazard ID 80

IMDG/IMO:

Class or Div.: 8
Label(s): 8
Packing group: II

EmS: F-A, S-B

ICAO/IATA

Class or Div.: 8

Label(s) 8

15. REGULATORY INFORMATION

In accordance with the criteria of NOHSC

Contains: Sodium hydroxide.

Indication of danger
• C - Corrosive

R-phrase(s):
• R35 - Causes severe burns

S-phrase(s):
• S26 - In case of contact with eyes, rinse immediately with plenty of water and seek medical advice
• S45 - In case of accident or if you feel unwell, seek medical advice immediately (show the label where possible)
• S37/39 - Wear suitable gloves and eye/face protection

International Inventories

Australia (AICS): All the constituents of this material are listed on the Australian Inventory of Chemical Substances (AICS).

16. OTHER INFORMATION

Text of R phrases mentioned in Section 3
• R35 - Causes severe burns

Section(s) revised: New

Prepared by: Well Services Safety & Environment

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End of Safety Data Sheet

Material Safety Data Sheet

M275

1 . Identification of the material and supplier

Names

Product name : M275

Product code : M275

ADG : Corrosive solid, acidic, organic, n.o.s. (isothiazolones)

Supplier : Baker Hughes, Australia
5 Walker Street,
Braeside,
Victoria 3195,
Australia

Tel: +613 9580 9004
Fax: +613 9580 6004

Emergency telephone number : CHEMTREC Emergency Telephone Numbers (Australasia Geomarket):
- Australia: (02) 9037 2994
- New Zealand: 9801 0034
- PNG: +(61) 2 9037 2994

- UK: +(44) 870-820-0418
- USA: +(1) 703-527-3887 (CHEMTREC International 24 hour)

Uses

Material uses : Biocide

2 . Hazards identification

Classification : Xn; R20/21/22
C; R34
R43
N; R51/53

Risk phrases : R20/21/22- Harmful by inhalation, in contact with skin and if swallowed.
R34- Causes burns.
R43- May cause sensitisation by skin contact.
R51/53- Toxic to aquatic organisms, may cause long-term adverse effects in the aquatic environment.

Safety phrases : S25- Avoid contact with eyes.
S26- In case of contact with eyes, rinse immediately with plenty of water and seek medical advice.
S36/37/39- Wear suitable protective clothing, gloves and eye/face protection.
S45- In case of accident or if you feel unwell, seek medical advice immediately (show the label where possible).
S51- Use only in well-ventilated areas.
S57- Use appropriate containment to avoid environmental contamination.
S61- Avoid release to the environment. Refer to special instructions/safety data sheet.

Statement of hazardous/dangerous nature : HAZARDOUS SUBSTANCE. DANGEROUS GOODS.

3 . Composition/information on ingredients

Ingredient name	CAS number	Concentration
reaction mass of: 5-chloro-2-methyl-4-isothiazolin-3-one [EC no. 247-500-7] and 2-methyl-2H-isothiazol-3-one [EC no. 220-239-6] (3:1)	55965-84-9	5 - 10

Other ingredients, determined not to be hazardous according to Safe Work Australia criteria, and not dangerous according to the ADG Code, make up the product concentration to 100%.

3 . Composition/information on ingredients

There are no additional ingredients present which, within the current knowledge of the supplier and in the concentrations applicable, are classified as hazardous to health or the environment and hence require reporting in this section.

4 . First-aid measures

Inhalation : Move exposed person to fresh air. Keep person warm and at rest. If not breathing, if breathing is irregular or if respiratory arrest occurs, provide artificial respiration or oxygen by trained personnel. If unconscious, place in recovery position and get medical attention immediately. Maintain an open airway. In case of inhalation of decomposition products in a fire, symptoms may be delayed. The exposed person may need to be kept under medical surveillance for 48 hours.

Ingestion : Get medical attention immediately. Wash out mouth with water. If material has been swallowed and the exposed person is conscious, give small quantities of water to drink. If vomiting occurs, the head should be kept low so that vomit does not enter the lungs. Chemical burns must be treated promptly by a physician. If unconscious, place in recovery position and get medical attention immediately. Maintain an open airway.

Skin contact : Get medical attention immediately. Flush contaminated skin with plenty of water. Remove contaminated clothing and shoes. Wash contaminated clothing thoroughly with water before removing it, or wear gloves. Continue to rinse for at least 15 minutes. Chemical burns must be treated promptly by a physician. In the event of any complaints or symptoms, avoid further exposure. Wash clothing before reuse. Clean shoes thoroughly before reuse.

Eye contact : Get medical attention immediately. Immediately flush eyes with plenty of water, occasionally lifting the upper and lower eyelids. Check for and remove any contact lenses. Continue to rinse for at least 15 minutes. Chemical burns must be treated promptly by a physician.

Protection of first-aiders : No action shall be taken involving any personal risk or without suitable training. If it is suspected that fumes are still present, the rescuer should wear an appropriate mask or self-contained breathing apparatus. It may be dangerous to the person providing aid to give mouth-to-mouth resuscitation. Wash contaminated clothing thoroughly with water before removing it, or wear gloves.

Advice to doctor : In case of inhalation of decomposition products in a fire, symptoms may be delayed. The exposed person may need to be kept under medical surveillance for 48 hours.

5 . Fire-fighting measures

Suitable : Use dry chemical powder.

Not suitable : Do not use water jet.

Special exposure hazards : Promptly isolate the scene by removing all persons from the vicinity of the incident if there is a fire. No action shall be taken involving any personal risk or without suitable training. Move containers from fire area if this can be done without risk. Use water spray to keep fire-exposed containers cool. This material is toxic to aquatic organisms. Fire water contaminated with this material must be contained and prevented from being discharged to any waterway, sewer or drain.

Hazardous thermal decomposition products : Decomposition products may include the following materials:
carbon dioxide
carbon monoxide
nitrogen oxides
sulfur oxides
halogenated compounds
metal oxide/oxides

Special protective equipment for fire-fighters : Fire-fighters should wear appropriate protective equipment and self-contained breathing apparatus (SCBA) with a full face-piece operated in positive pressure mode.

Hazchem code : 2X

6 . Accidental release measures

Personal precautions : No action shall be taken involving any personal risk or without suitable training. Evacuate surrounding areas. Keep unnecessary and unprotected personnel from entering. Do not touch or walk through spilt material. Shut off all ignition sources. No flares, smoking or flames in hazard area. Do not breathe dust. Provide adequate ventilation. Wear appropriate respirator when ventilation is inadequate. Put on appropriate personal protective equipment (see Section 8).

Environmental precautions : Avoid dispersal of spilt material and runoff and contact with soil, waterways, drains and sewers. Inform the relevant authorities if the product has caused environmental pollution (sewers, waterways, soil or air). Water polluting material. May be harmful to the environment if released in large quantities.

Small spill : Move containers from spill area. Vacuum or sweep up material and place in a designated, labelled waste container. Use spark-proof tools and explosion-proof equipment. Dispose of via a licensed waste disposal contractor.

Large spill : Move containers from spill area. Approach the release from upwind. Prevent entry into sewers, water courses, basements or confined areas. Vacuum or sweep up material and place in a designated, labelled waste container. Avoid creating dusty conditions and prevent wind dispersal. Use spark-proof tools and explosion-proof equipment. Dispose of via a licensed waste disposal contractor. Note: see section 1 for emergency contact information and section 13 for waste disposal.

7 . Handling and storage

Storage : Store in accordance with local regulations. Store in a segregated and approved area. Store in original container protected from direct sunlight in a dry, cool and well-ventilated area, away from incompatible materials (see section 10) and food and drink. Eliminate all ignition sources. Separate from oxidizing materials. Keep container tightly closed and sealed until ready for use. Containers that have been opened must be carefully resealed and kept upright to prevent leakage. Do not store in unlabelled containers. Use appropriate containment to avoid environmental contamination.

8 . Exposure controls/personal protection

Occupational exposure limits : **No exposure standard allocated.**

Recommended monitoring procedures : If this product contains ingredients with exposure limits, personal, workplace atmosphere or biological monitoring may be required to determine the effectiveness of the ventilation or other control measures and/or the necessity to use respiratory protective equipment.

Engineering measures : Use only with adequate ventilation. Use process enclosures, local exhaust ventilation or other engineering controls to keep worker exposure to airborne contaminants below any recommended or statutory limits. Use explosion-proof ventilation equipment.

Hygiene measures : Wash hands, forearms and face thoroughly after handling chemical products, before eating, smoking and using the lavatory and at the end of the working period. Wash contaminated clothing before reusing. Ensure that eyewash stations and safety showers are close to the workstation location.

Eyes : Safety eyewear complying with an approved standard should be used when a risk assessment indicates this is necessary to avoid exposure to liquid splashes, mists or dusts. If operating conditions cause high dust concentrations to be produced, use dust goggles.

Hands : Chemical-resistant, impervious gloves complying with an approved standard should be worn at all times when handling chemical products if a risk assessment indicates this is necessary.

Respiratory : Use a properly fitted, air-purifying or air-fed respirator complying with an approved standard if a risk assessment indicates this is necessary. Respirator selection must be based on known or anticipated exposure levels, the hazards of the product and the safe working limits of the selected respirator.

Skin : Personal protective equipment for the body should be selected based on the task being performed and the risks involved and should be approved by a specialist before handling this product.

8 . Exposure controls/personal protection

Environmental exposure controls : Emissions from ventilation or work process equipment should be checked to ensure they comply with the requirements of environmental protection legislation. In some cases, fume scrubbers, filters or engineering modifications to the process equipment will be necessary to reduce emissions to acceptable levels.

9 . Physical and chemical properties

Physical state : Solid. [Powder.]

Colour : Tan. / Red.

Odour : Faint odour.

Relative density : 0.714 to 0.726 (16°C)

Flash point : Closed cup: >93°C (>199.4°F)

Solubility : Miscible with water.

10 . Stability and reactivity

Chemical stability : The product is stable.

Possibility of hazardous reactions : Under normal conditions of storage and use, hazardous reactions will not occur.

Conditions to avoid : Avoid the creation of dust when handling and avoid all possible sources of ignition (spark or flame). Take precautionary measures against electrostatic discharges. To avoid fire or explosion, dissipate static electricity during transfer by earthing and bonding containers and equipment before transferring material. Prevent dust accumulation. Avoid release to the environment. Refer to special instructions/safety data sheet.

Materials to avoid : Reactive or incompatible with the following materials:
oxidizing materials

Hazardous decomposition products : Under normal conditions of storage and use, hazardous decomposition products should not be produced.

11 . Toxicological information

Potential acute health effects

Inhalation : Harmful by inhalation. May give off gas, vapor or dust that is very irritating or corrosive to the respiratory system. Exposure to decomposition products may cause a health hazard. Serious effects may be delayed following exposure.

Ingestion : Harmful if swallowed. May cause burns to mouth, throat and stomach.

Skin contact : Corrosive to the skin. Causes burns. Harmful in contact with skin. May cause sensitisation by skin contact.

Eye contact : Corrosive to eyes. Causes burns.

Acute toxicity

Product/ingredient name	Result	Species	Dose	Exposure
reaction mass of: 5-chloro-2-methyl-4-isothiazolin-3-one [EC no. 247-500-7] and 2-methyl-2H-isothiazol-3-one [EC no. 220-239-6] (3:1)	LD50 Oral	Rat	53 mg/kg	-

Conclusion/Summary : Not available.

Potential chronic health effects

Chronic toxicity

Conclusion/Summary : Not available.

Irritation/Corrosion

Conclusion/Summary : Not available.

Sensitiser

Conclusion/Summary : Not available.

Carcinogenicity

Conclusion/Summary : Not available.

Mutagenicity

11 . Toxicological information

Conclusion/Summary : Not available.

Teratogenicity

Conclusion/Summary : Not available.

Reproductive toxicity

Conclusion/Summary : Not available.

Chronic effects : Repeated or prolonged inhalation of dust may lead to chronic respiratory irritation. Once sensitized, a severe allergic reaction may occur when subsequently exposed to very low levels.

Carcinogenicity : No known significant effects or critical hazards.

Mutagenicity : No known significant effects or critical hazards.

Teratogenicity : No known significant effects or critical hazards.

Developmental effects : No known significant effects or critical hazards.

Fertility effects : No known significant effects or critical hazards.

Inhalation : Adverse symptoms may include the following:
respiratory tract irritation
coughing

Ingestion : Adverse symptoms may include the following: stomach pains Irritation to digestive system

Skin : Adverse symptoms may include the following:
pain or irritation
redness
blistering may occur

Eyes : Adverse symptoms may include the following:
pain
watering
redness

Target organs : Contains material which may cause damage to the following organs: upper respiratory tract, skin, eyes.

12 . Ecological information

Ecotoxicity : Toxic to aquatic organisms, may cause long-term adverse effects in the aquatic environment.

Aquatic ecotoxicity

Conclusion/Summary : Not available.

Other ecological information

Persistence/degradability

Conclusion/Summary : Not available.

Other adverse effects : No known significant effects or critical hazards.

13 . Disposal considerations

Methods of disposal : This material and its container must be disposed of in a safe way. Dispose of surplus and non-recyclable products via a licensed waste disposal contractor. Disposal of this product, solutions and any by-products should at all times comply with the requirements of environmental protection and waste disposal legislation and any regional local authority requirements. Avoid dispersal of spilt material and runoff and contact with soil, waterways, drains and sewers.

14 . Transport information

Regulation	UN number	Proper shipping name	Classes	PG*	Label	Additional information

14 . Transport information

ADG	UN3261	Corrosive solid, acidic, organic, n.o.s. (isothiazolones)	8	II		**Hazchem code** 2X
ADR	UN3261	Corrosive solid, acidic, organic, n.o.s. (isothiazolones)	8	II		**UK Hazchem:** 2X
IMDG	UN3261	Corrosive solid, acidic, organic, n.o.s. (isothiazolones)	8	II		-
IATA	UN3261	Corrosive solid, acidic, organic, n.o.s. (isothiazolones)	8	II		-

PG* : Packing group

15 . Regulatory information

Standard for the Uniform Scheduling of Drugs and Poisons

Not regulated.

Control of Scheduled Carcinogenic Substances

Ingredient name	Schedule
No listed substance	

Australia inventory (AICS) : All components are listed or exempted.

EU Classification : Xn; R20/21/22
C; R34
R43
N; R51/53

Risk phrases : R20/21/22- Harmful by inhalation, in contact with skin and if swallowed.
R34- Causes burns.
R43- May cause sensitisation by skin contact.
R51/53- Toxic to aquatic organisms, may cause long-term adverse effects in the aquatic environment.

Safety phrases : S25- Avoid contact with eyes.
S26- In case of contact with eyes, rinse immediately with plenty of water and seek medical advice.
S36/37/39- Wear suitable protective clothing, gloves and eye/face protection.
S45- In case of accident or if you feel unwell, seek medical advice immediately (show the label where possible).
S51- Use only in well-ventilated areas.
S57- Use appropriate containment to avoid environmental contamination.
S61- Avoid release to the environment. Refer to special instructions/safety data sheet.

15 . Regulatory information

National regulations : **National Code of Practice for the Control of Workplace Hazardous Substances. National Code of Practice for the Labelling of Workplace Substances. National Code of Practice for the Preparation of Material Safety Data Sheets. Approved Criteria for Classifying Hazardous Substances.**

16 . Other information

Date of printing : 17 October 2012.

Date of issue/ Date of revision : 17 October 2012

Date of previous issue : 16 October 2012

Version : 1.01

Indicates information that has changed from previously issued version.

Disclaimer

To the best of our knowledge, the information contained herein is accurate. However, neither the above-named supplier, nor any of its subsidiaries, assumes any liability whatsoever for the accuracy or completeness of the information contained herein.
Final determination of suitability of any material is the sole responsibility of the user. All materials may present unknown hazards and should be used with caution. Although certain hazards are described herein, we cannot guarantee that these are the only hazards that exist.

Schlumberger

Safety Data Sheet

(USA)

(Complies with USA OSHA 29 CFR 1910.1200 and ANSI Z 400.1)

Version: 3 *Revision date* 25/Jan/2013

1. Identification of the substance/preparation and the company/undertaking

Product code **S100**

Product name **Sand S100**

Use of the substance/preparation Used as a proppant in oilfield applications.

Company identification

Schlumberger Technology Corporation
110 Schlumberger Drive
Sugar Land, Texas 77478, USA
Telephone: 1-281-285-7873

Emergency telephone number **USA: +1-281-595-3518 (24hr)**

2. Hazards identification

Emergency Overview

Warning

Main physical hazards No classified physical hazards.

Main health hazards: Respirable dust. This product may contain small amounts of repirable crystalline silica. Repeated or prolonged inhalation of crystalline silica dust can cause delayed lung injury, and other diseases, including silicosis and lung cancer.

Precautions Avoid dust formation. Do not breathe dust. Wear suitable protective equipment.

HMIS classification: Health: 0 Flammability 0 Physical hazard: 0

Physical State solid / Powder **Color** Tan **Odor** None

Principle routes of exposure:
Inhalation. Eye contact.

3. Composition/information on ingredients

Component	CAS-No	Weight % - range
Crystalline silica	14808-60-7	60-100

4. First aid measures

Eye contact Rinse with water. Seek medical attention if irritation occurs.

Skin contact	Rinse with water.
Ingestion	Rinse mouth. Never give anything by mouth to an unconscious person. Consult a physician if necessary.
Inhalation	Move to fresh air. Consult a physician if necessary.

5. Fire-fighting measures

Fire hazard	Not combustible.
Flash point	Not applicable
Autoignition temperature	No data available
Flammability limits in air:	
Lower	Not Applicable
Upper	Not Applicable
Oxidizing properties	None.

Suitable extinguishing media
The product itself does not burn. Use extinguishing media appropriate for surrounding material.

Extinguishing media which must not be used for safety reasons
None known.

Special exposure hazards arising from the substance or preparation itself, its combustion products, or released gases
none.

Special protective equipment for firefighters
Use extinguishing measures that are appropriate to local circumstances and the surrounding environment.

NFPA Rating

Health	**0**
Flammability	**0**
Instability	**0**
Special firefighting procedures	**none**

6. Accidental release measures

Main physical hazards	No classified physical hazards.
Personal precautions	Do not breathe dust. Wear suitable protective equipment.
Methods for cleaning up	Shovel into suitable container for disposal.
Environmental precautions	Prevent product from entering drains.

7. Handling and storage

Handling

Precautions	Avoid dust formation. Do not breathe dust. Wear suitable protective equipment.
Safe handling advice	Provide appropriate exhaust ventilation at places where dust is formed.

Technical measures/ storage conditions No special storage conditions required.

Packaging requirements Paper bag (minimum 3 ply), or other industrial container designed for powders and granulated materials.

Incompatible products None known.

8. Exposure controls/personal protection

All chemical Personal Protective Equipment (PPE) should be selected based on an assessment of both the chemical hazard present and the risk of exposure to those hazards. The PPE recommendations below are based on an assessment of the chemical hazards associated with this product. Where this product is used in a mixture with other products or fluids, additional hazards may be created and as such further assessment of risk may be required. The risk of exposure and need of respiratory protection will vary from workplace to workplace and should be assessed by the user in each situation.

Engineering measures to reduce exposure Ensure adequate ventilation.

Hygiene measures Keep airborne concentrations below exposure limits.

Respiratory protection Use NIOSH approved respirator with dust and mist protection (3M 8210). If dust concentration exceeds 5 times the exposure limit, wear an approved HEPA respirator.

Eye protection Safety glasses with side-shields.

Hand protection Cotton gloves.

Skin and body protection No special precautions required.

Occupational exposure limits

	ACGIH - TLVs			OSHA - PELs		
Component	**TWA / Ceiling**	**STEL**	**Skin Notation**	**TWA / C**	**STEL**	**Final PELs - Skin**
Crystalline silica	0.025 mg/m³	-	-	total dust respirable fraction	-	-

Component	**OSHA - Final PELs - Table Z-3 Mineral Dusts**
Crystalline silica	(30)/(%SiO2 + 2) mg/m³ TWA, total dust; (250)/(%SiO2 + 5) mppcf TWA, respirable fraction; (10)/(%SiO2 + 2) mg/m³ TWA, respirable fraction

Particles Not Otherwise Regulated/Specified [PNOR or PNOS] (insoluble or poorly soluble):
- OSHA PEL's for Inert or Nuisance Dust are covered by PNOR limits: respirable fraction: 5 mg/m³; total dust 15 mg/m³.
- ACGIH PNOS Recommendations: airborne concentrations should be kept below 3 mg/m³, respirable particulate, and 10 mg/m³, inhalable particles.

9. Physical and chemical properties

Chemical characterization	Inorganic mineral. Inert.
Fire hazard	Not combustible.
Physical State	solid / Powder
Color	Tan
Odor	None
Odor threshold	Not applicable
pH	Not applicable
Boiling point/range	Not applicable
Flash point	Not applicable
Flammability limits in air:	
Lower	Not Applicable
Upper	Not Applicable
Bulk density	1100-1600 kg/m^3
Melting point/range	> 1700 °C
Decomposition temperature	No data available
Solubility:	
Water solubility	Insoluble
Fat solubility	Insoluble
Partition coefficient (n-octanol/water)	Not Applicable
Relative density	~ 2.6 (@ 20°C)
Vapor pressure	Not Applicable
Vapor density	Not Applicable
Viscosity	Not Applicable
Evaporation rate	Not Applicable
% Volatile (VOC)	None

10. Stability and reactivity

Stability
Stable.

Conditions to avoid
None known.

Incompatibility with other substances
Strong oxidizing agents.

Hazardous decomposition products
None.

Hazardous polymerization
Hazardous polymerization does not occur.

11. Toxicological information

PRODUCT TOXICOLOGICAL INFORMATION

Acute health hazard

Eye contact May cause mechanical irritation.
Skin contact No effect expected.
Ingestion Accidental ingestion of small amounts is not expected to cause adverse effects.
Inhalation Inhalation of dust may cause shortness of breath, tightness of the chest, a sore throat and cough. This product may contain small amounts of respirable crystalline silica. Repeated or prolonged inhalation of crystalline silica dust can cause delayed lung injury, and other diseases, including silicosis and lung cancer.
Sensitization - lung None known.
Sensitization - skin None known.
Toxicologically synergistic products Smoked tobacco.

Chronic health hazard

Carcinogenic effects Crystalline silica dust is listed by IARC in Group 1 as known to cause lung cancer in humans, if inhaled. Risk of cancer depends on duration and level of exposure.
Mutagenic effects None known.
Teratogenic effects None known.
Reproductive toxicity None known.
Target organ effects Lung cancer. silicosis.

COMPONENT TOXICOLOGICAL INFORMATION

Component	Target organ effects	LD50 / LC50
Crystalline silica	eyes, respiratory system (in animals: lung cancer)	= 500 mg/kg (Oral LD50; Rat)

Component	IARC Group 1 or 2	ACGIH - Carcinogens	OSHA listed carcinogens	NTP
Crystalline silica	Group 1; Monograph 100C [in preparation] Group 1; Monograph 68 [1997] Group 1; Supplement 7 [1987]	A2 - Suspected Human Carcinogen	Listed	Listed

12. Ecological information

Product information

Component information

Crystalline silica

Bioaccumulation Not applicable
Persistence / degradability Not applicable.
Other information Listed on PLONOR list of OSPAR

13. Disposal considerations

Waste from residues / unused products

Dispose of by sanitary landfilling or other acceptable method in accordance with local regulations.

Contaminated packaging
Send empty bags to sanitary landfill. Render other types of containers unuseable by puncturing or crushing and sanitary landfill unless prohibited by local regulations.

EPA RCRA Hazardous Waste Code:
None

14. Transport information

DOT:

CERCLA RQ	None
Proper shipping name	Not regulated
Label(s)	None required

IMDG/IMO:

Shipping name	Not regulated
UN number	None

ICAO/IATA:

Shipping name	Not regulated
UN number	None

TDG (Canada):

Shipping name	Not regulated
PIN	None

Note 1:
For the applicable placard selection refer to the appropriate transport regulations; the selection may vary depending on the cargo size and categories of other hazardous materials in the cargo.

15. Regulatory information

International Chemical Inventories

USA, Toxic Substances Control Act inventory (TSCA)
This product complies with TSCA requirements.
Canada, Domestic Substance List (DSL)
This product complies with DSL requirements.

U.S.A. Regulations
OSHA Hazard Communication Standard:
(Complies with USA OSHA 29 CFR 1910.1200 and ANSI Z 400.1)

EPA RCRA Hazardous Waste Code:
None

EPA, Sections 311 and 312 - Material Safety Data Sheet Requirements (40 CFR 370):

Immediate (Acute) Health Hazard:	None
Delayed (Chronic) Health Hazard:	Yes
Fire Hazard:	None

Sudden Release or Pressure Hazard: None
Reactive Hazard: None

EPA, Sections 313 - List of Toxic Chemicals (40 CFR 372):
This product contains the following substance(s), which appear(s) on the List of Toxic Chemicals:

Crystalline silica
EPA, CERCLA Section 102a/103 Hazardous Substances (40 CFR 302.4): None
CERCLA/SARA - Hazardous Substances and their RQs: None
EPA, SARA TITLE III Section 304, Extremely Hazardous Substances (40 CFR 355.40): None

Additional Regulatory Information

Crystalline silica
California Proposition 65: carcinogen

International Hazard Class

WHMIS Hazard Class:
D2A (Other Toxic Effects - Very Toxic Material)

16. Other information

Current references
1. Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices. *American Conference of Governmental Industrial Hygienists, Cincinnati OH.*
2. IARC Monograms on the Evaluation of the Carcinogenic Risk of Chemicals to Man. *World Health Organization, International Agency for Research on Cancer. Geneva, Switzerland.*
3. Annual Report on Carcinogens. National Toxicology Program. *U.S. Department of Heath and Human Services, Public Health Service.*
4. NIOSH Registry of Toxic Effects of Chemical Substances (RTECS). *National Institute for Occupational safety and Health. Cincinnati, OH.*
5. LOLI Database.

Explanation of terms
ACGIH: American Conference of Governmental Industrial Hygienist
ACGIH-TL: Threshold Limit Value
DSL: Domestic Substance List
HMIRC: Hazardous Materials Information Review Commission
IARC: International Agency for Research on Cancer
NFPA: National Fire Protection Association
NTP: National Toxicology Program
NIOSH: National Institute of Occupational Safety & Health
NIOSH-REL: Recommended Exposure Limit
OSHA: Occupational Safety & Health Administration
OSHA-PEL: Permissible Exposure Limit
TSCA: Toxic Substance Control Act (Inventory)

Occupational Exposure Limits indicators: TWA - Time Weighted Average; STEL - Short Term Limit; C - Ceiling Limit;units: [mg/m^3]

ACGIH Notations:
"Skin" refers to the potential significant contribution to the overall exposure by the cutaneous route, including mucous membranes and the eyes, either by contact with vapors or by direct skin contact with the substance.
"A" notation indicates carcinogenicity as follows:
ACGIH classification: A1 - Confirmed Human Carcinogen; A2 - Suspected Human Carcinogen; A3 - Confirmed Animal Carcinogen with Unknown Relevance to Humans; A4 - Not Classifiable as a Human Carcinogen; A5 - Not suspected as a Human Carcinogen.
"SEN" refers to the potential for an agent to product sensitization as confirmed by human and animal data.

Section(s) revised: 8, 11, 16

Prepared by: Global Chemical Regulatory Compliance (GCRC).

Revision date 25/Jan/2013

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End of the Material Safety Data Sheet

Schlumberger

MATERIAL SAFETY DATA SHEET

(USA)

(Complies with USA OSHA 29 CFR 1910.1200 and ANSI Z 400.1)

Version: 2 *Revision date:* 23 September 2008

1. IDENTIFICATION OF THE SUBSTANCE/PREPARATION AND THE COMPANY/UNDERTAKING

Product code: **S580-2040**

Product name: **Fracturing Additive S580 20/40**

Company identification:

Schlumberger Technology Corporation
110 Schlumberger Drive
Sugar Land, Texas 77478, USA
Telephone: 1-281-285-7873

Emergency telephone number: **USA: +1-281-595-3518 (24hr)**

2. HAZARDS IDENTIFICATION

EMERGENCY OVERVIEW

Main physical hazards:	No classified physical hazards.
Main health hazards:	May cause mechanical irritation to eyes. Respirable dust. Inhalation of dust may cause shortness of breath, tightness of the chest, a sore throat and cough.
Other hazards:	Dust.
Precautions:	Avoid dust formation. Do not breathe dust.
HMIS classification:	Health: **0** Flammability: **0** Physical hazard: **0**

Form: Dry flowable granules **Color:** Light grey **Odor:** None

Principle routes of exposure:
Eye contact. Skin contact. Respiratory system.

3. COMPOSITION/INFORMATION ON INGREDIENTS

Component	CAS-No	Weight % - Range
Calcined bauxite	66402-68-4	60 - 100

4. FIRST AID MEASURES

General advice:	Consult a physician if necessary.
Eye contact:	Rinse with water.
Skin contact:	Rinse with water.
Ingestion:	Rinse mouth. Never give anything by mouth to an unconscious person.
Inhalation:	Move to fresh air.

5. FIRE-FIGHTING MEASURES

Fire hazard:	Not combustible.
Flash point:	Does not flash.
Autoignition temperature:	Not applicable.
Flammability limits in air:	
Lower:	Not applicable

5. FIRE-FIGHTING MEASURES

Upper: Not applicable
Oxidizing properties: None.

Suitable extinguishing media:
None needed. Use extinguishing media appropriate for surrounding material.

Extinguishing media which must not be used for safety reasons:
None known.

Special exposure hazards arising from the substance or preparation itself, its combustion products, or released gases:
None known.

Special protective equipment for firefighters:
Use extinguishing measures that are appropriate to local circumstances and the surrounding environment.

NFPA rating:

Health:	**0**
Flammability:	**0**
Instability:	**0**
Special:	**None**

6. ACCIDENTAL RELEASE MEASURES

Main physical hazards:	No classified physical hazards.
Other hazards:	Dust.
Personal precautions:	Wear suitable protective equipment. See also Section 8.
Methods for cleaning up:	Sweep up and shovel into suitable containers for disposal.
Environmental precautions:	No special environmental precautions required.

7. HANDLING AND STORAGE

Handling:

Precautions:	Avoid dust formation. Do not breathe dust.
Safe handling advice:	Provide appropriate exhaust ventilation at places where dust is formed.
Technical measures/ storage conditions:	Keep material dry.
Packaging requirements:	Paper bag (minimum 3 ply), or other industrial container designed for powders and granulated materials.
Incompatible products:	None known.

8. EXPOSURE CONTROLS / PERSONAL PROTECTION

Engineering measures to reduce exposure:	Control the source.
Hygiene measures:	Keep airborne concentrations below exposure limits.
Respiratory protection:	In case of insufficient ventilation, wear suitable respiratory equipment. If dust or mist is generated use NIOSH approved respirator with dust and mist protection (3M 8210).
Eye protection:	Tightly fitting safety goggles.
Hand protection:	Cotton gloves.
Skin and body protection:	Clean, body-covering clothing.

Occupational Exposure Limits

	ACGIH - TLVs	OSHA - PELs

Particles Not Otherwise Regulated/Specified [PNOR or PNOS] (insoluble or poorly soluble):
OSHA PEL's for Inert or Nuisance Dust are covered by PNOR limits: respirable fraction: 5 mg/m³; total dust 15 mg/m³.
ACGIH PNOS Recommendations: airborne concentrations should be kept below 3 mg/m³, respirable particulate, and 10 mg/m³, inhalable particles.

9. PHYSICAL AND CHEMICAL PROPERTIES

Chemical characterization: Inorganic compound. Inert.
Fire hazard: Not combustible.
Form: Dry flowable granules
Color: Light grey
Odor: None
Odor threshold: Not applicable.
pH: Not applicable.
Boiling point/range: Not applicable.
Flash point: Does not flash.
Flammability limits in air:
Lower: Not applicable
Upper: Not applicable
Bulk density: No information available.
Melting point/range: > 2000 °C / 3632 °F
Decomposition temperature: No data available.
Solubility:
Water solubility: Insoluble
Fat solubility: Insoluble.
Partition coefficient (n-octanol/water): Not applicable.
Relative density: 2.7 (@ 20°C)
Vapor pressure: Not applicable.
Vapor density: Not applicable.
Viscosity: Not applicable.
Evaporation rate: Not applicable.
% Volatile (VOC): None.

10. STABILITY AND REACTIVITY

Stability:
Stable.

Conditions to avoid:
None known.

Incompatibility with other substances:
None known.

Hazardous decomposition products:
None reasonably foreseeable.

Hazardous polymerization:
Hazardous polymerization does not occur.

Other hazards:
Dust.

11. TOXICOLOGICAL INFORMATION

PRODUCT TOXICOLOGICAL INFORMATION

Acute Health Hazard

Eye contact: May cause mechanical irritation.
Skin contact: No effect expected.
Ingestion: Accidental ingestion of small amounts is not expected to cause adverse effects.
Inhalation: Inhalation of dust may cause shortness of breath, tightness of the chest, a sore throat and cough.
Sensitization - lung: Not known to cause allergic reaction.
Sensitization - skin: Not known to cause allergic reaction.

Chronic Health Hazard

Carcinogenic effects: None known.
Mutagenic effects: Not known to cause heritable genetic damage.
Teratogenic effects: Not known to cause birth defects or have a deleterious effect on a developing fetus.
Reproductive toxicity: Not known to adversely affect reproductive functions and organs.
Target organ effects: None known.

COMPONENT TOXICOLOGICAL INFORMATION

12. ECOLOGICAL INFORMATION

PRODUCT INFORMATION

COMPONENT INFORMATION

Calcined bauxite
Bioaccumulation: Not applicable
Persistence / degradability: The methods for determining biodegradability are not applicable to inorganic substances.

13. DISPOSAL CONSIDERATIONS

Waste from residues / unused products:
Dispose of by sanitary landfilling or other acceptable method in accordance with local regulations.

Contaminated packaging:
Send empty bags to sanitary landfill. Render other types of containers unuseable by puncturing or crushing and sanitary landfill unless prohibited by local regulations.

EPA RCRA Hazardous Waste Code:
None

14. TRANSPORT INFORMATION

DOT:

CERCLA RQ: None

14. TRANSPORT INFORMATION

Hazard class: Not regulated.
Proper shipping name: Not regulated
Label(s): None required.

IMDG/IMO

Shipping name: Not regulated.

UN number: None

ICAO/IATA

Shipping name: Not regulated.

UN number: None

TDG (Canada):

Shipping name: Not regulated.
PIN: None

Note 1:
For the applicable placard selection refer to the appropriate transport regulations; the selection may vary depending on the cargo size and categories of other hazardous materials in the cargo.

15. REGULATORY INFORMATION

International Chemical Inventories

Inventory - United States TSCA -	This product complies with TSCA requirements.
Canada DSL Inventory List -	This product complies with DSL requirements.
EC-No	This product complies with EINECS/ELINCS requirements.
China inventory of existing chemical substances list -	This product complies with China inventory requirements.
Inventory - Japan - Existing and New Chemicals list -	This product does not comply with JPENCS
Australia (AICS):	All the constituents of this material are listed on the Australian Inventory of Chemical Substances (AICS).

U.S.A. Regulations

OSHA Hazard Communication Standard:
(Complies with USA OSHA 29 CFR 1910.1200 and ANSI Z 400.1)

EPA RCRA Hazardous Waste Code:
None

EPA, Sections 311 and 312 - Material Safety Data Sheet Requirements (40 CFR 370):

Immediate (Acute) Health Hazard: None
Delayed (Chronic) Health Hazard: None

Fire Hazard: None
Sudden Release or Pressure Hazard: None
Reactive Hazard: None

EPA, Sections 313 - List of Toxic Chemicals (40 CFR 372):
This product contains the following substance(s), which appear(s) on the List of Toxic Chemicals:

Additional Regulatory Information

Calcined bauxite
EPA, CERCLA Section 102a/103 Hazardous Substances (40 CFR 302.4): None
CERCLA/SARA - Hazardous Substances and their RQs: None
EPA, SARA TITLE III Section 304, Extremely Hazardous Substances (40 CFR 355.40): None
California Proposition 65: None

International Hazard Class

WHMIS Hazard Class:
Non-controlled product.

16. OTHER INFORMATION

Current references:
1. Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices. *American Conference of Governmental Industrial Hygienists, Cincinnati OH.*
2. IARC Monograms on the Evaluation of the Carcinogenic Risk of Chemicals to Man. *World Health Organization, International Agency for Research on Cancer. Geneva, Switzerland.*
3. Annual Report on Carcinogens. National Toxicology Program. *U.S. Department of Heath and Human Services, Public Health Service.*
4. NIOSH Registry of Toxic Effects of Chemical Substances (RTECS). *National Institute for Occupational safety and Health. Cincinnati, OH.*
5. LOLI Database.

Explanation of terms:
ACGIH: American Conference of Governmental Industrial Hygienist
ACGIH-TL: Threshold Limit Value
DSL: Domestic Substance List
HMIRC: Hazardous Materials Information Review Commission
IARC: International Agency for Research on Cancer
NTP: National Toxicology Program
NIOSH: National Institute of Occupational Safety & Health
NIOSH-REL: Recommended Exposure Limit
OSHA: Occupational Safety & Health Administration
OSHA-PEL: Permissible Exposure Limit
TSCA: Toxic Substance Control Act (Inventory)

Occupational Exposure Limits indicators: TWA - Time Weighted Average; STEL - Short Term Limit; C - Ceiling Limit;units: [mg/m^3]

ACGIH Notations:
"Skin" refers to the potential significant contribution to the overall exposure by the cutaneous route, including mucous membranes and the eyes, either by contact with vapors or by direct skin contact with the substance.
"A" notation indicates carcinogenicity as follows:
ACGIH classification: A1 - Confirmed Human Carcinogen; A2 - Suspected Human Carcinogen; A3 - Confirmed Animal Carcinogen with Unknown Relevance to Humans; A4 - Not Classifiable as a Human Carcinogen; A5 - Not suspected as a Human Carcinogen.
"SEN" refers to the potential for an agent to product sensitization as confirmed by human and animal data.

Section(s) revised: 8

Additional advice:	Consult your supplier if the material is to be used for special applications such as in the food industry or for hygiene, medical or surgical end-use.
Prepared by:	Well Services Safety & Environment (WSSE).
Revision date:	23 September 2008

End of the Material Safety Data Sheet

Schlumberger

SAFETY DATA SHEET

(Australia)

According to the criteria of NOHSC:2011(2003)

Version: 1 *Revision date: 29 March 2012*

1. IDENTIFICATION OF THE SUBSTANCE/PREPARATION AND THE COMPANY/UNDERTAKING

Product Name: **Gelling Agent U28 - 30% Active**

Product Code: **U028**

Company Identification: Schlumberger Oilfield Australia Pty Ltd
ABN: 74 002 459 225
ACN: 002 459 225
256 St. Georges Terrace, Perth WA 6000

Emergency Telephone Number: 1-800-039-008 (24hr)

Use of the Substance/Preparation: Used as a fracturing additive in oilfield applications.

2. HAZARDS IDENTIFICATION

Indication of danger C - Corrosive.

Most important hazards R-phrase(s): Causes severe burns.

Health hazards: Causes burns to mouth, throat and stomach. Causes severe skin burns. Causes severe eye burns. Causes burns to respiratory tract.

S-phrase(s): S26 - In case of contact with eyes, rinse immediately with plenty of water and seek medical advice. S45 - In case of accident or if you feel unwell, seek medical advice immediately (show the label where possible).

Safety Combination Phrases: S36/37/39 - Wear suitable protective clothing, gloves and eye/face protection.

Environmental hazard: None known

Main physical hazards: Corrosive to metals.

3. COMPOSITION/INFORMATION ON INGREDIENTS

Component	CAS-No	EC-No.	Weight % - Range	Classification (67/548)
Sodium hydroxide	1310-73-2	215-185-5	30	C;R35

For the full text of the R phrases mentioned in this Section, see Section 16

4. FIRST AID MEASURES

Inhalation: Move to fresh air. Obtain medical attention.

Skin contact:	Take off contaminated clothing and shoes immediately. Rinse immediately with plenty of water for at least 30 minutes. Seek medical attention at once.
Eye contact:	Immediately flush eyes with water for 30 minutes while holding eyelids open. Seek medical attention at once.
Ingestion:	Do NOT induce vomiting. Immediately give large quantities of water to drink. Seek medical attention at once.

5. FIRE-FIGHTING MEASURES

Suitable extinguishing media:	The product itself does not burn. Use extinguishing media appropriate for surrounding material.
Extinguishing media which must not be used for safety reasons:	None known.
Special protective equipment for firefighters:	Wear protective fire fighting clothing and avoid breathing vapors. Use self-contained breathing apparatus in closed areas.
Special exposure hazards arising from the substance or preparation itself, its combustion products, or released gases:	None known.

6. ACCIDENTAL RELEASE MEASURES

Personal precautions:	Do not breathe vapors or spray mist. Use personal protective equipment. See also section 8.
Environmental precautions:	Prevent further leakage or spillage. Keep out of waterways.
Methods for cleaning up:	Dam up. Soak up with inert absorbent material. Shovel into suitable container for disposal. After cleaning, flush away traces with water. Keep people away from and upwind of spill/leak. See also section 13.

7. HANDLING AND STORAGE

Handling:

Technical measures/Precautions:	Ensure adequate ventilation.
Safe handling advice:	Keep airborne concentrations below exposure limits. Use personal protective equipment. See also section 8.

Storage:

Technical measures/Storage conditions:	Ensure adequate ventilation. Keep containers tightly closed in a dry, cool and well-ventilated place. Do not store in contact with aluminum.
Packaging requirements:	High density polyethylene (HDPE) drum or can.

Incompatible products: Acids, Metals, Aluminium, Zinc

8. EXPOSURE CONTROLS / PERSONAL PROTECTION

Engineering measures to reduce exposure: Ensure adequate ventilation, Keep airborne concentrations below exposure limits

Respiratory protection: In case of insufficient ventilation, wear suitable respiratory equipment.

Hand protection: Impervious gloves Neoprene

Eye protection: Chemical splash goggles and face shield.

Skin and body protection: Chemical resistant suit. Chemical resistant boots.

Environmental exposure controls

Exposure limit(s)

Component	Australia - Occupational Exposure Standards - TWAs	Australia - Occupational Exposure Standards - STELs
Sodium hydroxide	None	None

9. PHYSICAL AND CHEMICAL PROPERTIES

General Information

Form: Liquid
Odour: None
Colour: Colorless

Important Health, Safety and Environmental Information

pH: > 13
Boiling point/range: 115 °C
Flash point: Not combustible
Explosive properties:
Explosion data - sensitivity to mechanical impact: None
Explosion data - sensitivity to static discharge: None
Flammability Limits in Air:
lower: None
upper: None
Oxidizing properties: None
Relative density: 1.3 (@ 20°C)
Solubility:
Water solubility: Soluble
Fat solubility: No information available.
Partition coefficient (n-octanol/water): Not applicable.
Viscosity: 13 mPa.s (@ 20 °C)
Vapour density: No information available.
Vapour pressure: No information available.
Evaporation rate: No information available.

Other information

Melting point/range: ~ -20 °C

10. STABILITY AND REACTIVITY

Stability: Stable under recommended storage conditions.

Conditions to avoid: None reasonably foreseeable.

Materials to avoid: Acids, Metals, Aluminium, Zinc

Hazardous decomposition products: None known.

Hazardous polymerization: Hazardous polymerization does not occur.

11. TOXICOLOGICAL INFORMATION

Local effects

Skin: Corrosive; rapidly causes pain, burns, redness, swelling and damage to tissue.

Eyes: Corrosive. Rapidly causes pain, burns, corneal injury. May cause permanent damage and blindness.

Inhalation: Corrosive. Short exposure can injure lungs, throat, and mucous membranes. Causes pain, burns, choking, and coughing.

Ingestion: Corrosive. Causes pain and severe burns to mouth, throat and stomach.

Sensitization - skin: Not known to cause allergic reaction.

Sensitization - lung: Not known to cause allergic reaction

Chronic Health Hazard

Carcinogenic effects: None known.

Mutagenic effects: Not known to cause heritable genetic damage.

Teratogenic effects: Not known to cause birth defects or have a deleterious effect on a developing fetus.

Reproductive toxicity: Not known to adversely affect reproductive functions and organs.

Component	**LD50 / LC50**
Sodium hydroxide	- = 1350 mg/kg (Dermal LD50; Rabbit)

12. ECOLOGICAL INFORMATION

Ecotoxicity

COMPONENT INFORMATION

Sodium hydroxide

Bioaccumulation:	Not applicable
Persistence and degradability:	Not applicable
Freshwater Fish Species Data	45.4 mg/L LC50 (Oncorhynchus mykiss) = 96 h

13. DISPOSAL CONSIDERATIONS

Waste from residues / unused products:	Dispose of as special waste in compliance with local and national regulations
Contaminated packaging:	Empty containers should be transported/delivered using a registered waste carrier for local recycling or waste disposal

14. TRANSPORT INFORMATION

UN number: UN 1824
Shipping name: SODIUM HYDROXIDE SOLUTION

ADR/RID

Class:	8	**Subsidiary risk(s):**	-
Classification Code:	C5		
Packing Group:	II		
ADR/RID-Labels	8		
Hazard ID	80		

IMDG/IMO

Class or Div.:	8	**Subsidiary risk(s):**	-
Label(s):	8		
Packing Group:	II		
EmS:	F-A, S-B		

ICAO/IATA

Class or Div.:	8	**Subsidiary risk(s):**	-
Label(s)	8		
Packing group:	II		

15. REGULATORY INFORMATION

In accordance with the criteria of NOHSC

contains: Sodium hydroxide .

Indication of danger

- C - Corrosive

R-phrase(s):
- R35 - Causes severe burns.

S-phrase(s):
- S26 - In case of contact with eyes, rinse immediately with plenty of water and seek medical advice.
- S45 - In case of accident or if you feel unwell, seek medical advice immediately (show the label where possible).
- S36/37/39 - Wear suitable protective clothing, gloves and eye/face protection.

International Inventories

Australia (AICS):	All the constituents of this material are listed on the Australian Inventory of Chemical Substances (AICS).

16. OTHER INFORMATION

Text of R phrases mentioned in Section 3
- R35 - Causes severe burns.

Prepared by: Chemical Regulatory Compliance

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End of Safety Data Sheet

Schlumberger

SAFETY DATA SHEET

(Australia)

According to the criteria of NOHSC:2011(2003)

Version: 1 *Revision date: 01 April 2011*

1. IDENTIFICATION OF THE SUBSTANCE/PREPARATION AND THE COMPANY/UNDERTAKING

Product Name: **Chelating Agent U42**

Product Code: **U042**

Company Identification: Schlumberger Oilfield Australia Pty Ltd
ABN: 74 002 459 225
ACN: 002 459 225
256 St. Georges Terrace, Perth WA 6000

Emergency Telephone Number: 1-800-039-008 (24hr)

Use of the Substance/Preparation: Iron control agent in oilfield applications.

2. HAZARDS IDENTIFICATION

Indication of danger: Xi - Irritant.

Most important hazards
Risk Combination Phrases Irritating to eyes, respiratory system and skin.

Health hazards: This product contains small amounts of Nitrilotriacetic acid and/or its trisodium salt. They are listed by IARC in group 2B and by NTP as causing cancer in animals.

S-phrase(s): S26 - In case of contact with eyes, rinse immediately with plenty of water and seek medical advice. S37 - Wear suitable gloves.

Environmental hazard: The organic portion of this material is not biodegradable.

Main physical hazards: Corrosive to aluminum.

3. COMPOSITION/INFORMATION ON INGREDIENTS

Component	CAS-No	EC-No.	Weight % - Range	Classification
Tetrasodium ethylenediaminetetraacetate	64-02-8	200-573-9	30 - 60	Xi;R36/37/38
Sodium hydroxide	1310-73-2	215-185-5	< 5	C;R35
Trisodium nitrilotriacetate (impurity)	5064-31-3		0.1-1.0	Xn;R22 Xi;R36

For the full text of the R phrases mentioned in this Section, see Section 16

4. FIRST AID MEASURES

Inhalation: Move to fresh air. Consult a physician if necessary.

Skin contact: Take off contaminated clothing and shoes immediately. Wash off immediately with plenty of water for at least 15 minutes. Seek medical attention if irritation occurs.

Eye contact: Immediately flush eyes with water for 30 minutes while holding eyelids open. Seek medical attention at once.

Ingestion: Rinse mouth. Call a physician or poison control centre immediately. If delayed, consider giving activated charcoal in water, or 2 glasses milk or water.

5. FIRE-FIGHTING MEASURES

Suitable extinguishing media: Water Fog, Alcohol Foam, CO2, Dry Chemical. Water spray.

Extinguishing media which must not be used for safety reasons: None known.

Special protective equipment for firefighters: Wear protective fire fighting clothing and avoid breathing vapors. Use self-contained breathing apparatus in closed areas.

Special exposure hazards arising from the substance or preparation itself, its combustion products, or released gases: When heated strongly or burned, oxides of carbon, nitrogen oxides, ammonia and harmful organic chemical fumes are released.

6. ACCIDENTAL RELEASE MEASURES

Personal precautions: Avoid contact with the skin and the eyes. Use personal protective equipment. See also section 8.

Environmental precautions: Prevent further leakage or spillage. Prevent entry into sewage. Keep out of waterways.

Methods for cleaning up: Dam up. Soak up with inert absorbent material. Shovel into suitable container for disposal. See also section 13.

7. HANDLING AND STORAGE

Handling:

Technical measures/Precautions: Ensure adequate ventilation.

Safe handling advice: Avoid contact with skin and eyes. Use personal protective equipment. See also section 8.

Storage:

Technical measures/Storage conditions: Do not store in contact with aluminum. Store in well ventilated area out of direct sunlight.

Packaging requirements: Steel or high density polyethylene (HDPE) container.

Incompatible products: Aluminium, Oxidizing agents

8. EXPOSURE CONTROLS / PERSONAL PROTECTION

Engineering measures to reduce exposure: Ensure adequate ventilation

Respiratory protection: In case of insufficient ventilation, wear suitable respiratory equipment.

Hand protection: Impervious gloves Neoprene

Eye protection: Tightly fitting safety goggles.

Skin and body protection: Clean, body-covering clothing.

Environmental exposure controls

Exposure limit(s)

Component	Australia - Occupational Exposure Standards - TWAs	Australia - Occupational Exposure Standards - STELs
Tetrasodium ethylenediaminetetraacetate	None	None
Sodium hydroxide	None	None
Trisodium nitrilotriacetate (impurity)	None	None

9. PHYSICAL AND CHEMICAL PROPERTIES

General Information

Form: Liquid
Odour: amine-like
Colour: Light yellow, - , Brown

Important Health, Safety and Environmental Information

pH: 11 - 12
pH concentration: @ 10 g/l
Boiling point/range: 106 °C
Flash point: Not applicable.
Explosive properties:
Explosion data - sensitivity to mechanical impact: None known
Explosion data - sensitivity to static discharge: None known
Flammability Limits in Air:
lower: Not applicable
upper: Not applicable
Oxidizing properties: None
Relative density: 1.3 (@ 25°C)
Solubility:
Water solubility: Soluble
Fat solubility: No information available.

Partition coefficient (n-octanol/water):	See also section 12
Viscosity:	20 mPa.s (@ 20 °C)
Vapour density:	No information available.
Vapour pressure:	No information available.
Evaporation rate:	No information available.

Other information

Melting point/range:	-31 °C

10. STABILITY AND REACTIVITY

Stability:	Stable under recommended storage conditions.
Conditions to avoid:	None reasonably foreseeable.
Materials to avoid:	Aluminium, Oxidizing agents
Hazardous decomposition products:	When heated strongly or burned, oxides of carbon, nitrogen oxides, ammonia and harmful organic chemical fumes are released.
Hazardous polymerization:	Hazardous polymerization does not occur.

11. TOXICOLOGICAL INFORMATION

Local effects

Skin:	Irritant; may cause pain, redness, dermatitis.
Eyes:	Irritant. May cause pain, redness, discomfort.
Inhalation:	Irritant; may cause pain and coughing.
Ingestion:	May cause slight irritation.
Sensitization - skin:	Not known to cause allergic reaction.
Sensitization - lung:	Not known to cause allergic reaction

Chronic Health Hazard

Carcinogenic effects:	This product contains small amounts of Nitrilotriacetic acid and/or its trisodium salt. They are listed by IARC in group 2B and by NTP as causing cancer in animals.
Mutagenic effects:	Not known to cause heritable genetic damage.
Teratogenic effects:	Not known to cause birth defects or have a deleterious effect on a developing fetus.
Reproductive toxicity:	Not known to adversely affect reproductive functions and organs.

Component	**LD50 / LC50**
Tetrasodium ethylenediaminetetraacetate	- = 10 g/kg (Oral LD50; Rat)
Sodium hydroxide	- = 1350 mg/kg (Dermal LD50; Rabbit)

12. ECOLOGICAL INFORMATION

Ecotoxicity

Aquatic toxicity: See component information below.

COMPONENT INFORMATION

Tetrasodium ethylenediaminetetraacetate

Bioaccumulation:	log Pow = < -2.4
Persistence and degradability:	0 % (28d; OECD306)
Freshwater Fish Species Data	1.01 mg/L EC50 (Desmodesmus subspicatus) = 72 h
Freshwater Fish Species Data	41 mg/L LC50 (Lepomis macrochirus) = 96 h 59.8 mg/L LC50 (Pimephales promelas) = 96 h
Water Flea Data	610 mg/L EC50 (Daphnia magna) = 24 h

Sodium hydroxide

Bioaccumulation:	Not applicable
Persistence and degradability:	Not applicable
Freshwater Fish Species Data	45.4 mg/L LC50 (Oncorhynchus mykiss) = 96 h

Trisodium nitrilotriacetate (impurity)

Bioaccumulation:	No information available
Persistence and degradability:	No information available
Freshwater Fish Species Data	560 - 1000 mg/L EC50 (Chlorella vulgaris) = 96 h
Freshwater Fish Species Data	252 mg/L LC50 (Lepomis macrochirus) = 96 h 72-133 mg/L LC50 (Oncorhynchus mykiss) = 96 h 560-1000 mg/L LC50 (Poecilia reticulata) = 96 h 470 mg/L LC50 (Pimephales promelas) = 96 h 175-225 mg/L LC50 (Lepomis macrochirus) = 96 h 560-1000 mg/L LC50 (Oryzias latipes) = 96 h 93-170 mg/L LC50 (Pimephales promelas) = 96 h 114 mg/L LC50 (Pimephales promelas) = 96 h
Water Flea Data	560 - 1000 mg/L LC50 (Daphnia magna) = 48 h

13. DISPOSAL CONSIDERATIONS

Waste from residues / unused products: Dispose of as special waste in compliance with local and national regulations

Contaminated packaging: Empty containers should be transported/delivered using a registered waste carrier for local recycling or waste disposal

14. TRANSPORT INFORMATION

UN number: UN 3267

Shipping name: CORROSIVE LIQUID, BASIC, ORGANIC, N.O.S. (Tetrasodium ethylenediaminetetra acetic acid),

14. TRANSPORT INFORMATION

ADR/RID

Class:	8
Classification Code:	C7
Packing Group:	III
ADR/RID-Labels	8
Hazard ID	80

IMDG/IMO

Class or Div.:	8
Label(s):	8
Packing Group:	III
EmS:	F-A, S-B

ICAO/IATA

Class or Div.:	8	
Label(s):	8	
Packing group:	III	
Packing instruction (passenger aircraft):	852	**Max Net Qty/Pkg:** 5 L
Packing instruction (cargo aircraft):	856	**Max Net Qty/Pkg:** 60 L

15. REGULATORY INFORMATION

In accordance with the criteria of NOHSC

Indication of danger:

- Xi - Irritant

R-phrase(s):

-
- R36/37/38 - Irritating to eyes, respiratory system and skin.

S-phrase(s):

- S26 - In case of contact with eyes, rinse immediately with plenty of water and seek medical advice.
- S37 - Wear suitable gloves.

International Inventories

Australia (AICS):	All the constituents of this material are listed on the Australian Inventory of Chemical Substances (AICS).

16. OTHER INFORMATION

Text of R phrases mentioned in Section 3

- R35 - Causes severe burns.
- R36/37/38 - Irritating to eyes, respiratory system and skin.

Prepared by: Chemical Regulatory Compliance

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End of Safety Data Sheet

APPENDIX D

Tables

		Mass (kg)	Concentration (mg/L)
Chemical constituient	CAS No.	Slickwater	
Boric acid*	10043-35-3		
2,2',2"-nitrilotriethanol	102-71-6		
Magnesium nitrate*	10377-60-3	26.50	10.00
Fumaric acid	110-17-8		
2-butoxyethanol	111-76-2		
Decyldimethyl amine (impurity)	1120-24-7		
Triethylenetetramine	112-24-3	2649.50	1000.00
Butyl diglycol	112-34-5		
Tetraethylenepentamine	112-57-2		
Silica gel, pptd., cryst.-free	112926-00-8		
Potassium hydroxide	1310-58-3	2.65	1.00
Sodium hydroxide*	1310-73-2		
Sodium tetraborate*	1330-43-4		
Potassium borate	1332-77-0		
Disodium Ethylene Diamine Tetra Acetate (impurity)	139-33-3		
Cristobalite	14464-46-1	2.65	1.00
Magnesium silicate hydrate (talc)	14807-96-6		
Crystalline silica*	14808-60-7	26495.00	10000.00
Erucic amidopropyl dimethyl betaine	149879-98-1		
Trisodium Ethylenediaminetetraacetate (impurity)	150-38-9		
Octadecanoic acid, calcium salt	1592-23-0	26.50	10.00
Vinylidene chloride/methylacrylate copolymer	25038-72-6		
Acetic acid ethenyl ester, polymer with ethenol	25213-24-5		
Benzenesulfonic acid, 4-ethenyl-, sodium salt, homopolymer	25704-18-1		
Decyl-dimethyl amine oxide	2605-79-0		
5-chloro-2-methyl-2h-isothiazolol-3-one	26172-55-4	26.50	10.00
2-methyl-2h-isothiazol-3-one	2682-20-4	2.65	1.00
Sodium Glycolate (impurity)	2836-32-0		
Polyvinyl acetate, partially hydrolyzed	304443-60-5		
Polyethylene glycol monohexyl ether	31726-34-8	2649.50	1000.00
Acrylamide, 2-acrylamido-2-methylpropanesulfonic acid, sodium salt polymer	38193-60-1	2649.50	1000.00
Sodium chloroacetate	3926-62-3		
Pentaethylenehexamine	4067-16-7		
Sodium carbonate*	497-19-8		
Trisodium nitrilotriacetate (impurity)	5064-31-3		
Sodium gluconate	527-07-1		
Glycerol	56-81-5		
L-Glutamic acid	56-86-0		
Dicoco dimethyl quaternary ammonium chloride	61789-77-3	26.50	10.00
Tetrasodium ethylenediaminetetraacetate	64-02-8		
Ethanol*	64-17-5		
Acetic acid*	64-19-7		
Ceramic materials*	66402-68-4		
Ceramic materials and wares, chemicals	66402-68-4	397425.00	150000.00
Cholinium chloride*	67-48-1	26495.00	10000.00
Propan-2-ol	67-63-0	2.65	1.00
Sodium carboxylmethylhydroxypropyl guar	68130-15-4		
Ammonium c6-c10 alcohol ethoxysulfate	68187-17-7		
Alkyl(c12-16) dimethylbenzyl ammonium chloride	68424-85-1		
Alcohols, C6-C10, ethoxylated	68439-45-2		
ß-Alanine, N-coco alkyl derivs., sodium salts	68608-68-4		
Tetramethylammonium chloride*	75-57-0		
Carbonic acid, sodium salt (2:3)*	7542-12-3		
Non-crystalline silica	7631-86-9		
Hydrochloric acid*	7647-01-0	264.95	-
Sodium chloride*	7647-14-5		
Zirconium dichloride oxide	7699-43-6		
Hydrogen peroxide (impurity)	7722-84-1		
N2 (liquid)*	7727-37-9		
Diammonium peroxidisulphate*	7727-54-0		
Water*	7732-18-5	2252075.00	-
Sodium thiosulfate*	7772-98-7		
Magnesium chloride	7786-30-3	26.50	10.00
Sodium bromate	7789-38-0		
Cetylethylmorpholinium ethyl sulfate	78-21-7		
Hydroxypropyl cellulose	9004-64-2	26.50	10.00
Polyethylene glycol sorbitan monolaurate	9005-64-5		
Polylactide resin	9051-89-2		
Diatomaceous earth, calcined	91053-39-3	264.95	100.00

*= Chemicals not assessed in this report as have been previously assessed by other consultants. Ref: www.qgc.com.au

Santos Hydraulic Stimulation Chemical Assessment
Appendix D1 - Mass Balance Table
127666004

		Mass (kg)	Concentration (mg/L)	Mass (kg)	Concentration (mg/L)
Chemical constituient	CAS No.	ThermaFrac 40		HCl YF140HTD 30Q N2	
Boric acid*	10043-35-3			228.03	1000.00
2,2',2"-nitrilotriethanol	102-71-6	2649.50	1000.00	2280.27	10000.01
Magnesium nitrate*	10377-60-3	26.50	10.00	2.28	10.00
Fumaric acid	110-17-8	264.95	100.00		
2-butoxyethanol	111-76-2				
Decyldimethyl amine (impurity)	1120-24-7	26.50	10.00		
Triethylenetetramine	112-24-3	264.95	100.00		
Butyl diglycol	112-34-5				
Tetraethylenepentamine	112-57-2	2649.50	1000.00		
Silica gel, pptd., cryst.-free	112926-00-8	26.50	10.00		
Potassium hydroxide	1310-58-3			0.23	1.00
Sodium hydroxide*	1310-73-2	2649.50	1000.00	2280.27	10000.01
Sodium tetraborate*	1330-43-4	2649.50	1000.00		
Potassium borate	1332-77-0				
Disodium Ethylene Diamine Tetra Acetate (impurity)	139-33-3			2.28	10.00
Cristobalite	14464-46-1	2.65	1.00	0.23	1.00
Magnesium silicate hydrate (talc)	14807-96-6	26.50	10.00	2.28	10.00
Crystalline silica*	14808-60-7	26495.00	10000.00	2280.27	10000.01
Erucic amidopropyl dimethyl betaine	149879-98-1				
Trisodium Ethylenediaminetetraacetate (impurity)	150-38-9			2.28	10.00
Octadecanoic acid, calcium salt	1592-23-0				
Vinylidene chloride/methylacrylate copolymer	25038-72-6	2649.50	1000.00	228.03	1000.00
Acetic acid ethenyl ester, polymer with ethenol	25213-24-5				
Benzenesulfonic acid, 4-ethenyl-, sodium salt, homopolymer	25704-18-1				
Decyl-dimethyl amine oxide	2605-79-0	2649.50	1000.00		
5-chloro-2-methyl-2h-isothiazolol-3-one	26172-55-4	26.50	10.00	2.28	10.00
2-methyl-2h-isothiazol-3-one	2682-20-4	2.65	1.00	0.23	1.00
Sodium Glycolate (impurity)	2836-32-0			2.28	10.00
Polyvinyl acetate, partially hydrolyzed	304443-60-5				
Polyethylene glycol monohexyl ether	31726-34-8			22.80	100.00
Acrylamide, 2-acrylamido-2-methylpropanesulfonic acid, sodium salt polymer	38193-60-1				
Sodium chloroacetate	3926-62-3				
Pentaethylenehexamine	4067-16-7	264.95	100.00		
Sodium carbonate*	497-19-8				
Trisodium nitrilotriacetate (impurity)	5064-31-3			0.23	1.00
Sodium gluconate	527-07-1			2280.27	10000.01
Glycerol	56-81-5				
L-Glutamic acid	56-86-0	2649.50	1000.00		
Dicoco dimethyl quaternary ammonium chloride	61789-77-3			2.28	10.00
Tetrasodium ethylenediaminetetraacetate	64-02-8			22.80	100.00
Ethanol*	64-17-5	264.95	100.00		
Acetic acid*	64-19-7				
Ceramic materials*	66402-68-4	317940.00	120000.00	25083.01	110000.16
Ceramic materials and wares, chemicals	66402-68-4				
Cholinium chloride*	67-48-1			2280.27	10000.01
Propan-2-ol	67-63-0			0.23	1.00
Sodium carboxylmethylhydroxypropyl guar	68130-15-4	26495.00	10000.00	2280.27	10000.01
Ammonium c6-c10 alcohol ethoxysulfate	68187-17-7				
Alkyl(c12-16) dimethylbenzyl ammonium chloride	68424-85-1	2649.50	1000.00		
Alcohols, C6-C10, ethoxylated	68439-45-2				
ß-Alanine, N-coco alkyl derivs., sodium salts	68608-68-4				
Tetramethylammonium chloride*	75-57-0	26495.00	10000.00		
Carbonic acid, sodium salt (2:3)*	7542-12-3				
Non-crystalline silica	7631-86-9			2.28	10.00
Hydrochloric acid*	7647-01-0	264.95	-	2280.27	-
Sodium chloride*	7647-14-5				
Zirconium dichloride oxide	7699-43-6	264.95	100.00		
Hydrogen peroxide (impurity)	7722-84-1	26.50	10.00		
N2 (liquid)*	7727-37-9			52446.28	-
Diammonium peroxidisulphate*	7727-54-0				
Water*	7732-18-5	2225580.00	-	148217.76	-
Sodium thiosulfate*	7772-98-7	26495.00	10000.00	228.03	1000.00
Magnesium chloride	7786-30-3	26.50	10.00	2.28	10.00
Sodium bromate	7789-38-0	2649.50	1000.00	228.03	1000.00
Cetylethylmorpholinium ethyl sulfate	78-21-7			0.23	1.00
Hydroxypropyl cellulose	9004-64-2				
Polyethylene glycol sorbitan monolaurate	9005-64-5			22.80	100.00
Polylactide resin	9051-89-2			2280.27	10000.01
Diatomaceous earth, calcined	91053-39-3	264.95		22.80	100.00

*= Chemicals not assessed in this report as have been previously assessed by other consultants. Ref: www.qgc.com.au

Fluid System	WF130 with CBMF (L)	YF120LG	Slickwater	WF120+N2
Typical fluid Volume[1]	~ 368,343L	~ 96,400L	~ 2,649,500L	~ 90,706L
Additives	~ 14,784 kg (~4.1 %)	~ 844 kg (~1 %)	~ 34,875 kg (~1 %)	~ 5,382 kg (~5 %)
Proppant	~ 63,036 kg (~17.4 %)	~ 22,688 kg (~26 %)	~ 424,187 kg (~14 %)	~ 9,886 kg (~10 %)
Water*	~ 283,500 kg (~78.5 %)	~ 63,677 kg (~73 %)	~ 2,252,075 kg (~85 %)	~ 75,439 kg (~85 %)

Fluid System	YF140Flex	Waterfrac	WF130 Linear Gel	ThermaFrac 40
Typical fluid Volume[1]	~ 173,525L	~ 2,270,780L	~ 378,500L	~ 2,649,500L
Additives	~ 5,942 kg (~5 %)	~ 150 kg (<1 %)	~ 150 kg (<1 %)	~ 105,376 kg (~4 %)
Proppant	~ 20,840 kg (~10 %)	~ 71 kg (<1 %)	~ 71 kg (~12 %)	~ 397,425 kg (~15 %)
Water*	~ 150,967 kg (~87 %)	~ 2,270,780 kg (>99 %)	~ 2,270,780 kg (~87 %)	~ 2,225,580 kg (~82 %)

Fluid System	YF120LG 25k	ClearFrac XT	HCl YF140HTD 30Q N2
Typical fluid Volume[1]	~ 96,502L	~ 23,810L	~ 228,027L
Additives	~ 864 kg (~1 %)	~ 1,212 kg (~1 %)	~ 52,446 kg (~23 %)** N2 additive
Proppant	~ 22,688 kg (~26 %)	~ 8,949 kg (~33 %)	~ 27,364 kg (~12 %)
Water*	~ 63,677 kg (~73 %)	~ 18,452 kg (~66 %)	~ 148,218 kg (~65 %)

Human Health and Ecological Risk Assessment - Schlumberger Chemicals
Project No: 127666004

Appendix D
Table 1 - PBT Table

			Persistence									Bioaccumulation		Toxicity								SUMMARY				
Chemical	**Constituent Name**	**CAS Number**	**ORGANIC Solubility in water (mg/L)**	**INORGANIC Solubility in water (mg/L)**	**Solubility Considered in Conjunction with Acute Toxicity**	**Log Koc**	**Henry's Law (atm m3/mole)**	**EPISUITE Ready Biodegradability**	**EPISUITE Biowin 3 Ultimate Survey Biodegradation**	**EPISUITE Biowin 4 Primary Biodegradation**	**EPISUITE Biowin 7 Anaerobic Biodegradation**	**Fish BCF**	**Log Kow / Log Pow**	**FISH Chronic NOEC (mg/L)**	**INVERT Chronic NOEC (mg/L)**	**PLANT Chronic NOEC (mg/L)**	**FISH Chronic LOEC/MATC /EC_{x50} (mg/L)**	**INVERT Chronic LOEC/MATC /EC_{x50} (mg/L)**	**PLANT Chronic LOEC/MATC /EC_{x50} (mg/L)**	**FISH Acute LC/EC50 (mg/L)**	**INVERT Acute LC/EC50 (mg/L)**	**PLANT Acute LC/EC50 (mg/L)**	**Persistence**	**Bioaccumulation**	**Toxicity**	**Overall Score**	**Data Gaps %**
Crystalline Silica, Quartz		14808-60-7																								
Crystalline Silica, Cristobalite		14464-46-1																								
Non-crystalline Silica		7631-86-9																								
Silica Gel, pptd., cryst.-free		112926-00-8																								
Diatomaceous earth, calcined		91053-39-3																								
Guar gum		9000-30-0																								
Sodium carboxymethylhydroxypropyl guar		68130-15-4																								
Cholinium chloride		67-48-1	○			○	●	○	○	○	●	○	○		○	○				○	○		○	○	○	○	28%
2,2',2"-nitrilotriethanol		102-71-6	○			○	●	○	○	○	●	○	○		○				○	○	○	○	○	○	○	○	22%
Polyethylene Glycol Monohexyl Ether		31726-34-8	○			○	●	○	◖	○	●	○	○							●	●		◖	○	●	◖	39%
Polyethylene glycol sorbitan monolaurate		9005-64-5	○			●	●	●	●	○	●	○	○							○			●	○	○	○	44%
Sodium Glycolate (impurity)		2836-32-0	○			○	◖	○	○	○	○	○	○							○	○	○	○	○	○	○	33%
Dicoco Dimethyl Quarternary Ammonium Chloride		61789-77-3	●			●	●	○	◖	○	●	○	●							○	●		◖	◖	●	●	39%
Disodium Ethylene Diamine Tetra Acetate (Impurity)		139-33-3	○			○	●	○	○	○	●	○	○		○	◖		○	○	◖	○	◖	○	○	◖	○	11%
Trisodium Ethylene Diamine Tetra Acetate (Impurity)		150-38-9	○			○	●	○	○	○	●	○	○										○	○	○	○	50%
Tetrasodium ethylene diamine tetra acetate		64-02-8	○			○	●	○	○	○	●	○	○							○	○		○	○	○	○	39%
Trisodium Nitriloacetate (impurity)		5064-31-3	○			○	●	○	○	○	●	○	○		○					○		○	○	○	○	○	33%
Cetylethylmorpholinium Ethyl Sulfate		78-21-7	●			●	●	●	◖	○	●	○	●							○	○		●	◖	○	◖	39%
5-chloro-2-methyl-2h-isothiazolol-3-one		26172-55-4	○			○	◖	●	◖	○	○	○	○	●	◖			○		●	◖	●	○	○	●	◖	17%
2-methyl-2h-isothizolol-3-one		2682-20-4	○			○	◖	●	◖	○	○	○	○							●			○	○	●	◖	44%
Propan-2-ol		67-63-0	○			○	◖	○	○	○	○	○	○							○	○		○	○	○	○	39%
Alkyl(c12-16) dimethylbenzyl ammonium chloride		68424-85-1	●			●	●	●	◖	○	●	○	◖							●		●	●	○	●	●	39%
Butyl diglycol		112-34-5	○			○	◖	○	○	○	●	○	○			○				○	○		○	○	○	○	33%
Decyldimethyl amine (impurity)		1120-24-7	◖			◖	○	○	◖	○	●	○	◖		●	●				●	●	●	◖	○	●	◖	22%
Decyl-dimethyl amine oxide		2605-79-0	◖			◖	●	○	○	○	●	○	◖	◖	◖	●	○				◖	●	◖	○	●	◖	11%
Fumaric acid		110-17-8	○			○	●	○	○	○	○	○	○			○					○		○	○	○	○	39%
L-Glutamic acid		56-86-0	○			○	●	○	○	○	○	○	○			○				○	○		○	○	○	○	33%
Pentaethylenehexamine		4067-16-7	○			○	●	○	◖	○	○	○	○			◖				○	◖	●	○	○	●	◖	28%
Tetraethylenepentamine		112-57-2	○			◖	●	○	◖	○	○	○	○							○	◖	◖	○	○	◖	○	33%
Tetramethylammonium chloride		75-57-0	○			○	●	●	◖	○	●	○	○		●	○				○	◖	○	◖	○	●	◖	22%
Triethylenetetramine		112-24-3	○			○	●	○	◖	○	○	○	○		◖					○	◖	◖	○	○	◖	○	28%
Ethanol		64-17-5	○			○	◖	○	○	○	○	○	○	◖	●			○		◖	○		○	○	●	◖	22%
Hydrochloric Acid		7647-01-0		●	●														○	○			●		○	◖	64%
Sodium Hydroxide		1310-73-2		●	●															○	◖		●		◖	●	64%
Sodium Bromate		7789-38-0		●	●																		●		○	○	82%
Sodium Thiosulphate		7772-98-7		●	●															○	○		●		○	◖	64%
Potassium Hydroxide		1310-58-3		●	●															◖			●		◖	●	73%
Sodium Tetraborate		1330-43-4		●	●															◖	○	◖	●		◖	●	55%
Nitrogen, liquid form		7727-37-9		●	●															○	○	◖	●		◖	●	55%
Boric acid		10043-35-3		●	●									○	○	◖	◖	○	◖	◖	○		●		◖	●	9%
Magnesium nitrate		10377-60-3		●	●																○		●		○	◖	73%
Magnesium silicate hydrate (talc)		14807-96-6		●	●															○			●		◖	●	64%
Magnesium chloride		7786-30-3		●	●															○	◖		●		◖	●	64%
Hydrogen Peroxide (impurity)		7722-84-1		●	●									○	◖	○		○		◖	◖		●		◖	●	27%
Zirconium Dichloride Oxide		7699-43-6		●	●															◖	○		●		◖	●	64%
Surrogates																											
Surrogates for Vinylidene Chloride/Methacrylate Copolymer		75-35-4	○			○	○	●	◖	○	○	○	○			○	○			◖	◖	◖	○	○	◖	○	22%
Surrogate for Ceramic Materials and Wares		1332-58-7																									
Surrogate for Sodium Gluconate		526-95-4	○			○	●	○	○	○	○	○	○										○	○	○	○	50%
Surrogate for Polylactide Resin		50-21-5	○			○	◖	○	○	○	○	○	○							○	○	○	○	○	○	○	33%
Surrogate for Acrylamide, 2-acrylamido-2-methylpropanesulfonic acid, sodium salt polymer		5165-97-9	○			○	●	●	◖	○	●	○	○			○				○	○	○	◖	○	○	○	28%
Surrogate for Octadecanoic acid, calcium salt		57-11-4	●			●	◖	○	○	○	○	○	●							◖			◖	◖	◖	◖	44%
Surrogate for Hydoxypropyl cellulose		9004-65-3	○			○	●	○	○	○	○	○	○										○	○	○	○	50%

Comments

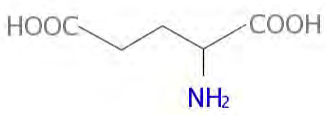
Inorganic
Organic
Surrogate
Not assessed

●	High hazard
◖	Moderate hazard
○	Low hazard

APPENDIX E

Human Health Hazard Summary

Project number: 127666004
Project name: Hydraulic Stimulation Chemicals Assessment, Southwest Queensland
Client name: Santos Ltd

Name	L-Glutamic acid
Synonyms	alpha.-Aminoglutaric acid; Glutaminic acid
CAS number	56-86-0
Molecular formula	C5H9NO4
Molecular Structure	

Overview	Reference
L-glutamic acid is a major amino acid naturally occurring in living organisms. It acts as neurotransmitters in the brain. In its pure form, it has a powder state. L-glutamic acid is a permitted food additive (E 260). It is also used as plant growth enhancer of specified plant and in pesticide products.). L-glutamic acid is classified *generally recognized as safe (GRAS)* for human consumption.	US EPA, 2004 FDA, 2013

Human Health Toxicity Summary	Reference
Carcinogenicity Not classified as a carcinogenic substance.	ECHA, 2013 IARC, 2013
Mutagenicity/Genotoxicity Not classified as mutagenic.	ECHA, 2013
Reproductive Toxicity Not classified as toxic to reproduction.	ECHA, 2013
Developmental Toxicity/Teratogenicity Not classified as developmental toxicant.	ECHA, 2013
Endocrine Disruption Not listed as an endocrine disruptor	EC, 2000a
Acute Toxicity (oral, dermal, inhalation) Not classified as acute toxic via oral or dermal route. Data lacking regarding acute toxicity via inhalation.	ECHA, 2013
Chronic/repeat dose toxicity (oral, dermal, inhalation) Not classified as a specific target organ toxicant (based on subchronic studies on rats and dogs with read-across substances administered via oral route).	ECHA, 2013
Sensitisation of the skin or respiratory system Not classified as a skin sensitiser. Data lacking regarding respiratory sensitisation.	ECHA, 2013
Corrosion (irreversible and reversible)/irritation of the skin or eye Not classified as corrosive or irritant to the skin or the eye.	ECHA, 2013

Physical Hazards	Reference
Flammable Potential Not classified as flammable	ECHA, 2013

Explosive Potential Not classified as explosive	ECHA, 2013

Toxicity Values	Value	Reference
Human Toxicity Data		
Acute Toxicity		
	No data found (NDF)	
	NDF	
High Chronic/Repeat dose Toxicity		
LOAEC	NDF	
LOAEL	NDF	
Animal Toxicity Data		
Acute Toxicity		
LD_{50}		
Rat, oral	5110 mg/kg	ECHA, 2013
Mouse, oral	NDF	
Rabbit, oral	NDF	
Rat, dermal	> 2000 mg/kg	ECHA, 2013
Rabbit, dermal	NDF	
Mouse, dermal	NDF	
LOAEL	NDF	
LOAEC	NDF	
LC_{50}		
Rat	NDF	
High Chronic/Repeat dose Toxicity		
LOAEL	NDF	
LOAEC	NDF	
NOAEL (dog, oral)	1500 mg/kg/day (read-across: monosodium glutamate 90 day study)	ECHA, 2013
NOAEL (rat, oral)	5100-5300 mg/kg/day (male); 4800-4900 mg/kg/day (female) (read-across: monosodium glutamate 90 day study)	ECHA, 2013

Footnotes:
LD_{50} – lethal dose for 50% of experimental population
LC_{50} – lethal air concentration for 50% of experimental population
LOAEL – Lowest Observed Adverse Effect Level
LOAEC – Lowest Observed Adverse Effect Concentration
NOAEL – No Observed Adverse Effect Level

Human Health Toxicity Ranking*		
	Hazard data	**Comment**
Hazard Band 4		
Carcinogenicity	No	
Mutagenicity/Genotoxicity	No	
Reproductive Toxicity	No	
Developmental Toxicity/ Teratogenicity	No	
Endocrine Disruption[1]	No	
Hazard Band 3		
Acute Toxicity (oral, dermal or inhalation) Very Toxic/Toxic • oral LD_{50} ≤ 300 mg/kg[2] • dermal LD_{50} ≤ 1000 mg/kg • inhalation LC_{50} ≤ 10 mg/L^3 (or mg/m^3) (vapour)	No	
Possible carcinogenicity, mutagenicity, reproductive or High Chronic/repeat dose toxicity • oral LOAEL ≤ 10 mg/kg/d[3]; • dermal LOAEL ≤ 2 0 mg/kg/d; • inhalation LOAEC (6 h/d) ≤ 50 ppm/d for gases, ≤ 0.2 mg/L/d for vapours or ≤ 0.02 mg/L/d for dust/mists/fumes[3]	No	
Corrosive (irreversible damage)	No	
Respiratory sensitiser	NDF	
Hazard Band 2		
Harmful chronic/repeat dose toxicity • oral LOAEL > 10 mg/kg and ≤ 100 mg/kg/d • dermal LOAEL > 20 mg/kg/d and ≤ 200 mg/kg/d • inhalation (6-h/d) LOAEC > 50 mg/L ≤ 250 mg/L/d for gases, > 0.2 mg/L ≤ 1 .0 mg/L/d for vapours or > 0.02 mg/L ≤ 0.2 mg/L/d for dust/mists/fumes[3]	No	
Skin Sensitiser	No	
Hazard Band 1		
Acute Toxicity-Harmful • oral LD_{50} > 300 mg/kg ≤ 2000 mg/kg • dermal LD_{50} >1 000 mg/kg ≤ 2000 mg/kg; • inhalation LC_{50} (6 h/d) > 10 mg/L ≤ 20 mg/L for vapours)[3]	No	
Irritant (reversible damage)	No	
Hazard Band 0 **All indicators outside criteria listed in Hazards 1-4**		
Physical Hazards		
Flammable potential	No	
Explosive potential	No	
Hazard Evaluation (highest band) not including physical hazards	Hazard Band 0	
Uncertainty analysis /data confidence	12/13	**92 %**

* Based on IMAP Framework [NICNAS (2013) Inventory Multi-tiered Assessment and Prioritisation (IMAP) Framework. National Industrial Chemicals Notification and Assessment Scheme. Department of Health and Aging, Canberra].

"[1]Based on list of endocrine disrupting chemicals from the European Commission's Endocrine Disrupters website.

[2]milligrams per kilogram body mass(mg/kg) or milligrams per kilogram body mas per day (mg/kg/d)

[3] Based on GHS cut-offs for hazard classification. For chronic/repeat dose toxicity, GHS cut-offs are provided as guidance values (i.e. the dose/concentration at or below which significant health effects are observed"). (p 18, NICNAS 2013).

Human Health Guidelines		
Media	**Concentration (mg/m^3; mg/L; mg/kg)**	**Reference**
Occupational Exposure Limits	No occupational limits established	EC, 2000b
Air (OEL)	NDF	
8-h TWA	NDF	
STEL	NDF	
Peak Limitation	NDF	
Environmental Exposure		
Air, ambient	NDF	
Air, indoor	NDF	
Water, potable	NDF	ADWG, 2011
Water, recreational	NDF	NEPM, 1999 - amended
Soil, residential	NDF	NEPM, 1999 - amended
Soil, commercial/industrial	NDF	NEPM, 1999 - amended

Footnotes:

OEL = Occupational Exposure Limit

TWA= 8 h Time-Weighted Average

STEL = (15 min) Short-term Exposure Limit

NDF - No data found within the limits of the search strategy.

Qualifying Summary Comments

L-glutamic acid has a low hazard profile to human health. It is not classified as a hazardous substance. Exposure of humans to L-glutamic acid mainly occurs through food intake and no occupational limits were found (within the limits of the search strategy). L-glutamic acid is deemed to be safe for human consumption and risk to humans from the use of L-glutamic acid as pesticides active ingredients are not expected.

References and Notes

Australian Drinking Water Guidelines (ADWG, 2011). National Health and Medical Research Council. Available from http://www.nhmrc.gov.au/_files_nhmrc/publications/attachments/eh52_aust_drinking_water_guidelines.pdf

European Chemicals Agency (ECHA 2013). Registered Chemical Substances Search. Available at http://echa.europa.eu/web/guest/information-on-chemicals/registered-substances. [Accessed 2 October 2013] (ECHA 2013)

European Commission (EC, 2000a) Towards the establishment of a priority list of substances for further evaluation of their role in endocrine disruption, preparation of a candidate list of substances as a basis for priority setting, Final Report (Incorporating corrigenda to final report dated 21 June 2000).

European Commission (EC, 2000b) Joint Research Center. European Commission (EC) Joint Research Centre (JRC) Institute for Health and Consumer Protection - European Chemical Substances Information. IUCLID Data Sheet. Available at http://esis.jrc.ec.europa.eu/doc/IUCLID/data_sheets/56860.pdf.

Food and Drug Administration (FDA, 2013) Generally Recognised As Safe (GRAS) Substances Database. Available at http://www.fda.gov/food/ingredientspackaginglabeling/gras/scogs/ucm260455.htm. [Accessed 9 October 2013].

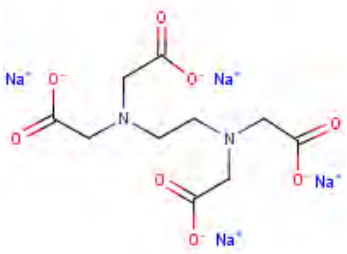
International Agency for Research on Cancer (IARC, 2013) Agents classified by IARC Monographs, Volumes 1-108. Available at http://monographs.iarc.fr/ENG/Classification/ClassificationsGroupOrder.pdf.

National Environment Protection (Assessment of Site Contamination) Measure 1999 (NEPM 1999 - amended).

United States Environmental Protection Agency (US EPA, 2004). G*amma aminobutyric acid (GABA) & L-Glutamic acid (030802, 374350) Fact Sheet.* Available at http://www.epa.gov/opp00001/chem_search/reg_actions/registration/fs_G-132_19-Oct-04.pdf.

Created by:	JC	Date: 9/10/2013
Reviewed and edited by:	JF	Date 8/11/2013

Project number: 127666004
Project name: Hydraulic Stimulation Chemicals Assessment, Southwest Queensland
Client name: Santos Ltd

Name	Tetrasodium ethylenediaminetetraacetate
Synonyms	Ethylenediaminetetraacetic acid tetrasodium salt Acetic acid, (ethylenedinitrilo)tetra-, tetrasodium salt N,N'-Ethylenediaminediacetic acid tetrasodium salt EDTA Tetrasodium
CAS number	64-02-8
Molecular formula	$C_{10}H_{12}N_2O_8Na_4$ / $((NaOOCCH_2)_2NCH_2)_2$
Molecular Structure	

Overview	References
Physical properties Tetrasodium EDTA is white powder with solubility of 500g/L at (20°C). Reacts with most divalent and trivalent metallic ions forming soluble metal chelates. Tetrasodium EDTA is highly reactive with oxidizing agents and acids, reactive with metals and slightly reactive to reactive with reducing agents and organic materials. It is highly corrosive in the presence of copper, corrosive in the presence of aluminium and zinc, slightly corrosive in the presence of steel and non-corrosive in the presence of glass. Tetrasodium EDTA has a melting point of > 300°C.	(HSDB, 2013; MSDS 2013; ECHA 2013)
Uses The sodium salt of EDTA is used as an antidote for metal poisoning, an anticoagulant, and an ingredient in a variety of detergents. By forming stable water soluble complexes with multivalent metal ions, chelating agents prevent undesired interaction by blocking normal reactivity of metal ions, such as in the case of the removal of corneal calcium deposits. Other applications include soap, textile dyeing, water softening, metal finishing and plating, pulp and paper, enzyme deactivation, photo chemistry, and bacteriocides.	(HSDB, 2013; ECHA 2013)

Human Health Toxicity Summary	Reference
Carcinogenicity Not classified as a carcinogen on the ECHA Registered Substances Database.	(IARC, 2010)
The International Agency for Research on Cancer (IARC) has not evaluated the evidence for the carcinogenicity of Tetrasodium EDTA.	(ECHA, 2013)
A lifetime (103 weeks) study in Fischer 344 rats was conducted with trisodium EDTA via the oral	

(feed) route. The chemical was administered to 50 males and 50 females at low (248 mg/kg) and high (495 mg/kg) concentrations, for 103 weeks. Matched-control groups were composed of 20 males and 20 females. Animals were analysed for mortality, clinical signs, histopathological as well as gross pathological changes. The study summary reports that no tumour appeared in a statistically significant positive trend in either dose groups or sexes. A variety of endocrine tumours were found, some types occurring only in treated animals. However, these tumours occurred in low numbers and have frequently been seen in untreated animals in other studies. Thus the study authors judged these to be "probably unrelated to treatment".	
Mutagenicity/Genotoxicity Not classified as a mutagen or genotoxic.	(ECHA, 2013)
Reproductive Toxicity Not classified as reproductive toxicant.	(ECHA, 2013)
Developmental Toxicity/Teratogenicity Not classified as developmental toxicant.	(ECHA, 2013)
Endocrine Disruption Not listed as an endocrine disruptor by European Commission.	(EC, 2000)
Neurotoxicity Not classified as toxic to the nervous system.	(ECHA, 2013)
Acute Toxicity (oral, dermal, inhalation) Tetrasodium EDTA has been classified as oral acute toxic 4 H205, harmful if swallowed. Studies on male and female rats show that the LD_{50} for Tetrasodium EDTA is >1780<2000 mg/kg bw. Tetrasodium EDTA has not been classified as acute dermal toxic or inhalation acute toxic.	(ECHA, 2013, ICPS, 2006)
Chronic/repeat dose toxicity (oral, dermal, inhalation) Systemic toxicity/Organ effects A 13 weeks feeding study on rats was performed using 3 different dose groups (500, 2500, 5000 mg/kg) and one control group. After 13 weeks 50% of the animals of each group were sacrificed and tissues examined for gross and histopathologic changes. The remaining animals were placed on control diet for 4 weeks. Thereafter animals were sacrificed and examined for gross and histopathologic changes. No treatment related histopatholigical changes were noted. Decreased weight gain probably due to diarrhea occurred at 2500 and 5000 mg/kg. The clear no observed effect level was 500 mg/kg.	
Sensitisation of the skin or respiratory system Not classified as a respiratory or skin sensitiser by ECHA.	ECHA, 2013
Corrosion (irreversible)/irritation (reversible) effects on the skin or eye Tetrasodium EDTA has been classified as causing serious eye damage, H318 and it is corrosive to eyes on contact. Information from the MSDS indicate that Tetrasodium EDTA is irritating to mucous membranes and upper respiratory tract. Liquid or spray mist may produce tissue damage particularly on mucous membranes of eyes, mouth and respiratory tract. Skin contact may produce burns. Inhalation of the spray mist may produce severe irritation of respiratory tract, characterized by coughing, choking, or shortness of breath. Inflammation of the eye is characterized by redness, watering, and itching. Skin inflammation is characterized by itching, scaling, reddening, or, occasionally, blistering.	(ECHA, 2013; MSDS 2013)

Project number: 127666004
Project name: Hydraulic Stimulation Chemicals Assessment, Southwest Queensland
Client name: Santos Ltd

Physical Hazards	Reference
Flammable Potential Tetrasodium EDTA is not ignited easily but above 350 °C, vapours (substance decomposition) are flammable. ECHA has classified it as not a highly flammable solid but ICPS has indicated that it is combustible and gives off irritating or toxic fumes (or gases) in a fire. Not Classified as Flammable by ECHA.	(ECHA, 2013; ICPS, 2006
Explosive Potential Not classified as an explosive by ECHA but ICPS states that finely dispersed particles can form explosive mixtures in air.	(ECHA, 2013; ICPS 2006)

Toxicity Values	Value	Reference
Human Toxicity Data		
High Chronic/Repeat Dose Toxicity		
LOAEC	NDF	
LOAEL	NDF	
Animal Toxicity Data		
Acute Toxicity		
LD_{50}		
Rat, oral	>1780<2000 mg/kg bw	(ECHA, 2013)
Rat, oral	>2000 mg/kg bw	(HSDB, 2013)
Rat, oral	3030 mg/kg bw	(MSDS, 2013)
Rat, ip	4000 mg/kg bw	(HSDB, 2013)
Mouse, ip	330 mg/kg	(HSDB, 2013)
Rabbit, oral	NDF	
Rat, dermal	NDF	
Rabbit, dermal	NDF	
Mouse, dermal	NDF	
LC_{50}		
Rat	NDF	
High Chronic/Repeat Dose Toxicity		
LOAEL, Rat	1210-1780 mg/kg bw	ECHA, 2013;
LOAEC, Rat	30 mg/m^3 air 6 hours per day for 5 days	For Disodium ethylene diamine tetraacetic acid (similar structure and formula)ECHA, 2013
NOAEL, Rat	500 mg/kg	ECHA, 2013

Footnotes:
LD_{50} – lethal dose for 50% of experimental population
LC_{50} – lethal air concentration for 50% of experimental population
LOAEL – Lowest Observed Adverse Effect Level
LOAEC – Lowest Observed Adverse Effect Concentration
NOAEL- NO Observed Adverse Effect Level

Project number: 127666004
Project name: Hydraulic Stimulation Chemicals Assessment, Southwest Queensland
Client name: Santos Ltd

Human Health Toxicity Ranking*		
	Hazard data	**Comment**
Hazard Band 4		
Carcinogenicity (IARC Group 1 or 2A)	No	No found on the IARC carcinogen classification lists.(IARC 2010)
Mutagenicity/Genotoxicity (GHS Category 1A and 1B)	No	
Reproductive Toxicity/Developmental toxicity (GHS Category 1, 1A and 1B)	No	
Endocrine Disruption[1]	No	Not Classified by European Commission (EC 2000)
Hazard Band 3		
Carcinogenicity (IARC Group 2B)	No	No found on the IARC carcinogen classification lists.(IARC 2010)
Mutagenicity/Genotoxicity (GHS Category 2)	No	
Reproductive Toxicity/Developmental toxicity (GHS Category 2)	No	
Acute Toxicity (oral, dermal or inhalation) Very Toxic/Toxic • oral LD_{50} ≤ 300 mg/kg[3] • dermal LD_{50} ≤ 1000 mg/kg inhalation LC_{50} ≤ 10 mg/L[4] (or mg/m^3) (vapour)	No	
Possible carcinogenicity, mutagenicity, reproductive or High Chronic/repeat dose toxicity • oral LOAEL ≤ 10 mg/kg/d[3]; • dermal LOAEL ≤ 2 0 mg/kg/d; • inhalation LOAEC (6 h/d) ≤ 50 ppm/d for gases, ≤ 0.2 mg/L/d for vapours or ≤ 0.02 mg/L/d for dust/mists/fumes[4]	No	
Corrosive (irreversible effect)	Yes	
Respiratory sensitiser	No	
Hazard Band 2		
Harmful chronic/repeat dose toxicity • oral LOAEL > 10 mg/kg and ≤ 100 mg/kg/d • dermal LOAEL > 20 mg/kg/d and ≤ 200 mg/kg/d • inhalation (6-h/d) LOAEC > 50 mg/L ≤ 250 mg/L/d for gases, > 0.2 mg/L ≤ 1 .0 mg/L/d for vapours or > 0.02 mg/L ≤ 0.2 mg/L/d for dust/mists/fumes[4]	No	LOAEL 1210-1780 mg/kg bw
Skin Sensitiser	No	
Hazard Band 1		
Acute Toxicity-Harmful • oral LD_{50} > 300 mg/kg ≤ 2000 mg/kg • dermal LD_{50} >1 000 mg/kg ≤ 2000 mg/kg; • inhalation LC_{50} (6 h/d) > 10 mg/L ≤ 20 mg/L for vapours)[4]	Yes,	LD_{50} >1780<2000 mg/kg bw
Irritant (reversible effect)	Yes, see Band 3	
Hazard Band 0 **All indicators outside criteria listed in Hazards 1-4**	NA	

Physical Hazards		
Flammable potential	Potentially, above 350 °C, vapours are flammable.	(IPCS 2006), Not Classified as Flammable by ECHA, 2013
Explosive potential	Potentially, Finely dispersed particles can form explosive mixtures in air.	ICPS (2006) Not Classified as Explosive by ECHA, 2013
Hazard Evaluation (highest band) not including physical hazards	Band 3	
Uncertainty analysis /data confidence (out of 12 parameters)	12/12	

* Based on IMAP Framework [NICNAS (2013) Inventory Multi-tiered Assessment and Prioritisation (IMAP) Framework. National Industrial Chemicals Notification and Assessment Scheme. Department of Health and Aging, Canberra].

"[1]Based on list of endocrine disrupting chemicals from the European Commission's Endocrine Disrupters website.

[2] Neurotoxicity based on REACH assessments.

[3] milligrams per kilogram body mass(mg/kg) or milligrams per kilogram body mas per day (mg/kg/d)

[4] Based on GHS cut-offs for hazard classification. For chronic/repeat dose toxicity, GHS cut-offs are provided as guidance values (i.e. the dose/concentration at or below which significant health effects are observed"). (p 18, NICNAS 2013).

Human Health Guidelines		
Media	**Concentration (mg/m^3; mg/L; mg/kg)**	**Reference**
Occupational Exposure Limits		
Air (OEL)	NDF	
8-h TWA	NDF	
STEL	NDF	
Peak Limitation	NDF	
DNEL	25 mg/kg bw/day	ECHA 2013
Environmental Exposure		
Air, ambient	NDF	
Air, indoor	NDF	
Water, potable	NDF	
Water, recreational	NDF	
Soil, residential	NDF	
Soil, commercial/industrial	NDF	

Footnotes:

OEL = Occupational Exposure Limit

TWA= 8 h Time-Weighted Average

STEL = (15 min) Short-term Exposure Limit

Qualifying Summary Comments

Tetrasodium EDTA is a hazardous substance due to its corrosive effects to eyes and irritant effects to skin. It is categorized as hazard band 3.

References and Notes

NDF - No data found within the limits of the search strategy.

European Chemicals Agency (ECHA), 2013. Summary of Classification a labelling for CAS Number 14807-96-6 Available at: http://clp-inventory.echa.europa.eu/SummaryOfClassAndLabelling.aspx?SubstanceID=55002&HarmOnly=no?DisclaimerAgr=Agree&Index=14807-96-6&ExecuteSearch=true&fc=true&lang=en [Accessed 28 November 2013].

European Commission (EC), 2000.Towards the establishment of a priority list of substances for further evaluation of their role in endocrine disruption, preparation of a candidate list of substances as a basis for priority setting, Final Report (Incorporating corrigenda to final report dated 21 June 2000).

Hazardous Substances Databank (HSDB), 2013. Toxicology Data Network, U.S. National Library of Medicine Available at: http://toxnet.nlm.nih.gov/ [Accessed 29 November 2013].

International Programme on Chemical Safety and the Commission of the European Communities (ICPS),2006. *Tetrasodium ethylenediaminetetraacetate: Summary*. October 2006. From http://www.inchem.org/documents/icsc/icsc/eics1688.htm [accessed on 28 November 2013].

International Agency for Research on Cancer (IARC), 16 June 2013. Agents Classified by the *IARC Monographs*, Volumes 1–108. Available at: http://monographs.iarc.fr/ENG/Classification/index.php. [Accessed 28 November 2013]

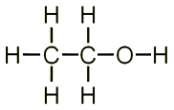
Sciencelab.com, Inc. (MSDS), 2013. *Material Safety Data Sheet: Tetrasodium ethylenediaminetetraacetate*. From http://www.sciencelab.com/msds.php?msdsId=9923981 accessed on 28 November 2011.

Created by:	AES	Date 28/11/2013
Reviewed by:	JF	Date 11/12/2013

Glossary

ATSDR – US Agency for Toxic Substances and Disease Registry
ECOTOX – ECOTOXicology database
EPI Suite – Estimation Program Interface Suite
ESIS – European chemical Substances Information System
SDS – Safety Data Sheet
HSDB – Hazardous Substances Databank
IRIS – Integrated Risk Information Service
IPCS – International Program on Chemical Safety
NICNAS – National Industrial Chemicals Notification and Assessment Scheme
RAIS – Risk Assessment Information System

Project number: 127666004
Project name: Hydraulic Stimulation Chemicals Assessment, Southwest Queensland
Client name: Santos Ltd

Name	Ethanol
Synonyms	Ethyl Alcohol, ethyl hydrate, ethyl hydroxide, alcohol, bioethanol, grain alcohol, aethanol, aethyl alcohol
CAS number	64-17-5
Molecular formula	C_2H_5OH
Molecular Structure	

Overview	References
The melting point for ethanol is -114 °C, the boiling point is 78.3 °C and the flashpoint is 14 °C. Ethanol is fully water miscible at ambient temperatures.	OECD (2004)
Ethanol use falls into four main categories. These include as a solvent; in the manufacture of chemicals; as a fuel additive; and for the production of alcoholic beverages. Solvent use is mainly in paint and ink manufacture and in pharmaceutical production. Ethanol is widely used in consumer products, mainly cosmetics, but also detergents, winter deicing and cleaning products, including detergents. Ethanol is also used as an additive in petroleum fuels to produce "gasohol".	
There is probably greater exposure to ethanol than to any other solvent with the exception of water, with the general population exposed to ethanol primarily through the consumption of alcoholic beverages containing this chemical.	HSDB (2012)
Ethanol is not accumulated in the body and is readily absorbed by the oral and inhalation routes and subsequently metabolised and excreted in humans.	OECD (2004)
Ethanol is a classified substance according to the Global Harmonised System (GHS) classification.	ECHA (2014)

Human Health Toxicity Summary	Reference
Carcinogenicity Ethanol (in alcoholic beverages) is classified as a Group 1 carcinogen by IARC.	IARC (2011)
Mutagenicity/Genotoxicity The studies provided on ECHA (2014) report that ethanol, when administered at low concentrations, is not reported to be genotoxic or mutagenic, however, when concentrations in studies are well in excess of guideline concentrations, mutagenic and genotoxic effects are observed. This dose-dependent effect requires consideration in view of the extensive use of ethanol in the community and that many exposures are well below concentrations used to generate adverse outcomes.	ECHA (2014)
Reproductive Toxicity Numerous studies have been reported on the effects of ethanol on reproductive toxicity. Studies have reported a threshold for effects in those cases where results have reported adverse outcomes.	ECHA (2014)

In one study in female rats administered 2.5% or 5% ethanol in a liquid diet for periods of 50 to 55 days reported suppression of ovarian function at 5% ethanol manifested by absence of oestrous cycles, a delay in vaginal opening, the absence of several generations of corpora lutea, inhibition of growth of the uteri and vaginae, and a reduction of ovarian and uterine weights. A NOAEL was established of approximately 8 g/kg/d.	
Developmental Toxicity/Teratogenicity Numerous studies are available on the effects of ethanol exposure on developmental toxicity. These studies have concluded that ethanol toxicity is only observed at very high doses. In one study, pregnant mice were fed a liquid diet containing 17%, 25%, or 30% ethanol-derived calories from day 4 to day 9 of gestation. Ethanol treatment did not induce any increase in mortality or change in weight gain with respect to controls but a dose-dependent increase in fetal resoprtions and congenital malformations was observed in groups treated with 25% and 30% ethanol-derived calorie diets. A LOAEL for maternal toxicity and teratogenicity was determined as 25% ethanol derived calories in feed. In humans, ethanol is a developmental toxin, and various effects have been associated with ethanol intake. Excessive consumption of alcoholic beverages during pregnancy is associated with the development of a syndrome of physical and mental manifestations in the offspring - the fetal alcohol syndrome. Ethanol at high blood levels affects the structure of the reproductive organs and causes significant reductions in fetal body weight, increased resorptions and teratogenic effects in a number of species.	ECHA (2014) IARC (1998)
Endocrine Disruption Not listed as an endocrine disruptor by European Commission.	BKH (2000)
Neurotoxicity In humans, alcohol may also cause defects in the central nervous system.	IARC (1998)
Acute Toxicity (oral, dermal, inhalation) **Oral** Five female and five male rats (per dose) were orally administered 8 200 mg/kg, 9 840 mg/kg, 11 480 mg/kg and 16 070 mg/kg of ethanol as 5% H_2O in 95% ethanol and observed for a 14 day period following administration. The study determined an LD_{50} of 10 470 mg/kg. A range of other oral toxicity studies have reported LD_{50} values ranging from 8 350 -15 010 mg/kg. Age dependent variability in responses in rat studies has also been observed and reported reflecting differing sensitivities to oral intakes with the following data reported: • LD_{50} (14 day old animals): 6 160mg/kg • LD_{50} (young adults): 17 750mg/kg • LD_{50} (old adults): 11 500mg/kg **Dermal** NDF. **Inhalation** Ten male and ten female rats per dose were exposed to a heated vapour of ethanol for a period of 4 h at concentrations of 62.0 mg/L, 79.1 mg/L, 93.4 mg/L, 115.4 mg/L and 155.0 mg/L and observed for a period of 14 days following administration. The following acute inhalation LC_{50}'s were determined: • Male rat: 116.9 mg/L air (4 h) • Female rat: 133.8 mg/L air (4 h) • Male/female rat: 124.7 mg/L air (4 h)	ECHA (2014)

Another study in ten female and ten male rats exposed to a concentration of 84.2 mg/L, 69.2 mg/L, 58.8 mg/L,53.2 mg/L, 48.6 mg/L and 16.5 mg/L of heated ethanol vapour over a duration of 6 h. The rats were then observed for a period of 14 days. The following acute inhalation LC_{50}'s were determined: • Male/female rat: 52.9 mg/L air (6 h) • Male rat: 51.3 mg/L air (6 h) • Female rat: 54.8 mg/L air (6 h)	
Chronic/repeat dose toxicity (oral, dermal, inhalation) **Oral** In a 90 day sub-chronic repeat dose study, male rats were given a liquid diet containing ethanol at a level of 1% w/v, 2% w/v, 3% w/v, 4% w/v, 5% w/v and 10% w/v. The only significant effect seen in the 1% and 2% dose groups were centrilobular steatosis (a fatty change). This is often associated with ethanol consumption but in its mild form is not considered to be a pathological condition. There was also evidence from glucose dosed animals, used as calorific controls which also showed the effect, that this finding is actually related to the caloric content of ethanol rather than being substance specific. It is not therefore considered an adverse effect. On this basis, the no effect level from this study was 2%, which was approximately equivalent to a dose of 3 900 mg/kg/day. **Dermal** NDF. **Inhalation** In a study to examine the repeat dose toxicity of ethanol, rats were exposed to a single dose of ethanol vapour at 20 mg/L for up to 26 days. Intermediate exposure groups were used to allow changes in clinical chemistry, histopathology and blood ethanol concentrations to be followed with time. The study found a number of transient effects (clinical signs, e.g. lethargy and ataxia, mild hepatic vacuolisation and changes to clinical chemistry parameters) but in animals exposed for the full 26 days, the only significant effect noted was an increase in plasma GPT levels, which, in isolation, was not regarded as biologically significant. It was noticeable that the blood ethanol levels in the animals exposed for 26 days were much lower than those exposed for shorter periods indicating pronounced induction of metabolic tolerance. The NOAEC for the study was determined as >20 mg/L air for male rats.	ECHA (2014)
Sensitisation of the skin or respiratory system **Skin** A study was carried out to evaluate the effect of vehicles (ethanol or diethyl phthalate) for use in the mouse local lymph node assay (LLNA), and their influence on the skin sensitisation potential of four test fragrance materials. Groups of 4 mice were treated with each test fragrance, at one of five concentrations, either in ethanol or diethyl phthalate (and 1:3 or 3:1 mixtures of the two), or with ethanol (or diethyl phthalate) alone. Although there were no true control data for comparison with the ethanol-alone treated animals, the level of induced T-lymphocyte proliferation was low for ethanol when compared with that for fragrance materials known to be mild to moderate skin sensitizers, and comparable to that for the other (negative) control vehicle tested, diethyl phthalate. The review in ECHA (2014) concluded that ethanol was not sensitising to skin. An ear swelling study was undertaken in mice to examine the skin sensitising potential of ethanol. Ethanol was applied twice on the right ear after an induction procedure involving two scapular subcutaneous injection of adjuvant and multiple topical ethanol applications to the abdomen over a period of 14 days. The degree of contact hypersensitivity is deduced from ear swelling measured 24 hours and 48 hours after application. Ethanol was found not to cause any statistical increase in ear swelling, in contrast to 3 positive controls which all caused a statistically significant increase. **Respiratory** NDF.	ECHA (2014)

Corrosion (irreversible)/irritation (reversible) effects on the skin or eye **Skin:** In a guideline and Good Laboratory Practices (GLP) skin irritation study, 0.2 mL of ethanol was applied to an intact skin test site on each of five rabbits for 24 h. After 24 h exposure the test sites were exposed and wiped. The sites were examined for erythema and edema at 1 day, 2 days, 3 days, 4 days, 5 days and 7 days. Alcohol was found to produce no significant irritation and was therefore concluded to be non-irritating to rabbit skin. Closed patch 24 h exposure to 0.2 mL aliquot of undiluted ethanol produced mild erythema responses at the intact skin site in four of five rabbits. Mild erythema was observed in four of five animals that persisted until the end of the observation period on day 7. Based on the observations it was concluded that alcohol, as tested, was a mild skin irritant but that the reaction is not sufficient to warrant classification. A range of studies including those on humans have supported the position that ethanol is a mild skin irritant. **Eye** In a reference handbook of peer reviewed, guideline GLP eye irritation study results in rabbits, ethanol was found to cause reversible eye irritation (Category 2 under EU GHS). This has been supported by other OECD rabbit studies with a US study supporting a position of ethanol's ECHA classification as an eye irritant.	ECHA (2014)

Physical Hazards	Reference
Flammable Potential Classified as highly flammable.	SafeWork (2005)
Explosive Potential NDF.	

Toxicity Values	Value	Reference
Human Toxicity Data		
High Chronic/Repeat Dose Toxicity		
LOAEC	NDF	
LOAEL	NDF	
Animal Toxicity Data		
Acute Toxicity		
LD_{50}		
Rat, oral	10 470 mg/kg 14 500 mg/kg – 15 010 mg/kg 11 850 mg/kg 9 920 mg/kg 6 160 mg/kg (14 days old) 17 750 mg/kg (young adults) 11 500 mg/kg (old adults)	ECHA (2014)
Mouse, oral	8 350 mg/kg	ECHA (2014)
Rat, dermal	NDF	
Rabbit, dermal 24 h	NDF	
Mouse, dermal	NDF	
LC_{50}		
Rat (inhalation)	Male rat: 116.9 mg/L air (4 h) Female rat: 133.8 mg/L air (4 h) Male/female rat: 124.7 mg/L air (4 h) Male/female rat: 52.9 mg/L air (6 h) Male rat: 51.3 mg/L air (6 h) Female rat: 54.8 mg/L air (6 h)	ECHA (2014)
High Chronic/Repeat Dose Toxicity		
LOAEL	3.16 g/kg 4 400 mg/kg 9 700 mg/kg	Oral repeat dose (ECHA, 2014) Female rats – repeat dose (ECHA, 2014) Male mice – repeat dose (ECHA, 2014)
LOAEC	NDF	
NOAEC	>20 mg/L air	Male rats (ECHA, 2014)
NOAEL	NOAEL would appear to be close to 5% ethanol diet, which is estimated to be ~14 g/kg/d ~8 g/kg/d 1.73 g/kg	For persistent effects relating to reproductive toxicity. (ECHA, 2014) Reproductive toxicity (ECHA, 2014) Oral repeat dose (ECHA, 2014)

Footnotes:
LD_{50} – lethal dose for 50% of experimental population
LC_{50} – lethal air concentration for 50% of experimental population
LOAEL – Lowest Observed Adverse Effect Level
LOAEC – Lowest Observed Adverse Effect Concentration
NOAEL – No Observed Adverse Effect Level
NOAEC – No Observed Adverse Effect Concentration
NDF – no data found within the limits of the search strategy
Conclusive data: means that the study itself was conclusive in its reported finding, but was not sufficient for classifying the material according to ECHA guidelines.

Human Health Toxicity Ranking*		
	Hazard data	**Comment**
Hazard Band 4		
Carcinogenicity (IARC Group 1 or 2A)	Yes	Group 1 (IARC, 2011)
Mutagenicity/Genotoxicity (GHS Category 1A and 1B)	No	ECHA (2014)
Reproductive Toxicity/Developmental toxicity (GHS Category 1, 1A and 1B)	Yes	'Conclusive but not sufficient for classification' in ECHA (2014) under the Global Harmonised System. However, intake of alcohol in pregnant women is associated with fetal alcohol syndrome and is a known teratogen (IARC ,1998)
Endocrine Disruption[1]	No	BKH (2000)
Hazard Band 3		
Carcinogenicity (IARC Group 2B)	No	IARC (2011)
Mutagenicity/Genotoxicity (GHS Category 2)	No	ECHA (2014)
Reproductive Toxicity/Developmental toxicity (GHS Category 2)	No	ECHA (2014)
Acute Toxicity (oral, dermal or inhalation) Very Toxic/Toxic • oral LD_{50} ≤ 300 mg/kg[3] • dermal LD_{50} ≤ 1000 mg/kg • inhalation LC_{50} ≤ 10 mg/L[4] (or mg/m[3]) (vapour)	Oral: No Dermal: NDF Inhalation: No	ECHA (2014)
Possible carcinogenicity, mutagenicity, reproductive or High Chronic/repeat dose toxicity • oral LOAEL ≤ 10 mg/kg/d[3]; • dermal LOAEL ≤ 20 mg/kg/d; • inhalation LOAEC (6 h/d) ≤ 50 ppm/d for gases, ≤ 0.2 mg/L/d for vapours or ≤ 0.02 mg/L/d for dust/mists/fumes[4]	Yes	Based on mutagenic and reproductive toxicity at high doses.(ECHA,2014)
Corrosive (irreversible effect)	No	ECHA (2014)
Respiratory sensitiser	NDF	
Hazard Band 2		
Harmful chronic/repeat dose toxicity • oral LOAEL > 10 mg/kg and ≤ 100 mg/kg/d • dermal LOAEL > 20 mg/kg/d and ≤ 200 mg/kg/d • inhalation (6 h/d) LOAEC > 50 mg/L ≤ 250 mg/L/d for gases, > 0.2 mg/L ≤ 1 .0 mg/L/d for vapours or > 0.02 mg/L ≤ 0.2 mg/L/d for dust/mists/fumes[4]	Oral: No Dermal: NDF Inhalation: NDF	ECHA (2014)
Skin Sensitiser	No	ECHA (2014)
Hazard Band 1		
Acute Toxicity-Harmful • oral LD_{50} > 300 mg/kg ≤ 2,000 mg/kg • dermal LD_{50} >1,000 mg/kg ≤ 2,000 mg/kg;	Oral: No Dermal: NDF Inhalation: No	ECHA (2014)

• inhalation LC_{50} (6 h/d) > 10 mg/L ≤ 20 mg/L for vapours)[4]		
Irritant (reversible effect)	Yes	Eye irritant ≥ 50% (ECHA, 2014)
Hazard Band 0 **All indicators outside criteria listed in Hazards 1-4**	No	
Physical Hazards		
Flammable potential	Yes	Highly flammable (ECHA, 2014)
Explosive potential	NDF	
Hazard Evaluation (highest band) not including physical hazards	Hazard Band 4	
Uncertainty analysis /data confidence (out of 12 parameters)	83%	

* Based on IMAP Framework [NICNAS (2013) Inventory Multi-tiered Assessment and Prioritisation (IMAP) Framework. National Industrial Chemicals Notification and Assessment Scheme. Department of Health and Aging, Canberra].

"[1] Based on list of endocrine disrupting chemicals from the European Commission's Endocrine Disrupters website.

[2] Based on list of neurotoxic chemicals from US Agency for Toxic Substances and Disease Registry (ATSDR).

[3] milligrams per kilogram body mass (mg/kg) or milligrams per kilogram body mass per day (mg/kg/d)

[4] Based on GHS cut-offs for hazard classification. For chronic/repeat dose toxicity, GHS cut-offs are provided as guidance values (i.e. the dose/concentration at or below which significant health effects are observed)". (p 18, NICNAS 2013).

Human Health Guidelines		
Media	**Concentration (mg/m^3; mg/L; mg/kg)**	**Reference**
Occupational Exposure Limits		
Air (OEL)		
8-h TWA	1 880 mg/m^3 (1,000 ppm)	SafeWork (2005)
STEL	NDF	
Peak Limitation	NDF	
Environmental Exposure		
Air, ambient	NDF	
Air, indoor	NDF	
Water, potable	NDF	
Water, recreational	NDF	
Soil, residential	NDF	
Soil, commercial/industrial	NDF	

Footnotes:

OEL = Occupational Exposure Limit

TWA= 8-h Time-Weighted Average

STEL = (15 min) Short-term Exposure Limit

Qualifying Summary Comments

Ethanol is a widely used component of beverages that are consumed by a large majority of the population due to its ability to cause intoxication and subsequent euphoria. There has been extensive historical information of the fermentation of fruits and grains to produce products such as wine, beer and distillate spirits and its basic effects

are well recognised. While moderate use has been reported to demonstrate beneficial effects, high level and long term consumption of ethanol-containing beverages has been linked to systemic and organ toxicity, mutagenic, developmental and reproductive effects and cancer at various sites. Ethanol has therefore been assigned a Human Health Toxicity Ranking of Hazard Band 4 based on it being a Group 1 carcinogen. In addition to this, very mild irritation of the skin and irritation of the eyes was reported in several studies following 24 hours of contact, including those on humans. While consumption is not anticipated, the volatile nature and dermal absorption potential of ethanol may present a concern for occupational settings and those involving large-scale spills and these require suitable management. In view of the developmental toxicity potential of ethanol exposure, a particular focus should be female workers in settings where ethanol exposure may exist. The exposure potential for workers would also be heightened should high percentage strengths of ethanol be used in mixture preparations and in settings where elevated temperatures are present. The degradation characteristics of ethanol preclude sustained environmental persistence and distribution and limit the residual exposure potential of this chemical.

References

BKH 2000, BKH Consulting Engineers. *Towards the establishment of a priority list of substances for further evaluation of their role in endocrine disruption: - preparation of a candidate list of substances as a basis for priority setting*. Final report (incorporating corrigenda to final report dated 21 June 2000), Annex 10: List of 564 substances with their selection criteria. Available at http://ec.europa.eu/environment/archives/docum/pdf/bkh_main.pdf [Accessed 9/01/2014]

OECD (Organisation for Economic Cooperation and Development) 2004, *Ethanol SIDS Initial Assessment Report For SIAM 19*. UNEP Publications. Available at http://www.inchem.org/documents/sids/sids/64175.pdf [Accessed 13/01/2014]

ECHA (European Chemical Agency) 2014, *Ethanol*. 2007 – 2014.

Available at http://apps.echa.europa.eu/registered/data/dossiers/DISS-9d8b4df8-d70a-6e6b-e044-00144f67d249/DISS-9d8b4df8-d70a-6e6b-e044-00144f67d249_DISS-9d8b4df8-d70a-6e6b-e044-00144f67d249.html [Accessed 13/01/2014]

HSDB (Hazardous Substances Data Bank) 2012, *Ethanol*. Last revised 20/12/2012. Available at http://toxnet.nlm.nih.gov/cgi-bin/sis/search/f?./temp/~8FPvlo:1 [Accessed 13/01/2014]

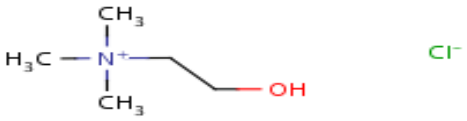
IARC 1998, Monographs Volume 44 Alcohol Drinking Summary of Data Reported and Evaluation. World Health Organisation. Available at http://monographs.iarc.fr/ENG/Monographs/vol44/volume44.pdf [Accessed 15/01/2014]

IARC 2011, International Agency for Research on Cancer (IARC). Available at http://monographs.iarc.fr/ENG/Classification/index.php. [Accessed 09/01/2014].

SafeWork Australia 2005, Hazardous Substance Information System (HSIS): *Ethyl alcohol [Ethanol]*. Available at http://hsis.safeworkaustralia.gov.au/HazardousSubstance/Details?hazardousSubstanceID=1930 [Accessed 09/01/2014]

Created by:	CM	13/01/2014
Reviewed:	LT	16/01/2014 Rev1

Project number: 127666004
Project name: Hydraulic Stimulation Chemicals Assessment, Southwest Queensland
Client name: Santos Ltd

Name	Choline Chloride
Synonyms	Ammonium (2-hydroxyethyl) trimethylchloride, biocoline, choline hydrochloride
CAS number	67-48-1
Molecular formula	$C_5H_{14}NOCl$
Molecular Structure	

Overview	References
Choline chloride is a quaternary ammonium salt which appears as a white crystalline solid and is used as a nutrient in food for human and animal consumption. It is generally recognized as safe (GRAS) when used in accordance with good manufacturing practice. Choline has several major metabolic functions in the body including as a precursor for phosphatidylcholine (a structural component of biological membranes) and acetylcholine (a neurotransmitter involved in memory formation) biosynthesis and as methyl donor. It also plays an important function as a precursor for phospholipids. It is largely derived from membrane lecithin or from dietary intake of choline and lecithin. Humans with choline deficiency, Huntington's Disease, or liver disease may be administered choline chloride therapeutically. Cells will die by apoptosis when deprived of adequate choline. Some free choline is excreted with urine, with the remainder metabolized in the intestines, liver or kidney. Metabolic products include betaine and methyamines.	HSDB (2012:, US FDA (2013); OECD (2004)

Human Health Toxicity Summary	Reference
Carcinogenicity Not classified by IARC A choline-devoid diet has been implicated as cancer-causing in rats.	HSDB (2012); IARC (2013)
Mutagenicity/Genotoxicity No indication of mutagenic or genotoxic effects.	OECD (2004)
Reproductive Toxicity One rat study suggested that prolonged administration of excess choline may prove to be toxic to male reproduction. No adverse fertility effects have been reported from the use of choline chloride as animal feed despite it being used for the purpose for several decades.	HSDB (2012); OECD (2004)

Developmental Toxicity/Teratogenicity No significant developmental toxicity in mice observed at high doses (1250 mg/kg bw/day), with the exception of very high doses (4160 mg/kg bw/day and higher) accompanied with maternal toxicity.	HSDB (2012)
Endocrine Disruption NDF	
Neurotoxicity NDF	
Acute Toxicity (oral, dermal, inhalation) One study reported that single oral doses of 10 g produce no obvious pharmacodynamic response in humans. Another reported a slight hypotensive effect in humans with the same dose. The critical adverse effect from high intake of choline is hypotension. The tolerable upper limit for choline has been set at 3-3.5 g/day. Humans orally dosed with >3000 mg/day choline magnesium trisalicylate did not display acute toxicity effects.	HSDB (2012); OECD (2004)
Chronic/repeat dose toxicity (oral, dermal, inhalation) Humans given choline 9 g/day (week 1) and 12 g/day (week 2) as a chloride or bitartrate, resulted in mild cholinergic toxicity such as lacrimation, blurred vision, anorexia, and diarrhea. Humans fed choline chloride 8 to 20 g/day for 2 to 17 weeks, exhibited fishy body odor and at 250 to 300 mg/kg/day, exhibited lacrimation, anorexia, vomiting, and diarrhea. Humans with and without cirrhosis have been treated with large doses of choline chloride (6 g/day for 4 weeks) with no resultant liver toxicity. 7.5 g of daily choline administered to some patients has resulted in nausea, diarrhea and a small decrease in blood pressure. Sufferers of trimethylaminuria, liver disease, renal disease, depression and Parkinson's disease experienced the highest risk at the upper limit of 3.5 g/day. Long-term memory was affected in another study on young human subjects. When 2 grams of chorine chloride was administered 4 times per day to nine human subjects, choline did not appear to have substantial effects on memory but produced small cognitive effects in some subjects. One rat study was shown to promote short-term memory while inhibiting long-term memory, while another rat study showed no effects on spatial short-term memory. Another rat study indicated improvements in spatial and temporal memory of adult rats exposed to elevated levels of choline chloride perinatally. One rat study concluded that choline diminishes endotoxin shock by preventing macrophage activation. No adverse effects were observed in rats given 500 mg/kg bw/day for 72 weeks.	HSDB (2012)
Sensitisation of the skin or respiratory system NDF for animals Negligible in humans - one case of contact dermatitis reported after dermal exposure to choline chloride (concentration unknown).	OECD (2004)
Corrosion (irreversible and reversible)/irritation of the skin or eye Slightly irritating to rabbit skin and eyes.	OECD (2004)

Physical Hazards	Reference
Flammable Potential When heated to decomposition it emits toxic fumes of chloride, sulfur oxides, and nitrogen oxides.	HSDB (2012)
Explosive Potential NDF	

Toxicity Values	Value	Reference
Human Toxicity Data		
Acute Toxicity		
	200-400 g for a man (estimated).	HSDB (2012)
High Chronic/Repeat Dose Toxicity		
NOAEL	>500 mg/kg bw/day	OECD (2004)
LOAEL	10 g/day	OECD (2004)
Animal Toxicity Data		
Acute Toxicity		
LD_{50}		
Rat, oral	6,640 mg/kg	HSDB (2012)
Rat, oral	3,400 mg/kg	HSDB (2012)
Mouse, oral	3,900 mg/kg	HSDB (2012)
LC_{50}		
	NDF	

Footnotes:
LD_{50} – lethal dose for 50% of experimental population
LC_{50} – lethal air concentration for 50% of experimental population
LOAEL – Lowest Observed Adverse Effect Level
LOAEC – Lowest Observed Adverse Effect Concentration

Human Health Toxicity Ranking*		
	Hazard data	**Comment**
Hazard Band 4		
Carcinogenicity	NDF	Not classified by IARC
Mutagenicity/Genotoxicity	No	OECD (2004)
Reproductive Toxicity	No	OECD (2004)
Developmental Toxicity/ Teratogenicity	No	OECD (2004)
Endocrine Disruption[1]	NDF	
Neurotoxicity[2]	NDF	
Hazard Band 3		
Acute Toxicity (oral, dermal or inhalation) Very Toxic/Toxic • oral LD_{50} ≤ 300 mg/kg[3] • dermal LD_{50} ≤ 1000 mg/kg • inhalation LC_{50} ≤ 10 mg/L[4] (or mg/m[3]) (vapour)	No	HSDB (2012)
High Chronic/repeat dose toxicity • oral LOAEL ≤ 10 mg/kg/d[3]; • dermal LOAEL ≤ 2 0 mg/kg/d; • inhalation LOAEC (6 h/d) ≤ 50 ppm/d for gases, ≤ 0.2 mg/L/d for vapours or ≤ 0.02 mg/L/d for dust/mists/fumes[4]	No	OECD (2004)
Corrosive (irreversible damage)	NDF	
Respiratory sensitiser	NDF	
Hazard Band 2		
Harmful chronic/repeat dose toxicity • oral LOAEL > 10 mg/kg and ≤ 100 mg/kg/d • dermal LOAEL > 20 mg/kg/d and ≤ 200 mg/kg/d • inhalation (6-h/d) LOAEC > 50 mg/L ≤ 250 mg/L/d for gases, > 0.2 mg/L ≤ 1 .0 mg/L/d for vapours or > 0.02 mg/L ≤ 0.2 mg/L/d for dust/mists/fumes[4]	No	OECD (2004)
Skin Sensitiser	No	OECD (2004)
Hazard Band 1		
Acute Toxicity-Harmful • oral LD_{50} > 300 mg/kg ≤ 2000 mg/kg • dermal LD_{50} >1 000 mg/kg ≤ 2000 mg/kg; • inhalation LC_{50} (6 h/d) > 10 mg/L ≤ 20 mg/L for vapours)[4]	No	OECD (2004)
Irritant (reversible damage)	Yes	Slight reaction in rabbits. (OECD, 2004)
Hazard Band 0 **All indicators outside criteria listed in Hazards 1-4**		
Physical Hazards		
Flammable potential	NDF	Exists as solid at STP
Explosive potential	NDF	
Hazard Evaluation (highest band) not including physical hazards	**Band 1**	Limited toxicity with some irritant effect potential
Uncertainty analysis /data confidence	7/14 x 100 =	**50%**

* Based on IMAP Framework [NICNAS (2013) Inventory Multi-tiered Assessment and Prioritisation (IMAP) Framework. National Industrial Chemicals Notification and Assessment Scheme. Department of Health and Aging, Canberra].

[1]Based on list of endocrine disrupting chemicals from the European Commission's Endocrine Disrupters website.

[2] *Based on list of neurotoxic chemicals from US Agency for Toxic Substances and Disease Registry (ATSDR).*
[3] *milligrams per kilogram body mass (mg/kg) or milligrams per kilogram body mass per day (mg/kg/d)*

[4] *Based on GHS cut-offs for hazard classification. For chronic/repeat dose toxicity, GHS cut-offs are provided as guidance values (i.e. the dose/concentration at or below which significant health effects are observed"). (p 18, NICNAS 2013).*

Human Health Guidelines		
Media	**Concentration (mg/m^3; mg/L; mg/kg)**	**Reference**
Occupational Exposure Limits		
Air (OEL)		
8-h TWA	NDF	
STEL	NDF	
Peak Limitation	NDF	
Environmental Exposure		
Air, ambient	NDF	
Air, indoor	NDF	
Water, potable	NDF	NEPM (1999; amended 2013)
Water, recreational	NDF	
Soil, residential	NDF	NEPM (1999; amended 2013)
Soil, commercial/industrial	NDF	NEPM (1999; amended 2013)

Footnotes:

OEL = Occupational Exposure Limit

TWA= 8 h Time-Weighted Average

STEL = (15 min) Short-term Exposure Limit

NDF - No data found within the limits of the search strategy.

Qualifying Summary Comments

Choline (as the chloride) is a dietary intake being found in many foods and exhibits negligible toxicity. It is subsequently assessed as being in Hazard Band 1. This is a consequence of its low acute toxicity and lack of reported genotoxicity, reproductive , developmental and teratogenic effects, however, it may result in minor skin irritation following dermal contact. High (oral) intake in humans has been associated with hypotension and cholinergic effects such as sweating and diarrhoea and fishy body odour.

It is not flammable or explosive and although a solid is usually supplied as a solution. As it degrades readily environmental persistence and distribution is not expected. Its mild irritancy may be readily managed in the occupational setting.

References

IARC (2013) Agents classified by IARC Monographs Volumes 1- 107. Available at http://monographs.iarc.fr/ENG/Classification/ClassificationsGroupOrder.pdf. [Accessed 11/07/2013].

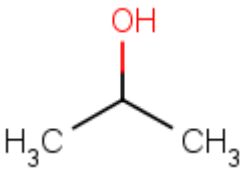
HSDB (2012) Hazardous Substances Data Bank. Toxicology Data Network (TOXNET) Available at http://toxnet.nlm.nih.gov/cgi-bin/sis/htmlgen?HSDB. [Accessed 11 July 2013.]

OECD (2004). Choline Chloride: SIDS initial assessment report. OECD publication. Available at <http://www.inchem.org/documents/sids/sids/67481.pdf>. [Accessed 11/07/2013].

US FDA (2013) Food Additive Status. List. U.S. Food and Drug Administration Available athttp://www.fda.gov/Food/IngredientsPackagingLabeling/FoodAdditivesIngredients/ucm091048.htm, (Accessed 11/07/2013).

Created by:	MER	Date 11/07/2013
Reviewed and edited by:	LT	Date 24 July 2013 Rev0
Updated	JC	Date 21 August 2013

Project number: 127666004
Project name: Hydraulic Stimulation Chemicals Assessment, Southwest Queensland
Client name: Santos Ltd

Name	Propan-2-ol
Synonyms	2-propanol, Isopropanol, n-Propan-2-ol, i-Propyl alcohol, Isopropyl alcohol, IPA, 2-hydroxypropane
CAS number	67-63-0
Molecular formula	C_3H_8O
Molecular Structure	

Overview	References
Propan-2-ol is an organic mono constituent substance, colourless liquid with a slight alcohol odour. It is miscible in water and is chemically stable.	
It is a high production volume chemical which is used as an industrial solvent, a component of industrial and consumer products and as a disinfectant.	Oxford University, 2006
It is used in the medical profession as a disinfectant, solvent, and preservative. It is applied topically as a disinfectant, astringent, hemostatic, and coolant.	Fisher Scientific, 2008
Toxicological data available from HSIS classifies propan-2-ol as highly flammable and an irritant to the eyes and the respiratory system. Exposure standards are 400 ppm TWA, and 500 ppm STEL. ECHA supports the classification that propan-2-ol can cause eye irritation and also identifies that single target organ toxicity (STOT) exposure through inhalation or oral may cause drowsiness or dizziness with no affects to the organ.	HSIS,2009 ECHA,2013

Human Health Toxicity Summary	Reference
Carcinogenicity Not classified on European Chemical Agency (ECHA) database (conclusive data but not sufficient for classification).	ECHA,2013
IARC has evaluated available evidence for the carcinogenicity of Isopropyl alcohol (Propan-2-ol), classification: group 3 - not classifiable as a human carcinogen.	IARC,2013
Mutagenicity/Genotoxicity Not classified on European Chemical Agency (ECHA) database (conclusive data but not sufficient for classification).	
A study similar to OECD Guideline 471 (Bacterial Reverse Mutation Assay) was carried out in vitro on test strains S. typhimurium TA 1535, TA 1537, TA 98 and TA 100, all strains/cell types tested. The dose concentrations were between 100 and 10,000 µg/plate. The test substance was not mutagenic in any of the strains tested with or without metabolic activation.	ECHA,2013
A study similar to OECD Guideline 474 (Mammalian Erythrocyte Micronucleus Test) was carried out in vivo on mice, strain ICR. Controls were used. The test species had negative results to genotoxicity.	
Reproductive Toxicity Not classified on European Chemical Agency (ECHA) database (conclusive data but not sufficient for classification).	

A study equivalent to OECD Guideline 416 (Two-Generation Reproduction Toxicity Study) was carried out on Sprauge-Dawley rats. Oral doses of Isopropanol were 100, 500, 1000 mg/kg bw/day. Exposure periods were 10 weeks before mating until the day prior to euthanasia. Parental test rats, NOAEL 500 mg/kg bw/day, clinical observation of increased organ weights at 1000 mg/kg bw/day. Reproductive test rats, NOAEL 1000 mg/kg bw/day, no clinical effects observed at highest dose. Offspring test rats, NOAEL 500 mg/kg bw/day, clinical observations of reduced body weights and increased mortality at 1000 mg/kg bw/day. A study equivalent to OECD Guideline 415 (One-Generation Reproduction Toxicity Study) was carried out on Wistar rats. Drinking water formulations were prepared with Isopropanol 0.5, 1.0 or 2.0%. Parents and offspring were exposed before mating until euthanasia. Parental test rats NOAEL 853mg/kg bw/day. Clinical observations of increased pre-implantation loss, decreased mean litter weight and decreased mean fetal body weight at the higest exposure (2.0%).	ECHA,2103
Developmental Toxicity/Teratogenicity Not classified on European Chemical Agency (ECHA) database (conclusive data but not sufficient for classification). A study equivalent to OECD Guideline 414 (Prenatal Developmental Toxicity Study) was carried out on Wistar rats. Drinking water formulations were prepared with Isopropanol 596, 1242, or 1605 mg/kg bw. Test species exposed for 3 weeks. Controls were used. NOAEL for maternal and fetal toxicity, of 596mg/kg bw/day. At higher dose levels maternal clinical observations of decreased food and water consumption and body weight for maternal toxicity and fetal observations of decreased mean body weight. No NOAEL was determined for developmental toxicity.	ECHA,2013
Endocrine Disruption Not classified on European Chemical Agency (ECHA) database (conclusive data but not sufficient for classification). Not listed as an endocrine disruptor by European Commission.	ECHA,2013 EC, 2000
Neurotoxicity Two studies according to OECD Guideline 426 (Developmental Neurotoxicity Study) were carried out on Sprauge-Dawley rats, via oral administration of test substance. No clinical observations at the highest administered doses. Maternal NOAEL of 700mg/kg bw/day and offspring NOAEL of 1.2E3 mg/kg bw/day.	ECHA via QSAR,2013
Acute Toxicity (oral, dermal, inhalation) Not classified on European Chemical Agency (ECHA) database (conclusive data but not sufficient for classification). A study that predates toxicity guidelines, similar to OECD Guideline 401 (Acute Oral Toxicity) reliability scoring based on 2001 guideline for Test No. 423. Test was carried out on Sherman rats, via oral administration. No observations are reported, effect level, LD50 of 5840 mg/kg bw. A study similar to OECD Guideline 403 (Acute Inhalation Toxicity) carried out on Fischer 344 rats. Vapour (inhalation) doses of Isopropanol 500, 1500, 5000 and 10,000ppm. Exposure period of 6 hours. LC50 of >10000ppm. Observations of transient concentration-related narcosis and central nervous system sedation effects. Substance classified under STOT single exposure category 3, H336 - may cause drowsiness or dizziness, according to CLP classification criteria A study that predates toxicity guidelines, similar to OECD Guideline 402 (Acute Dermal Toxicity) was carried out on rabbits. Duration of exposure was 24 hours. LD_{50} of 16,400 mg/kg bw.	ECHA,2013
Chronic/repeat dose toxicity (oral, dermal, inhalation) Not classified on European Chemical Agency (ECHA) database (conclusive data but not sufficient for classification). A study according to OECD Guideline 413 (Subchronic Inhalation Toxicity: 90-Day) was carried	

out on rat and mice. Whole body inhalation doses of Isopropanol 100, 500, 1500 or 5000ppm. Exposure period was 6 hours per day, 5 days per week for 13 weeks. NOAEL of 5000ppm.Clinical observations of increased relative liver weight and motor activity (female only). Toxicity on the central nervous system was observed however as an acute effect. A study of combined repeat dose and carcinogenicity according to guideline OECD 451 was carried out on rats. Whole body inhalation does of Isopropanol 0, 500, 2500, 5000ppm. Exposure period was 6 hours per day, 5 days per week for at least 104 weeks. Clinical observations in the 2500 and 5000ppm groups of toxicity including hypoactivity, lack of startle reflex, and/or narcosis, changes in body weight, and urinalysis and urine chemistry indicative of kidney changes. Toxicology effects NOEC of 500ppm. A number of non-neoplastic histopathological changes were observed, with the most significant being in the kidney for males.Oncogenicity effects NOEC of 500ppm. An oral study was undertaken on male rats via repeat dose of test substance in drinking water. Original value and LOEL was 1280mg/kg bw/day. No dermal dose data found.	ECHA,2013 Rep Dose Tox via QSAR,2013
Sensitisation of the skin or respiratory system Not classified on European Chemical Agency (ECHA) database (conclusive data but not sufficient for classification). A study according to OECD Guideline 406 (Skin Sensitisation) was carried out in vivo on Hartley guinea pigs. Epicutaneous doses of Isopropyl Alcohol 0.4ml for a period of 6 hours weekly over three induction exposures. No skin reactions were observed in the test and control animals, it was concluded that Isopropyl alcohol is not a sensitizer.	ECHA,2013
Corrosion (irreversible)/irritation (reversible) effects on the skin or eye A study for skin sensitisation predating toxicology guidelines was carried out on guinea pigs. Dermal application (no test substance or dose reported) for 4 hour exposure period. No irritation or tissue destruction was observed concluding that the test substance dose is not irritating. A study similar to OECD Guideline 405 (Acute Eye Irritation / Corrosion) was carried out in vivo on New Zealand white rabbits. A single ocular treatment of neat MRD-86-962, 0.1mL. At 24 hours, clinical observations for the corneal, conjunctival and iridial were not fully reversible. At 14days, study was terminated, results demonstrate a trend in reversibility however it is not conclusive. Substance classified as an eye irritant, category 2, H319: Causes eye irritation according to CLP classification criteria.	ECHA,2013

Physical Hazards	Reference
Flammable Potential Classified by ECHA as a flammable liquid, category 2, H225: highly flammable liquid and vapour. Classified on HSIS database as highly flammable	ECHA,2013 HSIS, 2009
Explosive Potential No data found.	ECHA,2013

Toxicity Values	Value	Reference
Human Toxicity Data		
High Chronic/Repeat Dose Toxicity		
LOAEC	No data found (NDF)	
LOAEL	(NDF)	
Animal Toxicity Data		
Acute Toxicity		
LD_{50}		
Rat, oral	5,000 - 5,045 mg/kg	Oxford, 2006 Fisher Scientific, 2008
Mouse, oral	3,600 mg/kg	Oxford, 2006
Rabbit, oral	16.4mL/kg bw	ECHA, 2013
Rat, dermal	NDF	
Rabbit, dermal	12,800 mg/kg	Oxford, 2006
Mouse, dermal		
LC_{50}		
Rat, inhalation	>10000ppm	classified under STOT, single exposure - category 3, H336 - may cause drowsiness or dizziness, ECHA, 2013
Mouse, inhalation	53,000 mg/m^3	Fisher Scientific, 2008
High Chronic/Repeat Dose Toxicity		
LOAEL	NDF	
LOAEC	NDF	
NOAEL	5000ppm	ECHA,2013

Footnotes:
LD_{50} – lethal dose for 50% of experimental population
LC_{50} – lethal air concentration for 50% of experimental population
LOAEL – Lowest Observed Adverse Effect Level
LOAEC – Lowest Observed Adverse Effect Concentration
NOAEL - No Observed Adverse Effect Level
Conclusive data: means that the study itself was conclusive in its reported finding, but was not sufficient for classifying the material according to ECHA guidelines.

Human Health Toxicity Ranking*		
	Hazard data	**Comment**
Hazard Band 4		
Carcinogenicity (IARC Group 1 or 2A)	No (Group 3)	Not classifiable as a human carcinogen, IARC, 2013
Mutagenicity/Genotoxicity (GHS Category 1A and 1B)	No	ECHA, 2013
Reproductive Toxicity/Developmental toxicity (GHS Category 1, 1A and 1B)	No	ECHA, 2013
Endocrine Disruption[1]	No	EC, 2000
Hazard Band 3		
Carcinogenicity (IARC Group 2B)	No (group 3)	Not classifiable as a human carcinogen, IARC, 2013
Mutagenicity/Genotoxicity (GHS Category 2)	No	ECHA, 2013
Reproductive Toxicity/Developmental toxicity (GHS Category 2)	No	ECHA, 2013
Acute Toxicity (oral, dermal or inhalation) Very Toxic/Toxic • oral LD_{50} ≤ 300 mg/kg[3] • dermal LD_{50} ≤ 1000 mg/kg inhalation LC_{50} ≤ 10 mg/L[4] (or mg/m[3]) (vapour)	No	Oral = LD50 of 5.84 g/kg bw. Inhalation = LC50 of >10000ppm Dermal = LD50 of 16.4 mL/kg bw. ECHA, 2013
Possible carcinogenicity, mutagenicity, reproductive or High Chronic/repeat dose toxicity • oral LOAEL ≤ 10 mg/kg/d[3]; • dermal LOAEL ≤ 2 0 mg/kg/d; • inhalation LOAEC (6 h/d) ≤ 50 ppm/d for gases, ≤ 0.2 mg/L/d for vapours or ≤ 0.02 mg/L/d for dust/mists/fumes[4]	No	ECHA, 2013
Corrosive (irreversible effect)	No	classified as an eye irritant, category 2, H319: Causes eye irritation
Respiratory sensitiser	NDF	
Hazard Band 2		
Harmful chronic/repeat dose toxicity • oral LOAEL > 10 mg/kg and ≤ 100 mg/kg/d • dermal LOAEL > 20 mg/kg/d and ≤ 200 mg/kg/d • inhalation (6-h/d) LOAEC > 50 mg/L ≤ 250 mg/L/d for gases, > 0.2 mg/L ≤ 1 .0 mg/L/d for vapours or > 0.02 mg/L ≤ 0.2 mg/L/d for dust/mists/fumes[4]	No	Oral = LD50 of 5.84 g/kg bw. Inhalation = LC50 of >10000ppm Dermal = LD50 of 16.4 mL/kg bw. ECHA, 2013
Skin Sensitiser	No	ECHA, 2013
Hazard Band 1		
Acute Toxicity-Harmful • oral LD_{50} > 300 mg/kg ≤ 2000 mg/kg • dermal LD_{50} >1 000 mg/kg ≤ 2000 mg/kg; • inhalation LC_{50} (6 h/d) > 10 mg/L ≤ 20 mg/L for vapours)[4]	No	Oral = LD50 of 5.84 g/kg bw. Inhalation = LC50 of >10000ppm Dermal = LD50 of 16.4 mL/kg bw. ECHA, 2013
Irritant (reversible effect)	Yes	ECHA, 2013

Hazard Band 0 **All indicators outside criteria listed in Hazards 1-4**		
Physical Hazards		
Flammable potential	Yes	ECHA, 2013 HSIS, 2009
Explosive potential	NDF	
Hazard Evaluation (highest band) not including physical hazards	1	
Uncertainty analysis /data confidence (out of 12 parameters)	10/12	**83%**

* Based on IMAP Framework [NICNAS (2013) Inventory Multi-tiered Assessment and Prioritisation (IMAP) Framework. National Industrial Chemicals Notification and Assessment Scheme. Department of Health and Aging, Canberra].

"[1]*Based on list of endocrine disrupting chemicals from the European Commission's Endocrine Disrupters website.*

[2] *Neurotoxicity based on REACH assessments.*

[3] *milligrams per kilogram body mass(mg/kg) or milligrams per kilogram body mas per day (mg/kg/d)*

[4] *Based on GHS cut-offs for hazard classification. For chronic/repeat dose toxicity, GHS cut-offs are provided as guidance values (i.e. the dose/concentration at or below which significant health effects are observed"). (p 18, NICNAS 2013).*

Human Health Guidelines		
Media	**Concentration (mg/m^3; mg/L; mg/kg)**	**Reference**
Occupational Exposure Limits		
Air (OEL)	NDF	
8-h TWA	400ppm	HSIS, 2009
STEL	500ppm	HSIS, 2009
Peak Limitation	NDF	
Environmental Exposure		
Air, ambient	NDF	
Air, indoor	NDF	
Water, potable	NDF	
Water, recreational	NDF	
Soil, residential	NDF	
Soil, commercial/industrial	NDF	

Footnotes:

OEL = Occupational Exposure Limit

TWA= 8 h Time-Weighted Average

STEL = (15 min) Short-term Exposure Limit

Qualifying Summary Comments

The toxicity associated with propan-2-ol is principally related to the irritation of the eyes and the respiratory tract along with acute toxicity levels, although limited data is available for studies on humans for dermal, oral and inhalation exposure pathways. Propan-2-ol falls into the Hazard Band 1 category. The primary effect of exposure via usual occupational routes is considered to be irritation of the eyes and respiratory tract. Exposure standards are 400 ppm TWA, and 500 ppm STEL. Evidence indicates that propan-2-ol is not classifiable as a human carcinogen due to lack of evidence. Environmental uses should be aware that propan-2-ol is highly flammable as a liquid and a vapour. Occupational use should avoid skin, eye and respiratory system exposure.

References and Notes

European Chemicals Agency (ECHA), 2013. Registered Substances List Dossier for Propan-2-ol Available at: <http://apps.echa.europa.eu/registered/data/dossiers/DISS-9d82bbf7-98d2-11d2-e044-00144f67d249/AGGR-4f139ba1-322b-47ff-adf8-9cf3a86ee9fa_DISS-9d82bbf7-98d2-11d2-e044-00144f67d249.html#AGGR-4f139ba1-322b-47ff-adf8-9cf3a86ee9fa> [Accessed 4 December 2013].

European Commission (EC) (2000). Towards the establishment of a priority list of substances for further evaluation of their role in endocrine disruption, preparation of a candidate list of substances as a basis for priority setting, Final Report (Incorporating corrigenda to final report dated 21 June 2000).

Fisher scientific. (2008), MSDS Sheet for Isopropyl Alcohol. <http://fscimage.fishersci.com/msds/89530.htm> [Accessed 4 December 2013].

Hazardous Substances information System (HSIS), Safework SA, Propan-2-ol [Isopropyl alcohol; Isopropanol], Available at: <http://hsis.safeworkaustralia.gov.au/HazardousSubstance/Details?hazardousSubstanceID=5383> [Accessed 4 December 2013].

IARC (International Agency for Research on Cancer). (2011), *Agents Classified by the IARC Monographs, Volumes 1 -102*. < http://www.iarc.fr/> [Accessed 4 December 2013].

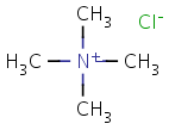
OECD (Organisation for Economic Co-operation & Development). (1997), *2-Propanol SIDS* (Screening Information Data Set). <http://www.inchem.org/documents/sids/sids/67630.pdf > [Accessed 4 December 2013].

Oxford University (2006), *Safety (MSDS) Data for 2-propanol* <http://msds.chem.ox.ac.uk/PR/2-propanol.html> [Accessed 4 December 2013].

NDF - No data found within the limits of the search strategy.

Created by:	C Shem	Date: 4/12/2013
Reviewed by:	JF	Date: 11/12/13

Project number: 127666004
Project name: Hydraulic Stimulation Chemicals Assessment, Southwest Queensland
Client name: Santos Ltd

Name	Tetramethylammonium chloride
Synonyms	N,N,N-trimethylmethanaminium chloride. Methanaminium, N,N,N-trimethyl-, chloride. Ammonium-, tetramethyl-, chloride. Tetramine chloride
CAS number	75-57-0
Molecular formula	$C_4H_{12}N.Cl$
Molecular Structure	

Overview	Reference
Tetramethylammonium chloride (TMAC) is a white crystalline solid with a molecular weight of 109.598. TMAC has a density of is 1.1690 g/cm^3 (at 20°C) and a melting point of 420°C (decomposes). The substance is soluble in water, very soluble in methanol, slightly soluble in ethanol and insoluble in ether, benzene or chloroform. TMAC reacts with oxidants. When heated to decomposition TMAC produces very toxic fumes including ammonia, carbon monoxide, hydrogen chloride and nitrogen oxides. If released to air, an estimated vapor pressure of 1.2 mm Hg at 25 °C indicating TMAC will exist in both the vapor and particulate phases in the atmosphere. Within industry tetramethylammonium chloride is produced and used as a chemical intermediate, catalyst, and inhibitor. It is also used in hydrofracking fluid as a clay stabiliser. Although most of the human health toxicity summaries are based on studies using TMAC for some of the end-points Tetramethylammonium hydroxide (TMAH) is used as a surrogate to infer toxicity of TMAC.	HSDB (2012) IPCM (2012)

Human Health Toxicity Summary	Reference
Carcinogenicity In the ECHA database data is lacking for a carcinogenicity classification. A search on the International Agency for Research on Cancer (IARC) website did not reveal any information on TMAC.	All proposed data sources
Mutagenicity/Genotoxicity Not classified as a mutagenic/genotoxic chemical. *Notes:* A gene mutation AMES test for TMAC was performed involving a Salmonella typhimurium reverse mutation test and in the Escherichia coli reverse mutation test with and without metabolic activation. All bacterial strains showed negative responses up to 5000 ug/plate, meaning that no significant dose-related increase in the number of revertants with or without metabolic activation was seen. The negative and strain-specific positive control values were within the laboratory historical control data ranges indicating that the test conditions were adequate and that the metabolic activation system functioned properly. Based on the results of this study it is concluded	ECHA (2013)

that TMAC is not mutagenic. In an in-vitro study Tetramethylammonium was used as a surrogate to infer read-across findings for TMAC. The study involved a chromosomal aberration test which showed that Tetramethylammonium was found not to induce polyploidy or other genetic aberrations. Another in-vitro study involving Tetramethylammonium hydroxide (TMAH) was used as a surrogate to infer mutagenicity of TMAC. The study was based on a mouse lymphoma test which concluded that TMAH is not mutagenic in the mouse lymphoma test system under the experimental conditions described in this report.	
Reproductive Toxicity Not classified as having reproductive toxicity effects. No reproductive toxicity studies were available for TMAC. However, a read-across oral study for Tetramethylammonium hydroxide (TMAH) was used as a surrogate to assess the reproductive toxicity of TMAC. *Notes:* A reproductive/developmental toxicity screening test was undertaken on rats where TMAH was administered orally at 0, 1, 5 and 20 mg/kg (10 females and 10 male rats used for each dose group). TMAH showed no effect on any of the following parental reproductive parameters: days required for successful copulation, copulation index, fertility indices of males and females, implantation index, gestation length and delivery index. There was no effect of TMAH on either the numbers of total newborns, sex ratio. No compound-related abnormality was observed either in external features. Based on the rest results, the NOAEL for parental toxicity was determined to be 5 mg/kg. No effects on development were seen at the highest test concentration and therefore for reproduction/developmental toxicity a NOAEL of ≥20 mg/kg was determined.	ECHA (2013)
Developmental Toxicity/Teratogenicity Not classified as having developmental toxicity. This is inferred from the same study as discussed for reproductive toxicity above.	ECHA (2013)
Endocrine Disruption Tetramethylammonium chloride has not been included in the European Commission's Endocrine Disrupters Priority List.	ECD (2013)
Acute Toxicity (oral, dermal, inhalation) Classified as having acute oral and dermal toxic effects. TMAC is fatal if swallowed (GHS Acute Toxicity classification 2 H300) and is toxic when in contact with the skin (GHS Acute Toxicity classification 3 H311). Acute toxicity data via the inhalation pathway is lacking. *Notes:* <u>Oral</u> TMAC (15% aqueous) was administered orally to 7 female rats at doses of 300, 550 or 2000 mg/kg. Deaths occurred within 2 hours of dosing. Prior to death, abnormal physical signs included prostration and lethargy. Necropsy did not reveal any abnormalities in any of the rats. Based on the data, the LD50 (female) of 15% aqueous TMAC was found to be 1146 mg/kg, equivalent to 171.9 mg/kg of pure TMAC. A second oral study, male and female rats were exposed to dilutions of a 50% aqueous solution of TMAC. Deaths occurred between 1 and 18 hours after dosing. Within a few hours after treatment the rats showed sedation, clonic convulsions and dacryorrhoea. Coma was frequently observed. The LD50 (male/female) of the 50% aqueous TMAC was found to be 0.094 ml/kg, equivalent to an LD50 of 47 mg/kg for pure TMAC. A third oral toxicity study involved exposing female rats to TMAC doses of 17.5 91 female), 55 (2 females) or 175 mg/kg (2 females). The deaths occurred within 24 hours of dosing. Pre-death signs included convulsions, tremors, sagging eyelids, nose/mouth area wet, flaccid muscle tone, prostration, lethargy, spasms, ataxia and eyes closed. Two survivors appeared normal at necropsy, but necropsy of one surviving animal revealed abnormalities of the pancreas, kidneys and ovaries. Based on the data, the LD50 (female) of TMAC was determined to be 55mg/kg.	ECHA (2013)

Dermal An acute dermal toxicity study was performed on ten rabbits at doses of 200 or 500 mg/kg and observed for 14 days. All of the rabbits survived at the 200 mg/kg dose while 6/10 died after exposure of 500 mg/kg. Lethargy, instances of diarrhea, few feces and soiling of the anogenital area were noted during the study. Dermal effects ranged from absent to very slight on Day 1 and were absent on Days 7 and 14. The dermal LD50 (male/female) was determined to be >200 mg/kg but less than 500 mg/kg.	
Chronic/repeat dose toxicity (oral, dermal, inhalation) No chronic data studies were available for TMAC. However, a read-across oral study for Tetramethylammonium hydroxide (TMAH) was used as a surrogate to infer oral chronic toxicity of TMAC. *Notes:* A 28-day oral repeated dose study was conducted with tetramethylammoniumhydroxide (TMAH). Female and male rats received oral doses of 5, 10 and 20 mg TMAH/ kg. No deaths were observed at any of the concentrations tested. A significant decrease in food consumption was observed in the first week of administration in male animals at 10 mg/kg, and male and female animals at 20 mg/kg. A decreased absolute and relative heart weight without dose-response and no correlated histopathological findings was also observed at 10 mg/kg and higher in males only. This effect was not seen at the end of the recovery period. Therefore, this effect was not considered to be toxicologically relevant for the time being, awaiting further data. The NOAEL for repeated dose oral toxicity was considered to be 5 mg/kg for males and 10 mg/kg for females. The LOAEL for male rats was 10 mg/kg based on decreases in food consumption s. For female rats the LOAEL was 20 mg/kg based on decreases in food consumption.	ECHA (2013)
Sensitisation of the skin or respiratory system Not classified as a skin sensitiser. Data is lacking for respiratory sensitisation evaluation. *Notes:* A skin sensitisation study was performed on female mice where TMAC was applied at concentrations of 5, 10 or 25%. Two of the three animals in the highest exposure (25%) group had to be sacrificed due to severe systemic toxicity and therefore data obtained at this concentration were not used for interpretation. In the other groups, no significant body weight loss was noted, and no irritation of the ears was observed. The auricular lymph nodes of animals at 5% test substance concentration were considered normal in size while the auricular lymph nodes of all (surviving) animals treated with a 10% and 25% test substance concentration appeared larger in size when compared to the other treated groups. The Stimulation Index (SI) values calculated for the TMAC concentrations of 5 and 10% were 0.5 and 1.1 respectively. Based on this data, TMAC is considered not to be a skin sensitiser.	ECHA (2013)
Corrosion (irreversible and reversible)/irritation of the skin or eye TMAC causes skin irritation (GHS Skin Irritation Category 2 H315). It is not classified as an eye irritant. *Notes:* Skin irritation In an in-vitro skin irritation test using a human skin model (EPISKIN Standard Model) TMAC was applied directly to 0.38 cm^2 cultured skin (10.5 to 11.8 mg, in presence of 5 µl Milli-Q water). After 15 minutes, the substance was removed and cells were cultured for 42 hours. As the mean relative tissue viability after exposure to the test substance was below 50%, it was concluded that the test substance is irritating in the in-vitro skin irritation test. In a second in-vitro skin corrosion test using a human skin model (EpiDerm Skin Model) TMAC was applied directly to 0.6 cm2 cultured skin (25mg, in presence of 25 µl Milli-Q water). After 3 minutes or 1 hour, the substance was removed and cells were cultured for 3 hours. Since the mean relative tissue viability after exposure to the test substance was above 50% or 15% after	ECHA (2013)

respective exposures of 3 minutes or 1 hour, it can be concluded that the test substance is not corrosive in the in vitro skin corrosion test. Eye irritation An eye irritation study was performed on 3 male New Zealand White rabbits where approximately 50 mg (a volume of approximately 0.1 mL) was instilled into one eye of each of three rabbits. In one animal on Day 1, the corneal injury consisted of slight dulling of the normal luster. Redness of conjunctivae and chemosis was noted for all animals which had completely resolved after 7 days. No systemic toxicity, changes in body weight gain or mortality occurred. Due to these results, TMAC is not irritating to the eyes and is not classified for eye irritation.	

Physical Hazards	Reference
Flammable Potential Not classified as a flammable/combustible chemical.	ECHA (2013) IPCM (2013)
Explosive Potential Not classified as an explosive chemical.	ECHA (2013)

Toxicity Values	Value	Reference
Human Toxicity Data		
Acute Toxicity		
	No data found.	All proposed data sources
High Chronic/Repeat dose Toxicity		
Animal Toxicity Data		
Acute Toxicity		
LD_{50}		
Rat, oral	171.9 mg/kg (female) 47 mg/kg (female/male) 55 mg/kg (female)	ECHA (2013)
Rat, dermal	No data found.	All proposed data sources
Rabbit, dermal	> 200 < 500 mg/kg (male/female)	ECHA (2013)
LOAEL	No data found.	All proposed data sources
LOAEC	No data found.	All proposed data sources
LC_{50}		
Rat	No data found.	All proposed data sources
High Chronic/Repeat dose Toxicity		
LOAEL	10 mg/kg (male rates) 20 mg/kg (female rats)	ECHA (2013)
NOAEL	5 mg/kg (male rates) 10 mg/kg (female rats)	ECHA (2013)
LOAEC	No data found.	All proposed data sources

Footnotes:
LD_{50} – lethal dose for 50% of experimental population
LC_{50} – lethal air concentration for 50% of experimental population
LOAEL – Lowest Observed Adverse Effect Level
LOAEC – Lowest Observed Adverse Effect Concentration
NOAEL – No Observed Adverse Effect Level

Human Health Toxicity Ranking*		
	Hazard data	**Comment**
Hazard Band 4		
Carcinogenicity	No data found.	
Mutagenicity/Genotoxicity	NO	
Reproductive Toxicity	NO	
Developmental Toxicity/ Teratogenicity	NO	
Endocrine Disruption[1]	NO	
Hazard Band 3		
Acute Toxicity (oral, dermal or inhalation) Very Toxic/Toxic • oral LD_{50} ≤ 300 mg/kg[2] • dermal LD_{50} ≤ 1000 mg/kg • inhalation LC_{50} ≤ 10 mg/L^3 (or mg/m^3) (vapour)	YES	Fatal if swallowed and toxic when in contact with the skin. No inhalation data found.
Possible carcinogenicity, mutagenicity, reproductive or High Chronic/repeat dose toxicity • oral LOAEL ≤ 10 mg/kg/d[3]; • dermal LOAEL ≤ 2 0 mg/kg/d; • inhalation LOAEC (6 h/d) ≤ 50 ppm/d for gases, ≤ 0.2 mg/L/d for vapours or ≤ 0.02 mg/L/d for dust/mists/fumes[3]	YES	For male rats an oral LOAEL of 10 mg/kg is inferred.
Corrosive (irreversible damage)	NO	
Respiratory sensitiser	No data found.	
Hazard Band 2		
Harmful chronic/repeat dose toxicity • oral LOAEL > 10 mg/kg and ≤ 100 mg/kg/d • dermal LOAEL > 20 mg/kg/d and ≤ 200 mg/kg/d • inhalation (6-h/d) LOAEC > 50 mg/L ≤ 250 mg/L/d for gases, > 0.2 mg/L ≤ 1 .0 mg/L/d for vapours or > 0.02 mg/L ≤ 0.2 mg/L/d for dust/mists/fumes[3]	YES	For male rats an oral LOAEL of 20 mg/kg is inferred.
Skin Sensitiser	NO	
Hazard Band 1		
Acute Toxicity-Harmful • oral LD_{50} > 300 mg/kg ≤ 2000 mg/kg • dermal LD_{50} >1 000 mg/kg ≤ 2000 mg/kg; • inhalation LC_{50} (6 h/d) > 10 mg/L ≤ 20 mg/L for vapours)[3]	NO	
Irritant (reversible damage)	YES	Causes skin irritation.
Hazard Band 0 **All indicators outside criteria listed in Hazards 1-4**		
Physical Hazards		
Flammable potential	NO	
Explosive potential	NO	
Hazard Evaluation (highest band) not including physical hazards	**Hazard Band 3**	
Uncertainty analysis /data confidence	11/13	**85%**

* Based on IMAP Framework [NICNAS (2013) Inventory Multi-tiered Assessment and Prioritisation (IMAP) Framework. National Industrial Chemicals Notification and Assessment Scheme. Department of Health and Aging, Canberra].

"[1]Based on list of endocrine disrupting chemicals from the European Commission's Endocrine Disrupters website.

[2]milligrams per kilogram body mass(mg/kg) or milligrams per kilogram body mas per day (mg/kg/d)

[3] Based on GHS cut-offs for hazard classification. For chronic/repeat dose toxicity, GHS cut-offs are provided as guidance values (i.e. the dose/concentration at or below which significant health effects are observed"). (p 18, NICNAS 2013).

Human Health Guidelines		
Media	**Concentration (mg/m^3; mg/L; mg/kg)**	**Reference**
Occupational Exposure Limits		
Air (OEL)		
8-h TWA	No data found.	All proposed data sources
STEL	No data found.	All proposed data sources
Peak Limitation	No data found.	All proposed data sources
Environmental Exposure		
Air, ambient	No data found.	All proposed data sources
Air, indoor	No data found.	All proposed data sources
Water, potable	No data found.	All proposed data sources
Water, recreational	No data found.	All proposed data sources
Soil, residential	No data found.	All proposed data sources
Soil, commercial/industrial	No data found.	All proposed data sources

Footnotes:

OEL = Occupational Exposure Limit

TWA= 8 h Time-Weighted Average

STEL = (15 min) Short-term Exposure Limit

NDF - No data found within the limits of the search strategy.

Qualifying Summary Comments

Tetramethylammonium chloride (TMAC) is a white crystalline solid with a molecular weight of 109.598. The substance is soluble in water, very soluble in methanol, slightly soluble in ethanol and insoluble in ether, benzene or chloroform. TMAC reacts with oxidants and when heated to decomposition it produces very toxic fumes including ammonia, carbon monoxide, hydrogen chloride and nitrogen oxides Although most of the human health toxicity summaries are based on studies using TMAC for some of the end-points Tetramethylammonium hydroxide (TMAH) is used as a surrogate to infer toxicity of TMAC.

No information or studies were found on carcinogenicity of TMAC and therefore the carcinogenicity classification is unknown. TMAC is not classified as having mutagenicity/genotoxicity effects, reproductive toxicity effects or developmental toxicity/teratogenicity effects. Based on its exclusion from the endocrine disrupting chemicals list from the European Commission's Endocrine website TMAC is not considered as an endocrine disruptor at this stage. In terms of acute toxicity TMAC is fatal if swallowed and toxic when in contact with the skin. Acute

inhalation data is lacking. Dermal and inhalation chronic/repeat data is lacking for TMAC however based on an oral chronic study a LOAEL of 10 mg/kg and 20 mg/kg was determined for male and female rats respectively. TMAC is not classified as a skin sensitiser with data lacking for the respiratory sensitisation. It is classified as a skin irritant but not as an eye irritant. Due to TMAC being fatal if swallowed it has been categorised as hazard band 3.

References and Notes

ECED (2013) European Commission's Endocrine Disrupters Priority List. Available at http://ec.europa.eu/environment/chemicals/endocrine/strategy/substances_en.htm#priority_list [Accessed 28 October 2013]

ECHA (2013) (European Chemicals Agency) Registered Substances List. Available at http://apps.echa.europa.eu/registered/data/dossiers/DISS-dffb4072-e390-47ae-e044-00144f67d031/DISS-dffb4072-e390-47ae-e044-00144f67d031_DISS-dffb4072-e390-47ae-e044-00144f67d031.html [Accessed 28 October 2013]

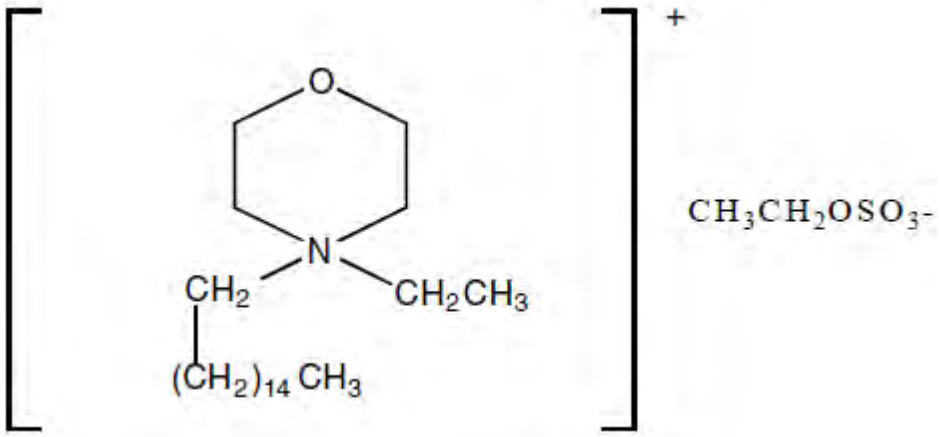
HSDB (2012). 'Tetramethylammonium chloride'. Hazardous Substance Data Bank (HSDB), U.S. National Library of Medicine. Available at http://toxnet.nlm.nih.gov/cgi-bin/sis/search [Accessed 28 October 2013]

IPCM (2012) International Programme on Chemical Safety. INCHEM, 'ICSC 1099 - TETRAMETHYLAMMONIUM CHLORIDE'. Available at Ehttp://www.inchem.org/documents/icsc/icsc/eics1099.htm [Accessed 28 October 2013]

NDF – No data found within the limits of the search strategy

Created by:	JH	Date: 29/10/2013
Reviewed and edited by:	JF	Date: 08/11/2013

Project number: 127666004
Project name: Hydraulic Stimulation Chemicals Assessment, Southwest Queensland
Client name: Santos Ltd

Name	Cetylethylmorpholinium ethyl sulfate
Synonyms	4-Ethyl-4-hexadecylmorpholinium, ethyl sulphate, Atlas G 263, Barquat cme-A, Morpholinium, 4-ethyl-4-hexadecyl-, ethyl sulfate, sulfuric acid, monoethyl ester, ion(1-), 4-ethyl-4-hexadecylmorpholinium, others
CAS number	78-21-7
Molecular formula	$C_{24}H_{51}NO_5S$
Molecular Structure	

Overview	References
Limited information is available on this compound with the exception of chemical supply and registry databases. Cetylethylmorpholinium ethyl sulfate (CEMES) is amber liquid with a sweet smelling odour. It is water soluble and has a pH of 5-5.5. Structurally it is a quaternary ammonium salt. Reported uses include as a pesticide, surfactant, antistatic and as a combing and detangling agent in hair conditioning. CEMES is a severe eye irritant and is expected to be harmful if swallowed. It is not classified as a skin or respiratory sensitiser No information is available on repeat dose toxicity or other chronic endpoints.	Chemical Book (2010), LookChem (2008), Lonza (2006)

Human Health Toxicity Summary	Reference
Carcinogenicity Not classified by IARC.	IARC (2013)
Mutagenicity/Genotoxicity No data found.	

Reproductive Toxicity No data found.	
Developmental Toxicity/Teratogenicity No data found.	
Endocrine Disruption No data found.	
Neurotoxicity No data found.	
Acute Toxicity (oral, dermal, inhalation) Harmful if swallowed.	Lonza (2006)
Chronic/repeat dose toxicity (oral, dermal, inhalation) No data found.	
Sensitisation of the skin or respiratory system No data found.	
Corrosion (irreversible and reversible)/irritation of the skin or eye Risk of serious damage to eyes. In a rabbit eye irritation study the conclusion was that CEMES is an extremely severe eye irritant,	Lonza (2006)

Physical Hazards	Reference
Flammable Potential No classified as a flammable liquid (flash point 93°C).	Lonza (2006)
Explosive Potential Not classified as an explosive.	

Toxicity Values	Value	Reference
Human Toxicity Data		
Acute Toxicity		
	No data found.	
High Chronic/Repeat Dose Toxicity		
LOAEC	No data found.	
LOAEL	No data found.	
Animal Toxicity Data		
Acute Toxicity		
LD_{50}		
Rat, oral	1700 mg/kg	Lonza (2006)
Mouse, oral	No data found.	
Rabbit, oral	No data found.	
Rat, dermal	No data found.	
Rabbit, dermal	No data found.	
Mouse, dermal	No data found.	
LOAEL	No data found.	
LOAEC	No data found.	
LC_{50}		
Rat	No data found.	
High Chronic/Repeat Dose Toxicity		
LOAEL	No data found.	
LOAEC	No data found.	

Footnotes:
LD_{50} – lethal dose for 50% of experimental population
LC_{50} – lethal air concentration for 50% of experimental population
LOAEL – Lowest Observed Adverse Effect Level
LOAEC – Lowest Observed Adverse Effect Concentration

Human Health Toxicity Ranking*		
	Hazard data	**Comment**
Hazard Band 4		
Carcinogenicity	No data found.	
Mutagenicity/Genotoxicity	No data found.	
Reproductive Toxicity	No data found.	
Developmental Toxicity/ Teratogenicity	No data found.	
Endocrine Disruption[1]	No data found.	
Hazard Band 3		
Acute Toxicity (oral, dermal or inhalation) Very Toxic/Toxic • oral $LD_{50} \leq 300$ mg/kg[3] • dermal $LD_{50} \leq 1000$ mg/kg • inhalation $LC_{50} \leq 10$ mg/L[4] (or mg/m^3) (vapour)	No data found.	
Possible carcinogenicity, mutagenicity, reproductive or High Chronic/repeat dose toxicity • oral LOAEL ≤ 10 mg/kg/d[3]; • dermal LOAEL ≤ 2 0 mg/kg/d; • inhalation LOAEC (6 h/d) ≤ 50 ppm/d for gases, ≤ 0.2 mg/L/d for vapours or ≤ 0.02 mg/L/d for dust/mists/fumes[4]	No data found.	
Corrosive (irreversible damage)	YES	Eye
Respiratory sensitiser	No data found.	
Hazard Band 2		
Harmful chronic/repeat dose toxicity • oral LOAEL > 10 mg/kg and ≤ 100 mg/kg/d • dermal LOAEL > 20 mg/kg/d and ≤ 200 mg/kg/d • inhalation (6-h/d) LOAEC > 50 mg/L ≤ 250 mg/L/d for gases, > 0.2 mg/L ≤ 1 .0 mg/L/d for vapours or > 0.02 mg/L ≤ 0.2 mg/L/d for dust/mists/fumes[4]	No data found.	
Skin Sensitiser	No data found.	
Hazard Band 1		
Acute Toxicity-Harmful • oral $LD_{50} > 300$ mg/kg ≤ 2000 mg/kg • dermal LD_{50} >1 000 mg/kg ≤ 2000 mg/kg; • inhalation LC_{50} (6 h/d) > 10 mg/L ≤ 20 mg/L for vapours)[4]	YES	
Irritant (reversible damage)	YES	skin
Hazard Band 0 **All indicators outside criteria listed in Hazards 1-4**		
Physical Hazards		
Flammable potential	NO	
Explosive potential	NO	
Hazard Evaluation (highest band) not including physical hazards	Hazard Band 3	
Uncertainty analysis /data confidence	4/13 = 31%	

* Based on IMAP Framework [NICNAS (2013) Inventory Multi-tiered Assessment and Prioritisation (IMAP) Framework. National Industrial Chemicals Notification and Assessment Scheme. Department of Health and Aging, Canberra].

"[1]Based on list of endocrine disrupting chemicals from the European Commission's Endocrine Disrupters website.

[2] Based on list of neurotoxic chemicals from US Agency for Toxic Substances and Disease Registry (ATSDR).
[3] milligrams per kilogram body mass(mg/kg) or milligrams per kilogram body mas per day (mg/kg/d)

[4] Based on GHS cut-offs for hazard classification. For chronic/repeat dose toxicity, GHS cut-offs are provided as guidance values (i.e. the dose/concentration at or below which significant health effects are observed"). (p 18, NICNAS 2013).

Human Health Guidelines		
Media	**Concentration (mg/m^3; mg/L; mg/kg)**	**Reference**
Occupational Exposure Limits		
Air (OEL)		
8-h TWA	No data found.	
STEL	No data found.	
Peak Limitation	No data found.	
Environmental Exposure		
Air, ambient	No data found.	
Air, indoor	No data found.	
Water, potable	No data found.	
Water, recreational	No data found.	
Soil, residential	No data found.	
Soil, commercial/industrial	No data found.	

Footnotes:

OEL = Occupational Exposure Limit

TWA= 8 h Time-Weighted Average

STEL = (15 min) Short-term Exposure Limit

Qualifying Summary Comments

Cetylethylmorpholinium ethyl sulfate (CEMES) is amber liquid with a sweet smelling odour. It is water soluble and has a pH of 5-5.5. Structurally it is a quaternary ammonium salt. Reported uses include as a pesticide, surfactant, antistatic and as a combing and detangling agent in hair conditioning.

CEMES is a severe eye irritant and is expected to be harmful if swallowed. It is not classified as a skin or respiratory sensitiser. No information is available on repeat dose toxicity or other chronic endpoints. Overall it is categorised as hazard band 3 based on severe irritation to the eyes.

References and Notes

Chemical Book (2010). Available at http://www.chemicalbook.com. [Accessed 3 September 2013].

IARC (2013) Agents classified by IARC Monographs Volumes 1- 107. Available at http://monographs.iarc.fr/ENG/Classification/ClassificationsGroupOrder.pdf. [Accessed 4 August 2013.]

Lonza Group Ltd (2006). Material Safety Data Sheet. Barquat™ CME-35.

LookChem (2008). Available at http://www.lookchem.com. [Accessed 3 September 2013].

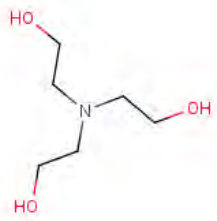
United States Environmental Protection Agency (US EPA, 2013). Aggregated Computational Toxicology Resource (ACToR) database. Available at http://actor.epa.gov/actor/faces/ACToRHome.jsp. [Accessed 3 September 2013]

Project number: 127666004
Project name: Hydraulic Stimulation Chemicals Assessment, Southwest Queensland
Client name: Santos Ltd

No data found. - No data found within the limits of the search strategy.

Created by:	MER	Date 3/9/2013
Reviewed and edited by:	JF	Date and Revision 11/09/2013

Project number: 127666004
Project name: Hydraulic Stimulation Chemicals Assessment, Southwest Queensland
Client name: Santos Ltd

Name	2,2`,2"-nitrilotriethanol
Synonyms	Trolamine, triethanolamine, sterolamide, nitrilotriethanol
CAS number	102-71-6
Molecular formula	$C_6H_{15}NO_3$
Molecular Structure	

Overview	References
2,2`,2"-nitrilotriethanol is a colourless to slightly liquid which is very hygroscopic and turns brown on exposure to air and light. It is a water-soluble strong base with a pH of 10.3 (concentration 1%) and emits a slight odour of ammonia.  2,2`,2"-nitrilotriethanol is used commercially and industrially in the manufacture of surfactants and detergents, textiles, waxes, polishes, herbicides, petroleum demulsifiers, toilet goods, cement additives, cutting oils and other products. Kinetic studies in rats and mice using radioactive tracers indicate that 2,2`,2"-nitrilotriethanol identified that the compound distributes to the heart, kidney, liver, lung, and spleen with 40% of an intravenously administered dose excreted within 24 hours.  2,2`,2"-nitrilotriethanol has a low order of acute and chronic toxicity. The principal route of exposure causing toxicity is through the skin, with some exposure occurring from inhalation of vapour and aerosols. Potential health effects in humans would be acute in nature and due to alkalinity rather than systemic toxicity. It is not genotoxic, carcinogenic, or toxic to development or the reproductive system.	HSDB (2009) ECHA (2013a) WHO (2012)

Human Health Toxicity Summary	Reference
Carcinogenicity - Not classifiable as to its carcinogenicity to humans (Group 3) based on inadequate evidence in experimental animals and humans. - Conclusive but not sufficient for classification	IARC (2000) ECHA (2013a)
Mutagenicity/Genotoxicity - Not classified as a mutagenic chemical. It is not genotoxic. - Triethanolamine did not induce mutations, DNA damage or other effects on genetic material in a number of non mammalian and mammalian tests both in vitro and in vivo.	IARC (2000) ECHA (2013a)

Reproductive Toxicity - Not classified as a reproductive toxicant. - No reproductive or developmental effects were produced when rats and mice were exposed by topical administration. Other routes of exposure have not been studied.	IARC (2000), WHO (2012), ECHA (2013)
Developmental Toxicity/Teratogenicity - Not classified as a developmental toxicant. Teratogenic at maternally toxic doses. - Maternal effects observed among rat dams given 225 mg/kg/day, however reproductive parameters in exposed rats were unaffected at this or lower dose levels (0-75 mg/kg/day). Maternal effects were observed in another rat study at 450 mg/kg/day. - Not classifiable as to its carcinogenicity to humans (Group 3) based on inadequate evidence in experimental animals and humans.	HSDB (2009) ECHA (2013a)
Endocrine Disruption - Not listed as an endocrine disruptor on the European Commission List of Endocrine Disruptors.	All proposed data sources
Neurotoxicity - NDF	All proposed data sources
Acute Toxicity (oral, dermal, inhalation) - Large doses produced minimal toxicity when administered orally to laboratory animals. - When heated to decomposition it emits toxic and irritating fumes of nitrogen oxides and hydrogen cyanides. - The probably oral lethal dose in humans is 5-15 g/kg bw. Toxicity is low following single exposures.	HSDB (2009) OECD (1997)
Chronic/repeat dose toxicity (oral, dermal, inhalation) - Human data are limited. Based on data from animal studies, chemical is anticipated to have low chronic toxicity under typical human exposure conditions. - Skin irritation and ulceration have been reported following repeated, subchronic, and chronic topical exposure in laboratory animals. - Kidney toxicity is reported in a number of experimental animal studies. Aside from nephrotoxicity (the primary effect), side effects reported in laboratory animals following long-term oral administration include hepatic congestion, and demyelination of peripheral and sciatic nerve fibers. - Classified as causing potential organ damage. - Classified as a potential respiratory irritant.	HSDB(2009) ECHA (2013 b)
Sensitisation of the skin or respiratory system - A skin sensitiser. - Not sensitising in a guinea pig study. - Very low sensitisation potential in humans in a volunteer human study.	SafeWork Australia (2013) ECHA (2013a) ECHA (2013b)
Corrosion (irreversible and reversible)/irritation of the skin or eye - Not irritating to skin in rabbit studies. - Not irritating to eyes in three rabbit studies. Irritating to eyes in two rabbit studies. - Conclusive but not sufficient for classification	ECHA (2013a) ECHA (2013b)
Flammable Potential - Non flammable. Combustible, when exposed to heat or flame.	ECHA (2013a)
Explosive Potential - There are no chemical groups associated with explosive properties in the molecule.	ECHA (2013a)

Toxicity Values	Value	Reference
Human Toxicity Data		
Acute Toxicity		
	NDF	All proposed data sources
High Chronic/Repeat Dose Toxicity		
NOAEL, rat (oral), dermal	1000 mg/kg bw	ECHA (2013a)
NOAEL (local effects), mouse	250 mg/kg bw/day	ECHA (2013a)

NOAEC (local effects), rat (inhalation)	0.02 mg/L air	ECHA (2013a)
NOAEC (local effects) male rat (dermal)	125 mg/kg bw/day	ECHA (2013a)
NOAEC (local effects) female rat (dermal)	250 mg/kg bw/day	ECHA (2013a)
Animal Toxicity Data		
Acute Toxicity		
LD_{50}		
Guinea pig (oral)	2200 mg/kg	TOXNET (2013)
Mouse (intraperitoneal)	1450 mg/kg	TOXNET (2013)
Mouse (oral)	5846 mg/kg	TOXNET (2013)
Rabbit (oral)	2200 mg/kg	TOXNET (2013)
Rabbit (skin)	>20 mL/kg	TOXNET (2013)
Rat (intraperitoneal)	1510 mg/kg	TOXNET (2013)
Rat (oral)	4920 uL/kg	TOXNET (2013)
Rat (skin)	> 16 mL/kg	TOXNET (2013)
Rat (oral)	8,000 mg/kg	HSDB (2009)
Guinea pig (oral)	5,300 mg/kg	HSDB (2009)
Rabbit (dermal)	> 2,000 mg/kg	ECHA (2013a)
Rats (oral)	6400 mg/kg	ECHA (2013a)
LC0		
Rat (inhalation, 8h)	Saturated atmosphere	ECHA (2013a)

Footnotes:
LD_{50} – lethal dose for 50% of experimental population
LC_{50} – lethal air concentration for 50% of experimental population
LOAEL – Lowest Observed Adverse Effect Level
LOAEC – Lowest Observed Adverse Effect Concentration
Conclusive data: means that the study itself was conclusive in its reported finding, but was not sufficient for classifying the material according to ECHA guidelines.

Human Health Toxicity Ranking*		
	Hazard data	**Comment**
Hazard Band 4		
Carcinogenicity	NO	Not classifiable based on inadequate evidence.
Mutagenicity/Genotoxicity	NO	-
Reproductive Toxicity	NO	ECHA (2013), IARC (2000)
Developmental Toxicity/ Teratogenicity	NO	ECHA (2013) IARC (2000)
Endocrine Disruption[1]	NO	-
Neurotoxicity[2]	NDF	-
Hazard Band 3		
Acute Toxicity (oral, dermal or inhalation) Very Toxic/Toxic • oral $LD_{50} \leq 300$ mg/kg[3] • dermal $LD_{50} \leq 1000$ mg/kg • inhalation $LC_{50} \leq 10$ mg/L[4] (or mg/m^3) (vapour)	NO	-
High Chronic/repeat dose toxicity • oral LOAEL ≤ 10 mg/kg/d[3]; • dermal LOAEL ≤ 2 0 mg/kg/d; • inhalation LOAEC (6 h/d) ≤ 50 ppm/d for gases, ≤ 0.2 mg/L/d for vapours or ≤ 0.02 mg/L/d for dust/mists/fumes[4]	NO	-
Corrosive (irreversible damage)	NO	Conclusive but not sufficient for classification.
Respiratory sensitiser	NO	-
Hazard Band 2		
Harmful chronic/repeat dose toxicity • oral LOAEL > 10 mg/kg and ≤ 100 mg/kg/d • dermal LOAEL > 20 mg/kg/d and ≤ 200 mg/kg/d • inhalation (6-h/d) LOAEC > 50 mg/L ≤ 250 mg/L/d for gases, > 0.2 mg/L ≤ 1 .0 mg/L/d for vapours or > 0.02 mg/L ≤ 0.2 mg/L/d for dust/mists/fumes[4]	YES	Potential local effects (irritation) in the respiratory tract.
Skin Sensitiser	YES	Reports vary.
Hazard Band 1		
Acute Toxicity-Harmful • oral $LD_{50} > 300$ mg/kg ≤ 2000 mg/kg • dermal LD_{50} >1 000 mg/kg ≤ 2000 mg/kg; • inhalation LC_{50} (6 h/d) > 10 mg/L ≤ 20 mg/L for vapours)[4]	NO	-
Irritant (reversible damage)	NO	-
Hazard Band 0 **All indicators outside criteria listed in Hazards 1-4**		
Physical Hazards		
Flammable potential	NO	-
Explosive potential	NO	-
Hazard Evaluation (highest band) not including physical hazards	**Band 2**	
Uncertainty analysis /data confidence	11 parameters, 11/14 x 100 =	**78.5%**

* Based on IMAP Framework [NICNAS (2013) Inventory Multi-tiered Assessment and Prioritisation (IMAP) Framework. National Industrial Chemicals Notification and Assessment Scheme. Department of Health and Aging, Canberra].

"[1]Based on list of endocrine disrupting chemicals from the European Commission's Endocrine Disrupters website.

[2] Based on list of neurotoxic chemicals from US Agency for Toxic Substances and Disease Registry (ATSDR).

[3] milligrams per kilogram body mass (mg/kg) or milligrams per kilogram body mass per day (mg/kg/d)

[4] Based on GHS cut-offs for hazard classification. For chronic/repeat dose toxicity, GHS cut-offs are provided as guidance values (i.e. the dose/concentration at or below which significant health effects are observed"). (p 18, NICNAS 2013).

Human Health Guidelines		
Media	**Concentration (mg/m^3; mg/L; mg/kg)**	**Reference**
Occupational Exposure Limits		
Air (OEL)		
TWA (duration not specified)	5 mg/m^3	Safe Work Australia (2013)
STEL	NDF	All proposed data sources
Peak Limitation	NDF	All proposed data sources
Environmental Exposure		
Air, ambient	NDF	All proposed data sources
Air, indoor	NDF	All proposed data sources
Water, potable	NDF	NEPM (1999; amended 2013)
Water, recreational	NDF	All proposed data sources
Soil, residential	NDF	NEPM (1999; amended 2013)
Soil, commercial/industrial	NDF	NEPM (1999; amended 2013)

Footnotes:

OEL = Occupational Exposure Limit

TWA= 8 h Time-Weighted Average

STEL = (15 min) Short-term Exposure Limit

NDF - No data found within the limits of the search strategy.

Qualifying Summary Comments

2,2`,2"-nitrilotriethanol is a colourless to slightly liquid which is very hygroscopic and turns brown on exposure to air and light. It is a water-soluble strong base with a pH of 10.3 (concentration 1%) and emits a slight odour of ammonia. 2,2`,2"-nitrilotriethanol is used commercially and industrially in the manufacture of surfactants and detergents, textiles, waxes, polishes, herbicides, petroleum demulsifiers, toilet goods, cement additives, cutting oils and other products. 2,2`,2"-nitrilotriethanol has a low order of acute and chronic toxicity. It is classified as a skin sensitiser. It is not genotoxic, carcinogenic, or toxic to development or the reproductive system. Given the relatively low to moderate hazard it is categorised in Hazard Band 2.

References

HSDB (2009) Hazardous Substances Data Bank. Toxicology Data Network (TOXNET) Available at http://toxnet.nlm.nih.gov/cgi-bin/sis/htmlgen?HSDB. [Accessed 14 August 2013.]

SafeWork Australia. Hazardous Substances Information System (HSIS). Available at http://hsis.safeworkaustralia.gov.au/HazardousSubstance. [Accessed 16 August 2013]

European Chemicals Agency. Registered Chemical Substances Search. Available at http://echa.europa.eu/web/guest/information-on-chemicals/registered-substances. [Accessed 16 August 2013] (ECHA 2013a)

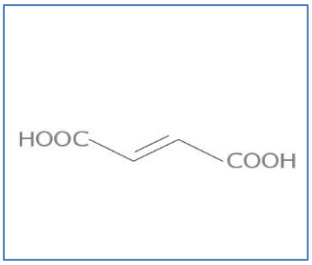
European Chemicals Agency. Classification and Labelling Inventory database Search. Available at http://echa.europa.eu/web/guest/information-on-chemicals/cl-inventory-database. [Accessed 16 August 2013] (ECHA 2013b)

National Industrial Chemicals Notification and Assessment Scheme (NICNAS) (2013). Australian Inventory of Chemical Substances database search. Available at http://www.nicnas.gov.au/regulation-and-compliance/aics/aics-search-page. [Accessed 16 August 2013].

OECD (1997). Triethanolamine.: SIDS initial assessment report. From INCHEM. Available at http://www.inchem.org/documents/sids/sids/102716.html

Created by:	**MER**	Date: **18/08/2013**
Reviewed and edited by:	**JF**	Date: **11/09/2013**

Project number: 127666004
Project name: Hydraulic Stimulation Chemicals Assessment, Southwest Queensland
Client name: Santos Ltd

Name	Fumaric Acid
Synonyms	but-2-enedioic acid, (E)-Butenedionic acid, *trans*-1,2-Ethylenedicarboxylic acid, 2-Butenedioic acid, *trans* butenedioic acid, Allomaleic acid, Boletic acid, Donitic acid, Lichenic acid
CAS number	110-17-8
Molecular formula	C4H4O4
Molecular Structure	

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Overview	Reference
Fumaric acid is a solid, crystalline, colourless organic chemical that is subject to aerobic biodegradation. Fumaric acid is not classified as flammable or explosive. It has been used extensively in a range of products including in the production and manufacture of polishes and wax blends, non-metal-surface treatment products, pH-regulators, flocculants, precipitants, neutralisation agents, leather tanning, in dyes, adhesives, sealants, coatings and paints, thinners, paint removes and ink and toners. It is also an approved food additive in the United States, Europe and Australia. Fumaric acid may result in serious eye irritation following direct contact. A key feature of fumaric acid is the production of maleic anhydride if heated to above 300°C. it rearranges to form maleic (cis-butendioic) acid, which can turn into maleic anhydride. Maleic anhydride is classified as harmful if swallowed, may result in severe skin burns and eye damage form direct contact and is classed as a respiratory sensitiser. Maleic anhydride does however rapidly hydrolyse to form maleic acid in the presence of water.	ECHA (2013); IPCS (2006);

Human Health Toxicity Summary	Reference
Carcinogenicity Not on the IARC International Agency for Research on Cancer Carcinogen list.	IARC (2013)
Mutagenicity/Genotoxicity Not classified as a mutagenic by ECHA.	ECHA (2013)
Reproductive Toxicity Not classified as reproductively toxic by ECHA.	ECHA (2013)
Developmental Toxicity/Teratogenicity No classified as having the ability to induce developmental or teratogenic effects.	ECHA (2013)
Endocrine Disruption Not classified as an endocrine disrupter by the European Commission.	EC (2000)
Acute Toxicity (oral, dermal, inhalation) **Oral** Not classified as exhibiting acute oral toxicity under ECHA guidelines.	ECHA (2013)

Inhalation Not classified as exhibiting acute inhalation toxicity under ECHA guidelines. **Dermal** Not classified as exhibiting acute dermal toxicity under ECHA guidelines.	
Chronic/repeat dose toxicity (oral, dermal, inhalation) **Oral** Not classified as exhibiting chronic oral toxicity under ECHA guidelines. **Inhalation** NDF. **Dermal** NDF.	ECHA (2013)
Sensitisation of the skin or respiratory system Not classified as a skin sensitiser by ECHA. No data found relating to the potential for respiratory sensitisation.	ECHA (2013)
Corrosion (irreversible)/irritation of the skin or eye Not classified as corrosive to the skin by ECHA. Classified as an eye irritant and can cause serious eye irritation. Classified under the GHS as level 2 eye irritant which indicated that effects are reversable.	ECHA (2013)

Physical Hazards	Reference
Flammable Potential Not classified as flammable.	ECHA (2013)
Explosive Potential Not Classified as explosive.	ECHA (2013)

Toxicity Values	Value	Reference
Human Toxicity Data		
Acute Toxicity		
NDF		
NDF		
High Chronic/Repeat dose Toxicity		
NOAEL	NDF	
NOAEL	NDF	
LOAEC	**Inhalation** Workers 175 mg/m^3 (respiratory tract irritation)	ECHA (2013)
NOAEL	**Oral** General Population 30 mg/kg bw/day	ECHA (2013)
Animal Toxicity Data		
Acute Toxicity		
LD_{50}		
Rat, oral	10 700 mg/kg bw (male) 9 300 mg/kg bw (female)	ECHA (2013)
Rat, Inhalation	>1.306 mg/l air	ECHA (2013)
Rabbit, dermal	20 000 mg/kg bw	ECHA (2013)
LC_{50}		
Rat	>1,306 mg/l air	ECHA (2013)

High Chronic/Repeat dose Toxicity		
NOAEL	Rat, oral 600 mg/kg bw/day	ECHA (2013)
LOAEL	Rat, oral 750 mg/kg bw/day	ECHA (2013)
LOAEC	NDF	

Footnotes:
LD_{50} – lethal dose for 50% of experimental population
LC_{50} – lethal air concentration for 50% of experimental population
LOAEL – Lowest Observed Adverse Effect Level
LOAEC – Lowest Observed Adverse Effect Concentration
NOAEL – No Observed Adverse Effect Level

Human Health Toxicity Ranking*		
	Hazard data	**Comment**
Hazard Band 4		
Carcinogenicity	NDF	Not on the IARC list for causing cancer (IARC 2013)
Mutagenicity/Genotoxicity	No	ECHA, 2013
Reproductive Toxicity	No	ECHA, 2013
Developmental Toxicity/ Teratogenicity	No	ECHA, 2013
Endocrine Disruption[1]	No	ECHA, 2013
Hazard Band 3		
Acute Toxicity (oral, dermal or inhalation) Very Toxic/Toxic • oral LD_{50} ≤ 300 mg/kg[2] • dermal LD_{50} ≤ 1000 mg/kg • inhalation LC_{50} ≤ 10 mg/L[3] (or mg/m^3) (vapour)	No	ECHA, 2013
High Chronic/repeat dose toxicity • oral LOAEL ≤ 10 mg/kg/d[3]; • dermal LOAEL ≤ 2 0 mg/kg/d; • inhalation LOAEC (6 h/d) ≤ 50 ppm/d for gases, ≤ 0.2 mg/L/d for vapours or ≤ 0.02 mg/L/d for dust/mists/fumes[3]	No	ECHA, 2013
Corrosive (irreversible damage)	No	ECHA, 2013
Respiratory sensitiser	NDF	ECHA, 2013
Hazard Band 2		
Harmful chronic/repeat dose toxicity • oral LOAEL > 10 mg/kg and ≤ 100 mg/kg/d • dermal LOAEL > 20 mg/kg/d and ≤ 200 mg/kg/d • inhalation (6-h/d) LOAEC > 50 mg/L ≤ 250 mg/L/d for gases, > 0.2 mg/L ≤ 1 .0 mg/L/d for vapours or > 0.02 mg/L ≤ 0.2 mg/L/d for dust/mists/fumes [3]	No	ECHA, 2013
Skin Sensitiser	No	ECHA, 2013
Hazard Band 1		
Acute Toxicity-Harmful • oral LD_{50} > 300 mg/kg ≤ 2000 mg/kg • dermal LD_{50} >1 000 mg/kg ≤ 2000 mg/kg; • inhalation LC_{50} (6 h/d) > 10 mg/L ≤ 20 mg/L for vapours)[3]	No	ECHA, 2013
Irritant (reversible damage)	Yes	Classified under the GHS as level 2 eye irritant which indicated that effects are revisable.
Hazard Band 0 **All indicators outside criteria listed in Hazards 1-4**		
Physical Hazards		
Flammable potential	No	ECHA, 2013
Explosive potential	No	ECHA, 2013
Hazard Evaluation (highest band) not including physical hazards	**Band 1**	
Uncertainty analysis /data confidence	11/13	**84.7%**

* Based on IMAP Framework [NICNAS (2013) Inventory Multi-tiered Assessment and Prioritisation (IMAP) Framework. National Industrial Chemicals Notification and Assessment Scheme. Department of Health and Aging, Canberra].

"[1]Based on list of endocrine disrupting chemicals from the European Commission's Endocrine Disrupters website.

[2]milligrams per kilogram body mass(mg/kg) or milligrams per kilogram body mas per day (mg/kg/d)

[3] Based on GHS cut-offs for hazard classification. For chronic/repeat dose toxicity, GHS cut-offs are provided as guidance values (i.e. the dose/concentration at or below which significant health effects are observed"). (p 18, NICNAS 2013).

Human Health Guidelines		
Media	**Concentration (mg/m^3; mg/L; mg/kg)**	**Reference**
Occupational Exposure Limits	NDF	
Air (OEL)	NDF	
8-h TWA	NDF	
STEL	NDF	
Peak Limitation		
Environmental Exposure		
Air, ambient	NDF	
Air, indoor	NDF	
Water, potable	NDF	
Water, recreational	NDF	
Soil, residential	NDF	
Soil, commercial/industrial	NDF	

Footnotes:

OEL = Occupational Exposure Limit

TWA= 8 h Time-Weighted Average

STEL = (15 min) Short-term Exposure Limit

NDF - No data found within the limits of the search strategy.

Qualifying Summary Comments

Fumaric acid is a colourless solid that is readily biodegradable under aqueous conditions. Direct contact may result in severe eye irritation but it is not considered harmful if swallowed. It is not classified as a, mutagen or teratogen and has not been shown to produce reproductive or developmental effects. It has not been evaluated for carcinogenicity. It is categorised in Hazard Band 1 on the basis of its reversible but severe irritant action for direct eye contact. Fumaric acid converts to the irritant maleic anhydride, upon partial combustion. Under aqueous conditions dissolution will occur and degradation such that no additional hazards will result. The fate and transport characteristics thus limit potential exposures to direct contact settings with the pure substance or in its concentrated form. This limits human health concerns to occupational exposures and public emergency spill settings.

References

ECHA (2013) European Chemicals Agency Registered Chemical Substances Search. Available at http://echa.europa.eu/web/guest/information-on-chemicals/registered-substances. [Accessed 31 October 2013]

EC (2000) European Commission Towards the establishment of a priority list of substances for further evaluation of their role in endocrine disruption, preparation of a candidate list of substances as a basis for priority setting, Final Report (Incorporating corrigenda to final report dated 21 June 2000).

HSDB (2009) Hazardous Substances Data Bank. Toxicology Data Network (TOXNET) Available at http://toxnet.nlm.nih.gov/cgi-bin/sis/search/f?./temp/~RXFIFI:1. [Accessed 31 October 2013.]

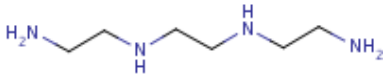
IARC (2013) International Agency for Research on Cancer Agents classified by IARC Monographs, Volumes 1-108. Available at http://monographs.iarc.fr/ENG/Classification/ClassificationsGroupOrder.pdf.

IPCS (2006) International Program on Chemical Safety. Fumaric acid summary. Available at http://www.inchem.org/documents/icsc/icsc/eics1173.htm [Accessed 31 October 2013)

NDF – No data found within the limits of the search strategy

Created by:	AES	Date: 6/12/2013
Reviewed and edited by:	LT Rev0	Date: 07/11/2013

Project number: 127666004
Project name: Hydraulic Stimulation Chemicals Assessment, Southwest Queensland
Client name: Santos Ltd

Name	Triethylemetetramine
Synonyms	TETA, 3,6-Diazaoctanethylenediamin
CAS number	112-24-3
Molecular formula	$C_6H_{18}N_4$
Molecular Structure	

Overview	Reference
Triethylemetramine (TETA) is a colourless to yellowish, moderately viscous, hygroscopic liquid which is completely miscible with water. It is the product of the reaction of aqueous ammonia with 1,2-dichloroethane. TETA uses include curing agent for epoxy resin, adhesive, binding agent, hardener for plastic. TETA is also used as intermediate for curing agents, for auxiliary agents (used in paper industry, textile industry and glue), for asphalt emulsifiers. TETA is not readily biodegradable and its target environmental niche is the hydrosphere. TETA is not expected to pass from water to air.	HSDB (2006) IPCS (2009) OECD (1998)

Human Health Toxicity Summary	Reference
Carcinogenicity Not assessed by IARC. The carcinogenic potential of this substance was assessed by applying 0.025 ml of a 5% aqueous solution to the back of 50 mice three times a week until the death of the animals. No treatment-related skin tumors were observed.	IARC (2013) OECD (1998)
Mutagenicity/Genotoxicity The genetic toxicity potential of TETA was assessed with in vivo and in vitro studies. While in vitro Ames test and mammalian cytogenetic tests showed positive genotoxicity, in vivo mouse micronucleus test following intraperitonal injections of 130 to 600 mg/kg bw showed negative genotoxic effects. Futhermore, negative effects were observed in another micronucleus test using oral application where mice received once 1500, 3000 and 6000 mg/kg bw. At the highest dose, a decrease in erythrocytes containing micronucleus was observed. In addition, no mutagenic activity was noted in the SLRL test in Drosophila melanogaster. Based on these findings, TETA is assumed to be not genotoxic.	OECD (1998)
Reproductive Toxicity No animal data on reproductive toxicity is available. However from experience with humans (substance used as a drug in the therapy of Wilsons disease), there are no evidence of reproductive toxic effects of TETA.	OECD (1998)
Developmental Toxicity/Teratogenicity No embryotoxic and teratogenic effects were observed in rabbits study. In a rat study where rats were dosed with 75, 375 and 750 mg/kg orally, no effects on dams and foetuses were observed except a slight increased foetal body weight.	OECD (1998)

Oral administration of TETA to pregnant rats dosed at 830 or 1670 mg/kg bw, resulted in increased foetal abnormalities in the highest dose group. These effects occurred when the copper content of the feed was simultaneously reduced suggesting that the developmental toxicity may have been a secondary consequence of the chelating properties of TETA.	
Endocrine Disruption TETA is not listed in the European Commission's Endocrine Disrupters Priority List.	EC (2000)
Acute Toxicity (oral, dermal, inhalation) TETA showed low acute toxicity via oral route on rats (LD_{50}> 2000 mg/kg) and moderate toxicity via dermal route on rabbits (LD_{50} = 550 - 805 mg/kg). As per the European Commission (EC) classification, TETA is classified as Xn = harmful; R21 = harmful in contact with skin.	OECD (1998) HSIS (2013)
Chronic/repeat dose toxicity (oral, dermal, inhalation) Subchronic (92d) studies in rats and mice received triethylenetetramine in drinking water at target concentrations of 0, 120, 600, 3000 ppm were conducted. Signs of toxicity (inflammation of the lung interstitium, hemapoetic cell proliferation of the spleen, liver periportal fatty infiltration, kidney weight reduction, reduced renal cytoplasmatic vacuolization and body weight gain reduction) were observed in mice at the highest concentration only. The NOAELs of 92 (male) mg/kg bw and 99 (female) mg/kg bw were reported. In a lifetime dermal toxicity study with mice (1.2 mg/mouse/d), no skin or other tumor types were observed.	OECD (1998)
Sensitisation of the skin or respiratory system Guinea Pig Maximization Test (GPMT) and Mouse Ear Swelling Test (MEST) were undertaken to assess the sensitization property of TETA. These studies concluded that TETA is a skin sensitizer for guinea pigs and mice. In addition, positive reactions to TETA were observed in skin tests carried out on workers exposed to epoxy resins. As per the European Commission (EC) classification, TETA is labelled R 43 = may cause an allergic skin reaction. No data found on respiratory sensitisation.	OECD (1998) HSIS (2013) IPCS (2009)
Corrosion (irreversible and reversible)/irritation of the skin or eye TETA is a severe irritant to eyes and skin. As per the EC classification, TETA is labelled C = corrosive and R34 = causes burn.	OECD (1998) HSIS (2013)

Physical Hazards	Reference
Flammable Potential TETA is a combustible liquid which gives off irritating or toxic fumes in a fire	IPCS (2009)
Explosive Potential Potential risk of fire and explosion on contact with oxidants.	IPCS (2009)

Toxicity Values	Value	Reference
Human Toxicity Data		
Acute Toxicity		
	NDF	

High Chronic/Repeat dose Toxicity		
Animal Toxicity Data		
Acute Toxicity		
LD_{50}		
Rat, oral	> 2000 mg/kg bw	OECD (1998)
Rat, dermal	NDF	
Rabbit, dermal	550 – 805 mg/kg bw	OECD (1998)
LOAEL	NDF	
LOAEC	NDF	
LC_{50}		
Rat	NDF	
High Chronic/Repeat dose Toxicity		
LOAEL	NDF	
NOAEL (mouse, oral)	92 mg/kg bw (male); 99 mg/kg bw (female)	OECD (1998)
LOAEC	NDF	

Footnotes:
LD_{50} – lethal dose for 50% of experimental population
LC_{50} – lethal air concentration for 50% of experimental population
LOAEL – Lowest Observed Adverse Effect Level
LOAEC – Lowest Observed Adverse Effect Concentration
NOAEL – No Observed Adverse Effect Level

Human Health Toxicity Ranking*		
	Hazard data	**Comment**
Hazard Band 4		
Carcinogenicity	No	OECD (1998)
Mutagenicity/Genotoxicity	No	OECD (1998)
Reproductive Toxicity	No	OECD (1998)
Developmental Toxicity/ Teratogenicity	No	OECD (1998)
Endocrine Disruption[1]	No	EC (2000)
Hazard Band 3		
Acute Toxicity (oral, dermal or inhalation) Very Toxic/Toxic • oral LD_{50} ≤ 300 mg/kg[2] • dermal LD_{50} ≤ 1000 mg/kg • inhalation LC_{50} ≤ 10 mg/L^3 (or mg/m^3) (vapour)	Yes	Dermal LD_{50} (rabbit) 550 – 805 mg/kg bw (OECD, 1998)
Possible carcinogenicity, mutagenicity, reproductive or High Chronic/repeat dose toxicity • oral LOAEL ≤ 10 mg/kg/d[3]; • dermal LOAEL ≤ 2 0 mg/kg/d; • inhalation LOAEC (6 h/d) ≤ 50 ppm/d for gases, ≤ 0.2 mg/L/d for vapours or ≤ 0.02 mg/L/d for dust/mists/fumes[3]	No	Oral NOAEL (mouse) > 10 mg/kg/day (92-99 mg/kg/day) ((OECD, 1998)
Corrosive (irreversible damage)	Yes	Labelled C = corrosive and R34 = causes burn (HSIS, 2013)
Respiratory sensitiser	NDF	May cause allergy or asthma symptoms or breathing difficulties if inhaled (IPCS 2009)
Hazard Band 2		
Harmful chronic/repeat dose toxicity • oral LOAEL > 10 mg/kg and ≤ 100 mg/kg/d • dermal LOAEL > 20 mg/kg/d and ≤ 200 mg/kg/d • inhalation (6-h/d) LOAEC > 50 mg/L ≤ 250 mg/L/d for gases, > 0.2 mg/L ≤ 1 .0 mg/L/d for vapours or > 0.02 mg/L ≤ 0.2 mg/L/d for dust/mists/fumes[3]	No	Classified R21 = harmful in contact with skin (HSIS, 2013)
Skin Sensitiser	Yes	Classified R 43 = may cause an allergic skin reaction (HSIS, 2013)
Hazard Band 1		
Acute Toxicity-Harmful • oral LD_{50} > 300 mg/kg ≤ 2000 mg/kg • dermal LD_{50} >1 000 mg/kg ≤ 2000 mg/kg; • inhalation LC_{50} (6 h/d) > 10 mg/L ≤ 20 mg/L for vapours)[3]	No	
Irritant (reversible damage)	Yes	Severe irritant to the skin and eyes (OECD, 1998)
Hazard Band 0 **All indicators outside criteria listed in Hazards 1-4**		

Physical Hazards		
Flammable potential	Yes	Combustible liquid (IPCS, 2009)
Explosive potential	Yes	Risk of fire and explosion in contact with oxidants (IPCS, 2009)
Hazard Evaluation (highest band) not including physical hazards	**Band 3**	
Uncertainty analysis /data confidence	13/13	**100%**

* Based on IMAP Framework [NICNAS (2013) Inventory Multi-tiered Assessment and Prioritisation (IMAP) Framework. National Industrial Chemicals Notification and Assessment Scheme. Department of Health and Aging, Canberra].

"[1]Based on list of endocrine disrupting chemicals from the European Commission's Endocrine Disrupters website.

[2]milligrams per kilogram body mass(mg/kg) or milligrams per kilogram body mas per day (mg/kg/d)

[3] Based on GHS cut-offs for hazard classification. For chronic/repeat dose toxicity, GHS cut-offs are provided as guidance values (i.e. the dose/concentration at or below which significant health effects are observed"). (p 18, NICNAS 2013).

Human Health Guidelines		
Media	**Concentration (mg/m^3; mg/L; mg/kg)**	**Reference**
Occupational Exposure Limits		
Air (OEL)		
8-h TWA	1.4 mg/m^3	HSIS (2013)
STEL	NDF	
Peak Limitation	NDF	
Environmental Exposure		
Air, ambient	NDF	
Air, indoor	NDF	
Water, potable	NDF	ADWG (2011)
Water, recreational	NDF	NEPM (1999 – amended)
Soil, residential	NDF	NEPM (1999 – amended)
Soil, commercial/industrial	NDF	NEPM (1999 – amended)

Footnotes:

OEL = Occupational Exposure Limit

TWA= 8 h Time-Weighted Average

STEL = (15 min) Short-term Exposure Limit

NDF - No data found within the limits of the search strategy.

Qualifying Summary Comments

Triethylenetetramine (TETA) is is a colourless to yellowish, moderately viscous, hygroscopic liquid which is completely miscible with water.

The carcinogenicity potential of TETA has not been assessed by IARC, but the results of a mouse study suggest that TETA is not a carcinogenic substance. Mutagenic/genotoxic effects were not observed in in-vivo studies however, some positive mutagenic/genotoxic effects were noted in some in-vitro tests. Reproductive toxicity data was not available for animals, but from experience with humans (substance used as a drug) there is no evidence of reproductive toxicity. No embryotoxic and teratogenic effects were observed in a rabbit study. In a rat study, increased foetal abnormalities were observed in the highest dose group (1670 mg/kg bw) when the copper content of the feed was simultaneously reduced. TETA is not listed on the European Commission's Endocrine Disrupters Priority List. Consequently TETA is not considered to be an endocrine disruptor. TETA is harmful in contact with skin. TETA is a skin sensitizer. Based on its dermal acute toxicity, corrosive and skin sensitisation properties, TETA falls in the Hazard Band 3 category.

References and Notes

ADWG (2011) Australian Drinking Water Guidelines. National Health and Medical Research Council. Available from http://www.nhmrc.gov.au/_files_nhmrc/publications/attachments/eh52_aust_drinking_water_guidelines.pdf

EC (2000) European Commission Towards the establishment of a priority list of substances for further evaluation of their role in endocrine disruption, preparation of a candidate list of substances as a basis for priority setting, Final Report (Incorporating corrigenda to final report dated 21 June 2000).

ECHA (2013). European Chemicals Agency Classification & Labelling Database. Available at http://echa.europa.eu/web/guest/information-on-chemicals/cl-inventory-database [Accessed 25 October 2013].

HSDB (2006) 'Triethylenetetramine'. Hazardous Substance Data Bank (HSDB), U.S. National Library of Medicine. Available at http://toxnet.nlm.nih.gov/cgi-bin/sis/search/r?dbs+hsdb:@term+@na+TRIETHYLENETETRAMINE. [Accessed 1 November 2013].

HSIS (2013) Hazardous Substances Information System. Available at http://hsis.safeworkaustralia.gov.au/HazardousSubstance [Accessed 1 November 2013].

IARC (2013) International Agency for Research on Cancer Agents classified by IARC Monographs, Volumes 1-108. Available at http://monographs.iarc.fr/ENG/Classification/ClassificationsGroupOrder.pdf.

IPCS (2009) International Programme on Chemical Safety 'ICSC 1123 – TRIETHYLENETETRAMINE'. Available at http://www.inchem.org/documents/icsc/icsc/eics1123.htm. [Accessed 1 November 2013].

NEPM (1999 - amended) National Environment Protection (Assessment of Site Contamination) Measure.

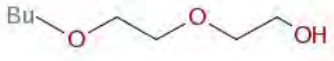
OECD (1998) Triethylene tetramine Cas No: 112-24-3. SIDS Initial Assessment Report and IUCLID Dataset Cas No: 112-24-3. Organization for Economic Cooperation and Development (OECD) Initial Assessment Reports for HPV Chemicals including Screening Information Data Sets (SIDS) as maintained by United Nations Environment Programme (UNEP) Chemicals. Available from http://www.chem.unep.ch/irptc/sids/OECDSIDS/112-24-3.pdf

Project number: 127666004
Project name: Hydraulic Stimulation Chemicals Assessment, Southwest Queensland
Client name: Santos Ltd

NDF – No data found within the limits of the search strategy

Created by:	JC	Date: 1/11/2013
Reviewed and edited by:	JF	Date: 08/11/2013

Project number: 127666004
Project name: Hydraulic Stimulation Chemicals Assessment, Southwest Queensland
Client name: Santos Ltd

Name	Butyl diglycol
Synonyms	2-(2-butoxyethoxy)ethanol, Diethylene glycol butyl ether (DEGBE).
CAS number	112-34-5
Molecular formula	$C_8H_{18}O_3$
Molecular Structure	

Overview	Reference
Butyl diglycol is the product of the reaction of ethylene oxide and n-butanol with an alkali catalyst. It is a colourless liquid with a neutral pH and a mild ether odour. It is miscible with oils and in water and evaporates slowly. Butyl diglycol is expected to have a very high mobility in soil as it is not expected to adsorb to solid or sediments. It is expected to exist only as vapour in the atmosphere and is biodegradable in aerobic environments. In 1999, the production of dutyl diglycol in Europe was about 44 000 tonnes per year. The uses of butyl diglycol include as a solvent in coatings and cleaning applications for industrial and consumer markets. Industrial markets include textile and printing industries. Butyl diglycol is also used as diluent in hydraulic brake fluid applications. It is also a chemical intermediate to produce diethylene glycol monobutyl ether acetate (DBA) and some herbicides, insecticides and plasticizers.	HSDB (2009) DEGBE (2010) Dow (2013)

Human Health Toxicity Summary	Reference
Carcinogenicity Not assessed by IARC.	IARC (2013)
Mutagenicity/Genotoxicity In vitro mammalian chromosome aberration test, Ames test, mammalian cell mutation test and in vivo micronucleus assay chromosome aberration test concluded that the substance did not exhibit any mutagenic activity under the conditions of the tests. ECHA has not reported this substance to be mutagenic or genotoxic.	ECHA (2013)
Reproductive Toxicity A two-generation study on mice and a one-generation study with rats concluded that this substance is not toxic to reproduction at the doses used during the tests. ECHA has not reported this substance to be toxic to reproduction.	ECHA (2013)
Developmental Toxicity/Teratogenicity Developmental toxicity studies on rabbits (dermal application), rats (feed) and mice (gavage) concluded that there was no evidence for developmental toxicity at the doses tested. ECHA has not reported this substance to be toxic to development.	ECHA (2013)
Endocrine Disruption	EC (2000a)

Not listed as an endocrine disruptor.	
Acute Toxicity (oral, dermal, inhalation) Acute toxicity data is beyond the thresholds established in Hazard Band 1, as per the GHS classification. ECHA has not reported this substance to be acutely toxic based on their classification methods.	ECHA (2013)
Chronic/repeat dose toxicity (oral, dermal, inhalation) Chronic toxicity data is beyond the thresholds established in Hazard Band 2 as per the GHS classification. ECHA has not reported this substance to be chronically toxic based on their classification methods.	ECHA (2013)
Sensitisation of the skin or respiratory system Not classified as a skin sensitiser. Data lacking regarding respiratory sensitisation.	ECHA (2013)
Corrosion (irreversible and reversible)/irritation of the skin or eye This substance causes reversible irritation of the eye (causes serious eye irritation. GHS classification, Eye Irritation. 2 H319)	ECHA (2013)

Physical Hazards	Reference
Flammable Potential Not classified as flammable.	ECHA (2013)
Explosive Potential Not classified as explosive.	ECHA (2013)

Toxicity Values	Value	Reference
Human Toxicity Data		
Acute Toxicity		
	No data found (NDF)	
High Chronic/Repeat dose Toxicity		
LOAEC	NDF	
LOAEL	NDF	
Animal Toxicity Data		
Acute Toxicity		
LD_{50}		
Rat, oral	3306 mg/kg	ECHA (2013)
Mouse, oral	2410 mg/kg (fasted animals) 5530mg/kg (fed animals)	ECHA (2013)
Rabbit, oral	2500 -3000 mg/kg	ECHA (2013)
Rat, dermal	NDF	
Rabbit, dermal	2764 mg/kg	ECHA (2013)
LOAEL	NDF	
LOAEC	NDF	
LC_{50}		
Rat	NDF	
High Chronic/Repeat dose Toxicity		
LOAEL (rat, oral)	650 mg/kg/day	ECHA (2013)
LOAEC (rat)	100-117 mg/m^3	EC (2000b)
NOAEL (rat, oral)	250 mg/kg/day	ECHA (2013)
NOAEC (rat)	94 mg/m^3	ECHA (2013)

Footnotes:
LD_{50} – lethal dose for 50% of experimental population
LC_{50} – lethal air concentration for 50% of experimental population
LOAEL – Lowest Observed Adverse Effect Level
LOAEC – Lowest Observed Adverse Effect Concentration
NOAEL – No Observed Adverse Effect Level

Human Health Toxicity Ranking*		
	Hazard data	**Comment**
Hazard Band 4		
Carcinogenicity	NDF	IARC (2013)
Mutagenicity/Genotoxicity	No	ECHA (2013)
Reproductive Toxicity	No	ECHA (2013)
Developmental Toxicity/ Teratogenicity	No	ECHA (2013)
Endocrine Disruption[1]	No	EC (2000a)
Hazard Band 3		
Acute Toxicity (oral, dermal or inhalation) Very Toxic/Toxic • oral LD_{50} ≤ 300 mg/kg[2] • dermal LD_{50} ≤ 1000 mg/kg • inhalation LC_{50} ≤ 10 mg/L^3 (or mg/m^3) (vapour)	No	ECHA (2013)
Possible carcinogenicity, mutagenicity, reproductive or High Chronic/repeat dose toxicity • oral LOAEL ≤ 10 mg/kg/d[3]; • dermal LOAEL ≤ 20 mg/kg/d; • inhalation LOAEC (6 h/d) ≤ 50 ppm/d for gases, ≤ 0.2 mg/L/d for vapours or ≤ 0.02 mg/L/d for dust/mists/fumes[3]	Yes	ECHA (2013)(NDF regarding carcinogenicity)
Corrosive (irreversible damage)	No	ECHA (2013)
Respiratory sensitiser	NDF	
Hazard Band 2		
Harmful chronic/repeat dose toxicity • oral LOAEL > 10 mg/kg and ≤ 100 mg/kg/d • dermal LOAEL > 20 mg/kg/d and ≤ 200 mg/kg/d • inhalation (6-h/d) LOAEC > 50 mg/L ≤ 250 mg/L/d for gases, > 0.2 mg/L ≤ 1 .0 mg/L/d for vapours or > 0.02 mg/L ≤ 0.2 mg/L/d for dust/mists/fumes[3]	No	ECHA (2013)
Skin Sensitiser	No	ECHA (2013)
Hazard Band 1		
Acute Toxicity-Harmful • oral LD_{50} > 300 mg/kg ≤ 2000 mg/kg • dermal LD_{50} >1 000 mg/kg ≤ 2000 mg/kg; • inhalation LC_{50} (6 h/d) > 10 mg/L ≤ 20 mg/L for vapours)[3]	No	ECHA (2013)
Irritant (reversible damage)	Yes	ECHA (2013)
Hazard Band 0 **All indicators outside criteria listed in Hazards 1-4**		
Physical Hazards		
Flammable potential	No	ECHA (2013)
Explosive potential	No	ECHA (2013)
Hazard Evaluation (highest band) not including physical hazards	Hazard Band 3	
Uncertainty analysis /data confidence	11/13	**85 %**

* Based on IMAP Framework [NICNAS (2013) Inventory Multi-tiered Assessment and Prioritisation (IMAP) Framework. National Industrial Chemicals Notification and Assessment Scheme. Department of Health and Aging, Canberra].

"[1]Based on list of endocrine disrupting chemicals from the European Commission's Endocrine Disrupters website.

[2]milligrams per kilogram body mass(mg/kg) or milligrams per kilogram body mas per day (mg/kg/d)

[3] Based on GHS cut-offs for hazard classification. For chronic/repeat dose toxicity, GHS cut-offs are provided as guidance values (i.e. the dose/concentration at or below which significant health effects are observed"). (p 18, NICNAS 2013).

Human Health Guidelines		
Media	**Concentration (mg/m^3; mg/L; mg/kg)**	**Reference**
Occupational Exposure Limits		
Air (OEL)		
8-h TWA	NDF	
STEL	up to 100 mg/ m^3	EC (2000b)
Peak Limitation	NDF	
Environmental Exposure		
Air, ambient	NDF	
Air, indoor	NDF	
Water, potable	NDF	ADWG (2011)
Water, recreational	NDF	NEPM (1999 – amended)
Soil, residential	NDF	NEPM (1999 – amended)
Soil, commercial/industrial	NDF	NEPM (1999 – amended)

Footnotes:

OEL = Occupational Exposure Limit

TWA= 8 h Time-Weighted Average

STEL = (15 min) Short-term Exposure Limit

NDF - No data found within the limits of the search strategy.

Qualifying Summary Comments

Butyl diglycol is a colourless liquid. It is miscible with water and oils and evaporates slowly. Butyl diglycol can cause severe eye irritation. It has a low order of acute oral toxicity but moderate chronic toxicity following inhalation. Butyl diglycol is not classified as a carcinogen, mutagen or reproductive toxicant. On the basis of chronic inhalation concerns it is categorised as Hazard Band 3. A broad range of toxicological data has been identified providing some confidence to the report of the chronic inhalation toxicity and irritancy properties being the main concern for this chemical. On this basis and taking into account the rapid degradation in the environment under aqueous conditions, the public health concerns are restricted to occupational exposures from direct contact and inhalation to the pure product and emergency spill settings as specific environmental concerns for public health.

References

ADWG (2011) Australian Drinking Water Guidelines. National Health and Medical Research Council. Available from http://www.nhmrc.gov.au/_files_nhmrc/publications/attachments/eh52_aust_drinking_water_guidelines.pdf

DEGBE (2010). Diethylene Glycol Monobutyl Ether. California Environmental Protection Agency. Draft Interim REL March 2010. Available from http://www.arb.ca.gov/consprod/regact/2010ra/degbe112345.pdf

Dow(2013). *Product Safety Assessment (PSA): Diethylene Glycol Butyl Ether.* The Dow Chemical Company . Available from http://www.dow.com/productsafety/finder/dgbe.htm [Accessed on 8 October 2013].

ECHA (2013) European Chemicals Agency Registered Chemical Substances Search. Available at http://echa.europa.eu/web/guest/information-on-chemicals/registered-substances. [Accessed 2 October 2013].

EC (2000a) European Commission Towards the establishment of a priority list of substances for further evaluation of their role in endocrine disruption, preparation of a candidate list of substances as a basis for priority setting, Final Report (Incorporating corrigenda to final report dated 21 June 2000).

EC (2000b) European Commission Joint Research Center. European Chemicals Bureau (ECB, 2000). European Union Risk Assessment Report 2-(2-butoxyethoxy)ethanol. Institute for Health and Consumer Protection, 1St Priority List Volume 2. Available from http://echa.europa.eu/documents/10162/6434698/orats_final_rar_2-2-butoxyethoxyethanol_en.pdf .

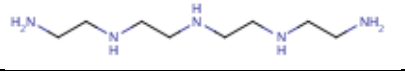
HSDB (2009) Hazardous Substances Data Bank. Toxicology Data Network (TOXNET) Available at http://toxnet.nlm.nih.gov/cgi-bin/sis/htmlgen?HSDB. [Accessed 8 October 2013.]

IARC (2013) International Agency for Research on Cancer Agents classified by IARC Monographs, Volumes 1-108. Available at http://monographs.iarc.fr/ENG/Classification/ClassificationsGroupOrder.pdf.

NEPM (1999 - amended) National Environment Protection (Assessment of Site Contamination) Measure 1999

Created by:	JC	Date: 8/10/2013
Reviewed and edited by:	LT	Date 21/10/2013 Rev0

Project number: 127666004
Project name: Hydraulic Stimulation Chemicals Assessment, Southwest Queensland
Client name: Santos Ltd

Name	Tetraethylenepentamine
Synonyms	1. N-(2-Aminoethyl)-N-(2-((2-aminoethyl)amino)ethyl-1,2-ethanediamine) 2. 1,2-ETHANEDIAMINE, N-(2-AMINOETHYL)-N'-(2-((2-AMINOETHYL)AMINO)ETHYL) 3. 1,4,7,10,13-PENTAAZATRIDECANE 4. 3,6,9-TRIAZAUNDECANE-1,11-DIAMINE
CAS number	112-57-2
Molecular formula	C_8-H_{23}-N_5
Molecular Structure	

Overview	Reference
Tetraethylenepentamine (TEPA) is a polyamine organic compound as it has two or more primary amino groups $–NH_2$. TEPA is a viscous and hygroscopic yellow liquid. It is an alkaline liquid which is soluble in most organic solvents and water. It has a molecular weight of 189.31 and a specific gravity of 0.9980 (at 20°C). TEPA has a boiling temperature of 340.30°C (at 760 mm hg) and a melting temperature of -30°C. TEPA does not occur naturally but is produced only from the ethylene dichloride (EDC) process, which is a reaction of EDC and ammonia. The process involves a reaction of aqueous ammonia with 1,2-dichlotoethane followed by neutralisation (e.g. with aqueous caustic soda) and fractional distillation. TEPA is used primarily as a closed system intermediate in the synthesis of other products which are involved in the manufacturing of lubricating oil additives, fuel additives, paints and asphalt adhesives. In developing hazard classifications for 'Amines, polyethylenepoly-, tetraethylenepentamine fraction' which has a CAS# 90640-66-7 ECHA used hazard data for amine compounds including 'Tetraethylenepentamine' (CAS# 90640-66-7). For some of the human health toxicity summaries below read across interpretations from studies undertaken on triethylenetetramine (TETA) have been considered. TEPA is similar toxicologically to TETA based on its structure and chelation properties and therefore TETA is an appropriate surrogate. TETA (molecular formula C6H15N4), is a yellow, moderately viscous liquid. It is completely soluble in water and is also soluble in alcohols and acids. As TETA has less amino groups it has a slightly smaller molecular weight of 146.24 and a density of 0.9818 at 20°C. Its boiling point is 266-267°C at 760 mm hg and melting point is 12°C.	HSDB (2003) HSDB (2002) SIDS (2001)

Human Health Toxicity Summary	Reference
Carcinogenicity Based on the GHS classification criteria Tetraethylenepentamine is not classifiable as to its carcinogenicity to humans. A search on the International Agency for Research on Cancer (IARC) website did not reveal any information on Tetraethylenepentamine. *Notes:* The GHS carcinogenicity classification for TEPA is based on a read across studies using TETA.	ECHA (2013)

The dermal carcinogenic potential of TETA was assessed by applying 25 µl of a 5% (v/v) solution in deionized water to the backs of 50 male mice three times a week until the death of the animals. No treatment-related skin tumors were observed and therefore TETA was not locally carcinogenic when applied to the skin of mice. In another dermal study TETA was applied to the skin of male mice (50/group) at concentrations of 0, 0.2, or 2% (w/w) in ethanol, 3 times a week for up to 2 years. Although malignant cutaneous tumors were noted in both control and treated groups none were located at the site of application of the test material. Four of the five observed cutaneous tumors were on the ear associated with the metal ear tag, and one fibrosarcoma was present on the tail of a high dose mouse. Therefore none of the tumors were interpreted as related to dermal administration of TETA.	
Mutagenicity/Genotoxicity Not classified as a mutagenic/genotoxic chemical. *Notes:* The genetic toxicity classification for TEPA is based on read across in-vivo studies using TETA. TETA was injected and evaluated for potential clastogenic (chromosome-damaging) activity with the in-vivo micronucleus test system using both female and male mice. Test results showed that TETA was not an active agent in producing treatment-related increases in micronuclei in male and female mice. In another study, fifty chemicals, including TETA, were tested for mutagenic activity in post-meiotic and meiotic germ cells of male Drosophila melanogaster using the sex linked recessive lethal (SLRL) assay. Feeding was chosen as the first route of administration followed by injection. TETA was ambiguous after feeding and negative after injection. In a third study TETA was administered in a single intraperitoneal dose of 150 mg/kg to mice. Results from the micronucleus determination demonstrated that TETA did not produce an increase in the incidence of micronuclei in peripheral blood polychromatic erythrocytes of the test animals at any of the sample periods tested. The absence of positive effects of TETA upon the incidence of micronuclei indicates that TETA does not possess clastogenic activity in vivo under the test conditions. However, some in-vitro studies for both TEOA and TETA have shown mutagenic effects. TEPA was evaluated for potential genotoxic activity using the Sister Chromatid Exchange (SCE) test in Chinese hamster ovary (CHO) cells. Although one of the samples produced dose-related and statistically significant increases in the incidence of SCEs in the CHO cells the increases were small and were seen at concentration levels close to cytotoxicity producing an ambiguous positive genotoxic effect in this test. In an in-vitro study TETA was tested for potential mutagenic activity using the Salmonella/microsome bacterial mutagenicity assay (Ames test). Due to growth inhibition TETA was considered to be mutagenic in this in-vitro bacterial study. Although these two in-vitro studies indicate some potential for positive genetic effects the in-vivo TETA studies did not show any potential for mutagenic effects.	ECHA (2013)
Reproductive Toxicity Not classified as having reproductive toxicity effects. *Notes:* There are no reproductive toxicity studies available for TEPA but there is one study for TETA. TETA which was administered in drinking water to female and male rats and mice. A complete histopathologic examination, including reproductive organs, was conducted. TETA data showed no effects on reproductive organs in rats up to 276 mg/kg/day (males) and 352 mg/kg/day (females) and in mice (up to 500 mg/kg/day) when administered in drinking water.	SIDS (2001)
Developmental Toxicity/Teratogenicity Inferred to have no developmental/teratogenic effects.	

Notes: The developmental/teratogenic classification is based on TETA studies. TETA was orally administered to timed-pregnant rats at at dosages of 75, 325 or 750 mg/kg per day. The test substance was devoid of any embryotoxic activity and did not reveal teratogenic potential in the rat under the present experimental conditions. In another TETA study, timed-pregnant rabbits were treated with TETA by occluded cutaneous application at dosages of 5.0, 50.0 or 125.0 mg/kg per day. TETA produced maternal toxicity at the 125.0 mg/kg dose but no developmental toxicity (including teratogenicity) was observed at any dosages employed. Although no developmental/ teratogenic effects were noted with the above two studies this was not the case with two studies using TETA dihydrochloride and triethylenetetramine tetrachlorhydrate. The effects noted for these two studies are discussed below. Pregnant mice received 3000, 6000 or 12000 ppm to TETA dihydrochloride in the drinking water on days 6-15 of gestation. At levels greater than 3000 ppm, foetal resorptions, reduced foetal and cerebral weight, brain malformations and decreased copper concentration in maternal liver were observed. Sample size was too small to determine whether maternal toxicity occurred. A study using triethylenetetramine tetrachlorhydrate (TETA.4HCl) showed teratogenic effects in rats. TETA.4HCl was fed during pregnancy (day 0 -21) at levels of 0 (control), 0.17, 0.83, or 1.66%. The frequency of resorptions and the frequency of abnormal foetuses at term increased with increasing levels of the substance. Maternal and foetal tissue copper levels were significantly lower in the TETA.4HCl groups than in controls, with levels decreasing in a dose-related manner. Maternal kidney and fetal liver zinc levels increased within the TETA.4HCl groups in a dose-related manner. Maternal liver iron was increased in the high-dose group compared to controls. Fetal iron concentration and maternal and fetal manganese level were not significantly affected by the drug. These results show that TETA.4HCl can be a teratogenic agent in the presence of maternal toxicity..	ECHA (2013) SIDS (2001)
Endocrine Disruption Tetraethylenepentamine has not been included in the European Commission's Endocrine Disrupters Priority List.	ECED (2013)
Acute Toxicity (oral, dermal, inhalation) TEPA is harmful if swallowed (GHS Acute Toxicity 4 H302) and when in contact with the skin (GHS Acute Toxicity 4 H312). *Notes:* <u>Oral</u> TEPA was orally administered via intubation to five male rats per dose group of 2.0, 4.0 and 8.0 mL/kg. The respective death per each group was 0/5, 4/5 and 5/5. The LD50 was determined to be 3.25 mL/kg. Based on using a specific gravity of 0.998 for TEPA this converts to 3244 mg/kg. In another acute oral TEPA study five female rats were administered 1.0, 2.0, 3.98, 7.95 g/kg of a 39.8% solution in water and observed for two weeks. A LD50 of 2140 mg/kg was determined. However it is not considered a reliable study as it was performed pre-GLP and pre-guideline, it had limited reporting and no information on the composition or purity of the test substance. Two read across studies can also be considered using the surrogate TETA. In the first acute oral toxicity study TETA was administered to rats at doses of 800, 1250, 1600 or 2000 mg/kg. The acute oral LD50 for males, females and combined sexes was determined to be 1861.9 mg/kg, 1591.4 mg/kg and 1716.2 mg/kg, respectively. In a second read across rat study using TETA, an LD50 value was estimated to be ca. 1400 mg/kg. <u>Dermal</u> TEPA was applied directly onto the skin of two to four male rabbits at dose levels of 1.0, 2.0, and 4.0 mL/kg. The respective death per group were 1/4, 4/4 and 2/. The acute dermal LD50 was	ECHA (2013) SIDS (2001)

calculated to be 1.26 mL/kg. Based on using a specific gravity of 0.998 for TEPA this converts to 1257mg/kg. In another dermal acute toxicity rabbit study the LD50 was 660 mg/kg. The higher toxicity via the dermal route is most likely due to the corrosive nature of TEPA to the skin whereas TEPA would be neutralized by stomach acid. In a read across dermal study TETA was applied to the skin of New Zealand White rabbits at concentrations of 1000, 2000 and 3000 mg/kg with a 14 day observation period. The acute dermal LD50 in male rabbits and combined sexes was determined to be 1720 mg/kg and 1465.4 mg/kg, respectively. <u>Inhalation</u> In an acute inhalation toxicity rat study with saturated vapor and whole body exposure, the LC50 was calculated to be >9.9 ppm as this was the highest dose tested.	
Chronic/repeat dose toxicity (oral, dermal, inhalation) Repeat dose studies show oral and dermal effects. *Notes:* <u>Oral</u> TEPA was orally administered to 5 male and female rats. At the highest doses given to the rats (3990 mg/kg for males and 3630 mg/kg for females) the following were observed: decrease in food intake, body weight loss, decreased absolute and relative liver weight and decreased relative kidney weight. The NOAEL of this 7-day diet study, based on a limited numbers of parameters was 2800 mg/kg and 3140 mg/kg for males and females, respectively. Due to these effects described the LOAEL for males and females is inferred to be 3990 mg/kg and 3630 mg/kg respectively. In another repeat dose study TETA was administered in drinking water to male and female rats for 90-92 days. The NOEL was 276 mg/kg/day in males and 352 mg/kg/day in females, the highest dose administered in the study. In this same study in mice the NOEL was 487 mg/kg in males and 551 mg/kg in females, the highest dose administered. <u>Dermal</u> TEPA was applied to the skin of 5 male and 5 female rabbits at doses of 50, 100 or 200 mg/kg for approximately 6 hours per day, 5 days a week for a period of 31 days. At 100 and 200 mg/kg the only lesions noted were skin lesions with the degree of irritation being dose-related (i.e. effects in the 200 mg/kg group were generally more severe than in the 100 mg/kg group). Because no changes were observed in the 50 mg/kg group, the NOEL was 50 mg/kg with an inferred LOAEL of 100 mg/kg. A lifetime study was conducted via dermal administration in fifty male mice with a solution of 35% TEPA. There were 20 cases of hyperkeratosis, 13 cases of epidermal necrosis and no evidence of dermal hyperplasia.	ECHA (2013) SIDS (2001)
Sensitisation of the skin or respiratory system May cause an allergic skin reaction (GHS classification Skin Sensitiser 1 H317). *Notes:* A group of nine alkyleneamines were investigated for their potential to induce skin sensitisation and to cross-react with one another to elicit a hypersensitivity response. The sensitising potency was inversely correlated with the number of amine units. Cyclic amines had a lower sensitising potency than the corresponding olefinic amines. The results suggest that there was a direct correlation of the potencies to cause sensitisation and cross-sensitisation in this family of alkyleneamines. From the results of this study it was concluded that Tetraethylenepentamine is a skin sensitiser.	ECHA (2013)

A read across skin sensitisation study involved skin application of the surrogate TETA to guinea pigs at a dose of 0.3 ml/site area. At the first reading (24 hours after), 18/20 animals showed skin reactions and at the second reading (48 hours after), 19/20 animals were positive. It was therefore concluded that TETA is a skin sensitiser. In terms of human studies exposure to low molecular polyamines, including tetraethylenepentamine, during road paving was investigated. Fatty amine wetting agents are used to increase adhesion in bitumen emulsions used in road paving however commercially produced fatty amines are contaminated with low molecular polyamines and alkanol polyamines which are released from the hot bitumen during paving. The highest concentration of TEPA (which is present at low levels in these products) measured during road paving was 0.05 mg/m3 As polyamines and alkanol polyamines are known to cause eye and respiratory tract irritation and skin sensitisation it was concluded they may contribute to the symptoms experienced by the road pavers.	
Corrosion (irreversible and reversible)/irritation of the skin or eye Causes severe skin burns and eye damage (GHS Skin Corrosion 1B H314) Causes serious eye damage (GHS Eye Damage 1 H318) *Notes:* <u>Skin</u> TEPA was applied to the skin of five rabbits at a volume of 0.01 ml and observed for at least up to 24 hour. One rabbit showed moderate erythema, a second rabbit showed marked erythema whereas the other 3 showed moderate necrosis. Due to 3 out of 5 rabbits showing moderate necrosis TEPA has the potential to cause a severe skin burns. Read across studies can also be considered using the surrogate TETA. TETA was applied undiluted directly on the intact and abraded skin sites of 3 male and 3 female New Zealand White rabbits. It was applied at a concentration of 0.5 mL/ site (6 m²) for 3 minutes, 60 minutes, 4hours or 24 hours. Necrosis was observed after a 3 minute exposure. The animals that had been exposed for 60 minutes, 4 hours, or 24 hours scored 4 (necrosis) for erythema and edema immediately after unwrapping. Severe erythema and severe edema remained present in all animals at all observation periods during the study (up to 14 days). In another dermal study TETA was applied to rabbits for 1, 5, 15 minutes and 20 hours. Effects were examined after 10 minutes, 1, 24, 48, 72 hours as well as after 8 days. After a 15 min or 20 h exposure soft necrosis (24 hour evaluation) was observed which turned into a leathery necrosis at the end of the observation period. It was concluded that TETA caused necrosis after a 15 minute exposure. <u>Eye</u> TEPA was applied undiluted at a volume of 0.02 mL to the conjunctival sac of five rabbits. Rabbits showed moderate corneal injury with 1/5 rabbits showing iritis. A volume of 0.005 mL per eye showed minor injury. Because a volume of 0.02 ml was used, it is expected that the amount required according the current OECD guideline (0.1 mL) will induce more severe eye injury and therefore TEPA is considered to be at least 'highly irritating'. Due to lack of information when using a volume of 0.1 mL, and on reversibility, classification in OECD-GHS categories is not possible. <u>Respiratory effects</u> As well as being corrosive to the eyes and the skin TEPA is also irritating to the respiratory tract. Under short-term exposure inhalation of mist may cause severe swelling of the throat.	ECHA (2013) IPCS (2008)

Physical Hazards	Reference
Flammable Potential Combustible. Gives off irritating or toxic fumes (or gases) in a fire.	IPCS (2008)
Explosive Potential	All

No data found.	proposed data sources.

Toxicity Values	Value	Reference
Human Toxicity Data		
Acute Toxicity		
	No data found.	All proposed data sources
High Chronic/Repeat dose Toxicity		
Animal Toxicity Data		
Acute Toxicity		
LD_{50}		
Rat, oral	3244 mg/kg (male; TEPA) 2140 mg/kg (female; TEPA) 1861.9 mg/kg (male;TETA) 1591.4 mg/kg (female; TETA) 1716.2 (combined sex; TETA) Ca. 1400 mg/kg (TETA)	ECHA (2013)
Rat, dermal		
Rabbit, dermal	1257 mg/kg (male; TEPA) 660 mg/kg (TEPA) 1720 mg/kg (male; TETA) 1465.4 mg/kg (combined sex; TETA)	ECHA (2013) SIDS(2001)
Inhalation	>9.9 ppm (rat)	SIDS (2001)
LOAEL		
LOAEC		
LC_{50}		
Rat	No data found.	All proposed data sources
High Chronic/Repeat dose Toxicity		
LOAEL	3390 mg/kg (male rats, oral; TEPA, 7 day study) 3630 mg/kg (female rats, oral; TEPA 7 day study) 100 mg/kg (dermal; TEPA, 90 day study)	ECHA (2013)
LOAEC	No data found.	All proposed data sources

Footnotes:
LD_{50} – lethal dose for 50% of experimental population
LC_{50} – lethal air concentration for 50% of experimental population
LOAEL – Lowest Observed Adverse Effect Level
LOAEC – Lowest Observed Adverse Effect Concentration
NOAEL – No Observed Adverse Effect Level

Human Health Toxicity Ranking*		
	Hazard data	**Comment**
Hazard Band 4		
Carcinogenicity	NO	Based on dermal studies using TETA
Mutagenicity/Genotoxicity	NO	Based on in-vivo studies using TETA. Acknowledged that in-vitro PETA and TETA studies show positive mutagenic effects.
Reproductive Toxicity	NO	
Developmental Toxicity/ Teratogenicity	NO	Based on TETA studies. However, developmental/ teratogenic effects were noted with the two studies using TETA dihydrochloride and triethylenetetramine tetrachlorhydrate
Endocrine Disruption[1]	NO	
Hazard Band 3		
Acute Toxicity (oral, dermal or inhalation) Very Toxic/Toxic • oral $LD_{50} \leq 300$ mg/kg[2] • dermal $LD_{50} \leq 1000$ mg/kg • inhalation $LC_{50} \leq 10$ mg/L^3 (or mg/m^3) (vapour)	NO	
Possible carcinogenicity, mutagenicity, reproductive or High Chronic/repeat dose toxicity • oral LOAEL ≤ 10 mg/kg/d[3]; • dermal LOAEL ≤ 2 0 mg/kg/d; • inhalation LOAEC (6 h/d) ≤ 50 ppm/d for gases, ≤ 0.2 mg/L/d for vapours or ≤ 0.02 mg/L/d for dust/mists/fumes[3]	NO	
Corrosive (irreversible damage)	YES	Causes severe skin burns and serious eye damage.
Respiratory sensitiser	NO	Short-term exposure can cause respiratory tract irritation as inhalation of mist may cause severe swelling of the throat.
Hazard Band 2		
Harmful chronic/repeat dose toxicity • oral LOAEL > 10 mg/kg and ≤ 100 mg/kg/d • dermal LOAEL > 20 mg/kg/d and ≤ 200 mg/kg/d • inhalation (6-h/d) LOAEC	YES	Dermal LOAEL of100 mg/kg

> 50 mg/L ≤ 250 mg/L/d for gases, > 0.2 mg/L ≤ 1 .0 mg/L/d for vapours or > 0.02 mg/L ≤ 0.2 mg/L/d for dust/mists/fumes [3]		
Skin Sensitiser	YES	May cause an allergic skin reaction.
Hazard Band 1		
Acute Toxicity-Harmful • oral LD_{50} > 300 mg/kg ≤ 2000 mg/kg • dermal LD_{50} >1 000 mg/kg ≤ 2000 mg/kg; • inhalation LC_{50} (6 h/d) > 10 mg/L ≤ 20 mg/L for vapours)[3]	YES	
Irritant (reversible damage)	YES	
Hazard Band 0 **All indicators outside criteria listed in Hazards 1-4**		
Physical Hazards		
Flammable potential	YES	
Explosive potential	No data found.	
Hazard Evaluation (highest band) not including physical hazards	**Hazard Band 3**	
Uncertainty analysis /data confidence	13/13	**100%**

* Based on IMAP Framework [NICNAS (2013) Inventory Multi-tiered Assessment and Prioritisation (IMAP) Framework. National Industrial Chemicals Notification and Assessment Scheme. Department of Health and Aging, Canberra].

"[1]Based on list of endocrine disrupting chemicals from the European Commission's Endocrine Disrupters website.

[2]milligrams per kilogram body mass(mg/kg) or milligrams per kilogram body mas per day (mg/kg/d)

[3] Based on GHS cut-offs for hazard classification. For chronic/repeat dose toxicity, GHS cut-offs are provided as guidance values (i.e. the dose/concentration at or below which significant health effects are observed"). (p 18, NICNAS 2013).

Human Health Guidelines		
Media	**Concentration (mg/m^3; mg/L; mg/kg)**	**Reference**
Occupational Exposure Limits		
Air (OEL)		
8-h TWA	No data found.	All proposed data sources
STEL	No data found.	All proposed data sources
Peak Limitation	No data found.	All proposed data sources
Environmental Exposure		
Air, ambient	No data found.	All proposed data sources
Air, indoor	No data found.	All proposed data sources
Water, potable	No data found.	All proposed data sources
Water, recreational	No data found.	All proposed data sources
Soil, residential	No data found.	All proposed data sources
Soil, commercial/industrial	No data found.	All proposed data sources

Footnotes:

OEL = Occupational Exposure Limit

TWA= 8 h Time-Weighted Average

STEL = (15 min) Short-term Exposure Limit

NDF - No data found within the limits of the search strategy.

Qualifying Summary Comments

Tetraethylenepentamine (TEPA) is a polyamine organic compound. It is an alkaline, viscous and hygroscopic yellow liquid. For some of the human health toxicity summaries read across interpretations from studies undertaken on triethylenetetramine (TEPA) have been considered. TEPA is similar toxicologically to TETA based on its structure and chelation properties and therefore TETA is an appropriate surrogate. In all of the studies summarised it has been indicated where TETA has been used.

TEPA is not classifiable as to its carcinogenicity to humans. In-vivo studies did not indicate mutagenic/genotoxic effects however mutagenic/genotoxic are noted in some in-vitro tests. Reproductive toxicity testing has been conducted in rats and mice (only one study in each species) in which no effects were noted on reproductive organs. Developmental toxicity/teratogenicity is not noted for the surrogate TETA however, developmental/ teratogenic effects were noted in two studies using TETA dihydrochloride and triethylenetetramine tetrachlorhydrate. Neither TEPA nor TETA are listed on the European Commission's Endocrine Disrupters Priority List and therefore TEPA is not considered an endocrine disrupter. TEPA is harmful if swallowed or when in contact with the skin. Repeat dose studies have shown oral and dermal effects such as decreased body weight, decreased liver and kidney weight and skin lesions. TEPA may cause an allergic skin reaction with an absence of data for the respiratory system sensitisation. Short-term exposure can cause respiratory tract irritation as inhalation of mist may cause severe swelling of the throat. Due to TEPA's ability to cause severe skin burns and serious eye damage it has been categorised as hazard band 3.

References and Notes

ECED (2013) European Commission's Endocrine Disrupters Priority List. Available at http://ec.europa.eu/environment/chemicals/endocrine/strategy/substances_en.htm#priority_list [Accessed 29 October 2013]

ECHA (2013) (European Chemicals Agency) Registered Substances List. Available at http://apps.echa.europa.eu/registered/data/dossiers/DISS-97d9b8de-919d-0fc7-e044-00144f67d031/AGGR-9151a308-e978-4f0f-93c0-24147e440982_DISS-97d9b8de-919d-0fc7-e044-00144f67d031.html#L-b05dc300-087c-4b97-8a74-507116721cb4 [Accessed 29 October 2013]

HSDB (2002). 'Triethylenetetramine'. Hazardous Substance Data Bank (HSDB), U.S. National Library of Medicine. Available at http://toxnet.nlm.nih.gov/cgi-bin/sis/search/f?./temp/~V4ZvQU:1 [Accessed 28 October 2013]

HSDB (2003). 'Tetraethylenepentamine'. Hazardous Substance Data Bank (HSDB), U.S. National Library of Medicine. Available at http://toxnet.nlm.nih.gov/cgi-bin/sis/search/f?./temp/~f6LyTi:1 [Accessed 29 October 2013]

IPCS (2008). International Programme on Chemical Safety 'ICSC 1718 – TETRAETHYLENEPENTAMINE'. Available at http://www.inchem.org/documents/icsc/icsc/eics1718.htm [Accessed 30 October 2013]

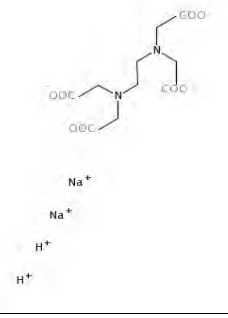
SIDS (2001). OECD SIDS 'Initial Assessment Report For 13th SIAM', Tetraethylenepentamine. Available at

http://www.inchem.org/documents/sids/sids/Tetraethylenepentamine.pdf [Accessed 30 October 2013]

NDF – No data found within the limits of the search strategy

Created by:	JH	Date: 30/10/13
Reviewed and edited by:	JF	Date: 08/11/2013

Project number: 127666004
Project name: Hydraulic Stimulation Chemicals Assessment, Southwest Queensland
Client name: Santos Ltd

Name	Disodium Ethylene Diamine Tetra Acetate (impurity)
Synonyms	Ethylenediaminetetraacetic acid disodium salt, EDTA disodium salt, Na2 EDTA
CAS number	139-33-3
Molecular formula	C10H16N2O8.2Na
Molecular Structure	

Overview	Reference
Disodium Ethylene Diamine Tetra Acetate (EDTA) is an EDTA salt. EDTA is a binding agent with affinity for metals. Uses of disodium EDTA include food additive and component of sanitizing solutions (for use on food processing equipment). It is also used as a stabilizer for vitamin B12, promoter for color retention, and as a cure accelerator with sodium ascorbate or ascorbic acid. EDTA salts are also used in cosmetics. Disodium EDTA is low order of acute toxicity (harmful if swallowed) and the principal health effect is severe eye irritation Disodium EDTA is soluble in water and doesn't adsorb strongly to soil and sediments. It is biodegradable under certain conditions.	US EPA, 2004

Human Health Toxicity Summary	Reference
Carcinogenicity Not classified as carcinogen	ECHA, 2013
Mutagenicity/Genotoxicity Not classified as genotoxic	ECHA, 2013
Reproductive Toxicity Not classified as toxic to reproduction	ECHA, 2013
Developmental Toxicity/Teratogenicity Not classified as toxic to embryo development	ECHA, 2013
Endocrine Disruption Not listed as an Endocrine Disruptor	ECa, 2000

Acute Toxicity (oral, dermal, inhalation) Harmful if swallowed	ECHA, 2013
Chronic/repeat dose toxicity (oral, dermal, inhalation) Not classified as chronic toxic	ECHA, 2013
Sensitisation of the skin or respiratory system Not classified as sensitiser to skin or respiratory system	ECHA, 2013
Corrosion (irreversible and reversible)/irritation of the skin or eye In general, EDTA and its salts are mild skin irritants but considered severe eye irritants.	US EPA 2004

Physical Hazards	Reference
Flammable Potential Not classified as flammable (in its solid form)	ECHA, 2013
Explosive Potential Not classified as explosive	ECHA, 2013

Toxicity Values	Value	Reference
Human Toxicity Data		
Acute Toxicity		
	No data found (NDF)	
High Chronic/Repeat Dose Toxicity		
LOAEC	NDF	
LOAEL	NDF	
Animal Toxicity Data		
Acute Toxicity		
LD_{50}		
Rat, oral	> 2000 mg/kg bw	OECD, 2012
Mouse, oral	2050 mg/kg	US EPA, 2004
Rabbit, oral	2300 mg/kg bw	IPCS, 1974
Rat, dermal	NDF	
Rabbit, dermal	NDF	
Mouse, dermal	NDF	
LOAEL	NDF	
LOAEC	NDF	
LC_{50}		
Rat		
High Chronic/Repeat Dose Toxicity		
LOAEL	NDF	
LOAEC	NDF	
NOAEL (mouse, oral)	>= 500 mg/kg bw/day	ECHA, 2013
NOAEL (rat, oral)	692 mg/kg bw/day	OECD, 2012

Footnotes:
LD_{50} – lethal dose for 50% of experimental population
LC_{50} – lethal air concentration for 50% of experimental population
LOAEL – Lowest Observed Adverse Effect Level
LOAEC – Lowest Observed Adverse Effect Concentration
NOAEL – No Observed Adverse Effect Level

Human Health Toxicity Ranking*		
	Hazard data	**Comment**
Hazard Band 4		
Carcinogenicity	NO	
Mutagenicity/Genotoxicity	NO	
Reproductive Toxicity	NO	
Developmental Toxicity/ Teratogenicity	NO	
Endocrine Disruption[1]	NO	
Hazard Band 3		
Acute Toxicity (oral, dermal or inhalation) Very Toxic/Toxic • oral LD_{50} ≤ 300 mg/kg[3] • dermal LD_{50} ≤ 1000 mg/kg • inhalation LC_{50} ≤ 10 mg/L[4] (or mg/m^3) (vapour)	NO	
Possible carcinogenicity, mutagenicity, reproductive or High Chronic/repeat dose toxicity • oral LOAEL ≤ 10 mg/kg/d[3]; • dermal LOAEL ≤ 2 0 mg/kg/d; • inhalation LOAEC (6 h/d) ≤ 50 ppm/d for gases, ≤ 0.2 mg/L/d for vapours or ≤ 0.02 mg/L/d for dust/mists/fumes[4]	NO	
Corrosive (irreversible damage)	YES	
Respiratory sensitiser	NO	
Hazard Band 2		
Harmful chronic/repeat dose toxicity • oral LOAEL > 10 mg/kg and ≤ 100 mg/kg/d • dermal LOAEL > 20 mg/kg/d and ≤ 200 mg/kg/d • inhalation (6-h/d) LOAEC > 50 mg/L ≤ 250 mg/L/d for gases, > 0.2 mg/L ≤ 1 .0 mg/L/d for vapours or > 0.02 mg/L ≤ 0.2 mg/L/d for dust/mists/fumes[4]	NO	
Skin Sensitiser	NO	
Hazard Band 1		
Acute Toxicity-Harmful • oral LD_{50} > 300 mg/kg ≤ 2000 mg/kg • dermal LD_{50} >1 000 mg/kg ≤ 2000 mg/kg; • inhalation LC_{50} (6 h/d) > 10 mg/L ≤ 20 mg/L for vapours)[4]	YES	
Irritant (reversible damage)	NO	
Hazard Band 0 **All indicators outside criteria listed in Hazards 1-4**		
Physical Hazards		
Flammable potential	NO	
Explosive potential	NO	
Hazard Evaluation (highest band) not including physical hazards	**Band 3**	
Uncertainty analysis /data confidence	13/13	**100%**

* Based on IMAP Framework [NICNAS (2013) Inventory Multi-tiered Assessment and Prioritisation (IMAP) Framework. National Industrial Chemicals Notification and Assessment Scheme. Department of Health and Aging, Canberra].

"[1]Based on list of endocrine disrupting chemicals from the European Commission's Endocrine Disrupters website.

[2] Based on list of neurotoxic chemicals from US Agency for Toxic Substances and Disease Registry (ATSDR).

[3] milligrams per kilogram body mass(mg/kg) or milligrams per kilogram body mas per day (mg/kg/d)

[4] Based on GHS cut-offs for hazard classification. For chronic/repeat dose toxicity, GHS cut-offs are provided as guidance values (i.e. the dose/concentration at or below which significant health effects are observed"). (p 18, NICNAS 2013).

Human Health Guidelines		
Media	**Concentration (mg/m^3; mg/L; mg/kg)**	**Reference**
Occupational Exposure Limits		
Air (OEL)		ECb, 2000
8-h TWA	6 mg/m^3 (MAK value)	
STEL	NDF	
Peak Limitation	NDF	
Environmental Exposure		
Air, ambient	NDF	
Air, indoor	NDF	
Water, potable	NDF	
Water, recreational	NDF	
Soil, residential	NDF	
Soil, commercial/industrial	NDF	

Footnotes:

OEL = Occupational Exposure Limit

TWA= 8 h Time-Weighted Average

STEL = (15 min) Short-term Exposure Limit

NDF - No data found within the limits of the search strategy.

Qualifying Summary Comments

Disodium EDTA fells into the Hazard band category 3. Principal health effects include mild irritation of the skin and severe irritation of the eye. Disodium EDTA is also harmful if swallowed. There are no occupational exposure limits established for this chemical. Disodium EDTA is not readily biodegradable but can biodegrade under certain conditions.

References and Notes

European Chemicals Agency (ECHAa 2013). Registered Chemical Substances Search. Available at http://echa.europa.eu/web/guest/information-on-chemicals/registered-substances. [Accessed 29 August 2013]

European Chemicals Agency. Classification and Labelling Inventory database Search. Available at http://echa.europa.eu/web/guest/information-on-chemicals/cl-inventory-database [Accessed 29 August 2013] (ECHA 2013b)

European Commission (ECa, 2000) Towards the establishment of a priority list of substances for further evaluation of their role in endocrine disruption, preparation of a candidate list of substances as a basis for priority setting, Final Report (Incorporating corrigenda to final report dated 21 June 2000).

European Commission (ECb, 2000) Joint Research Centre (JRC) Institute for Health and Consumer Protection - European Chemical Substances Information (ESIS). Available at http://esis.jrc.ec.europa.eu/doc/IUCLID/data_sheets/139333.pdf . [Accessed 29 August 2013].

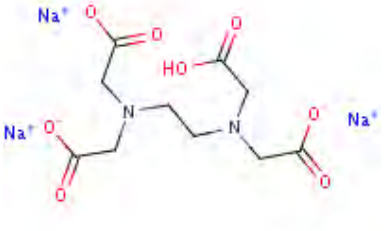
International Program on Chemical Safety (IPCS, 1974) document. Available at http://www.inchem.org/documents/jecfa/jecmono/v05je25.htm. [Accessed 30 August 2013].

Organization for Economic Cooperation and Development (OECD, 2012). Available at http://webnet.oecd.org/Hpv/UI/handler.axd?id=823fc6fd-affd-4610-8e57-87e17b72f9f3. [Accessed 29 August 2013].

United States Environmental Protection Agency (US EPA, 2004). Memorandum: Ethylenediaminetetraacetic acid (EDTA) and the salts of EDTA: Science Assessment Document for Tolerance Reassessment. Available at http://www.epa.gov/opprd001/inerts/edta.pdf. Accessed 29 August 2013].

Created by:	JC	Date: 30/08/2013
Reviewed and edited by:	JF	Date 11/09/2013

Project number: 127666004
Project name: Hydraulic Stimulation Chemicals Assessment, Southwest Queensland
Client name: Santos Ltd

Name	Trisodium Ethylenediaminetetraacetate (impurity)
Synonyms	Edetate trisodium, trisodium EDTA, trisodium hydrogen ethylene diaminetetraacetate, N,N'-1,2-Ethanediylbis(N-(carboxymethyl)glycine), trisodium salt, glycine, N,N'-1,2-ethanediylbis(N-(carboxymethyl)-trisodium salt
CAS number	150-38-9
Molecular formula	$C_{10}H_{16}N_2O_8 \cdot 3Na$
Molecular Structure	

Overview	References
Trisodium ethylenediaminetetraacetate is an odourless white solid and is water soluble. It rapidly dissociates in water to ethylenediaminetetraacetate (EDTA). Trisodium EDTA isan organic chelating agent. Chelating agents sequester a variety of polyvalent cations. It is a low production volume (LPV) chemical which is an ingredient in sunscreen and fracking mixtures and is also used in pharmaceutical manufacturing and as a food additive. The toxicity of tri and tetra sodium salts of EDTA are very similar and are dependent on the toxicity of free acid (EDTA). On this basis toxicity information for the acid and tri and tetra sodium salts has been in this profile.	US EPA (2013), US NLM (2013b)

Human Health Toxicity Summary	Reference
Carcinogenicity Not classified as a carcinogenic substance (Tetra sodium EDTA). Negative in mice and rat carcinogenicity bioassays. Not classified by IARC.	ECHA (2013) US EPA (2013). IARC (2013)
Mutagenicity/Genotoxicity Not classified as a carcinogenic substance (Tetra sodium EDTA). In vitro genetic toxicity assays were negative.	US EPA (2013)
Reproductive Toxicity Not classified as a carcinogenic substance (Tetra sodium EDTA). n al 2 year feeding study on Wistar rats including reproductive and lactation experiments in	ECHA (2013)

four successive generations groups of 25 male and 25 female animals were exposed to $CaNa_2EDTA$ at dietary levels providing daily doses of approximately 50, 125, and 250 mg/kg bw .No treatment related effects on reproduction or fertility were observed (i.e. no observed adverse effect level for reproductive toxicity >250 mg/kg/day)..	
Developmental Toxicity/Teratogenicity EDTA and four of its salts, disodium, trisodium, calcium di-sodium, and tetrasodium edetate, were studied for teratogenic potential in rats. Equimolar doses based on 1000 mg/kg were given by gastric intubation on Days 7 to 14 of gestation. On day 21 of gestation the dams of each group were sacrificed and litter data for each dam collected.No treatment related developmental effects were observed.	
Endocrine Disruption Not listed as an endocrine disruptor.	EC (2000)
Neurotoxicity Neurotoxicity has been observed in repeat dose toxicity studies. .	
Acute Toxicity (oral, dermal, inhalation) Harmful if swallowed or inhaled. Related compound tetrasodium EDTA is toxic to blood, kidneys, lungs, liver, mucous membranes. Repeated or prolonged exposure to the substance can produce target organs damage.	ECHA (2013), Sciencelab.com, Inc. (2008)
Chronic/repeat dose toxicity (oral, dermal, inhalation) In a range of repeat dose toxicity tests via the oral route (mainly dietary) for a period of one month through to daily exposure effects (such as mortality) and calcium homostatis issues, exhibited increased lethality but no epidemiologic darakidney, ureter and bladder effects (changed in tubules, including acute renal failure and acute tubular necrosis) In a subacute repeated dose toxicity study 10 male Wistar rats per dose were exposed to a respirable dust aerosol of Na_2H_2EDTA for 6 hours per day for 5 consecutive days at concentrations of 0, 30, 300, 1000 mg/m³ air. Exposure in the high dose group (1000 mg/m3) was for one day only due to mortality observed. Inhalation exposure to 1000 mg/m³ disodium EDTA for 6 hours caused lethality in 6 out of 20 male rats. Histological examination of the lung of the dead rats revealed congestion, edema, multifocal hemorraghes and inflammatory cell infiltrates. Inhalation exposure of rats to disodium EDTA for 6 hours per day, 5 consecutive days cause concentration dependant lesions in the larynx and lungs that were fully reversible within 14 days. Due to histopahological changes in the low dose group a no observed effect level could not be determined. The LOAEC was considered to be 30 mg/m³ air.	US EPA (2013)
Sensitisation of the skin or respiratory system Not classified as a skin or respiratory .	
Corrosion (irreversible and reversible)/irritation of the skin or eye Causes serious eye irritation. Causes skin irritation. May cause respiratory irritation. Related compound tetrasodium EDTA can result in skin redness and sensitivity, inhalation (cough, sore throat), eye contact (irritant) and ingestion (burning sensation in the throat and chest, abdominal pain, diarrhoea) as well as corrosive to skin and eyes on contact. Tetrasodium EDTA is irritating to mucous membranes and upper respiratory tract. Liquid or spray mist of tetrasodium EDTA may produce tissue damage particularly on mucous membranes of eyes, mouth and respiratory tract.. Inhalation of the spray mist of tetrasodium EDTA may produce severe irritation of respiratory tract, characterized by coughing, choking, or shortness of breath. Inflammation of the eye is characterized by redness, watering, and itching. Skin inflammation is characterized by itching, scaling, reddening, or, occasionally, blistering.	ECHA (2013), IPCS(2006), Sciencelab.com, Inc. (2008)

Physical Hazards	Reference
Flammable Potential No classified as a flammable solid.	ECHA (2013)
Explosive Potential Not classified as an explosive.	ECHA (2013)

Toxicity Values	Value	Reference
Human Toxicity Data		
Acute Toxicity		
	No data found.	-
High Chronic/Repeat Dose Toxicity		
LOAEC	No data found.	-
LOAEL	No data found.	-
Animal Toxicity Data		
Acute Toxicity		
LD_{50}		
Rat, oral	2150 mg/kg	US NLM (2013a)
Mouse, oral	2150 mg/kg	US NLM (2013a)
Rabbit, oral	No data found.	-
Rat, dermal	No data found.	-
Rabbit, dermal	No data found.	-
Mouse, dermal	No data found.	-
LOAEL	No data found.	-
LOAEC	No data found.	-
LC_{50}		
Rat	No data found.	-
High Chronic/Repeat Dose Toxicity		
LOAEL	No data found.	-
LOAEC	30 mg/m3	ECHA (2013)

Footnotes:
LD_{50} – lethal dose for 50% of experimental population
LC_{50} – lethal air concentration for 50% of experimental population
LOAEL – Lowest Observed Adverse Effect Level
LOAEC – Lowest Observed Adverse Effect Concentration

Project number: 127666004
Project name: Hydraulic Stimulation Chemicals Assessment, Southwest Queensland
Client name: Santos Ltd

Human Health Toxicity Ranking*		
	Hazard data	**Comment**
Hazard Band 4		
Carcinogenicity	No	Negative in bioassays
Mutagenicity/Genotoxicity	No	Negative in bioassays
Reproductive Toxicity	No	
Developmental Toxicity/ Teratogenicity	No	
Endocrine Disruption[1]	No	
Hazard Band 3		
Acute Toxicity (oral, dermal or inhalation) Very Toxic/Toxic • oral LD_{50} ≤ 300 mg/kg[3] • dermal LD_{50} ≤ 1000 mg/kg • inhalation LC_{50} ≤ 10 mg/L[4] (or mg/m^3) (vapour)	No	
Possible carcinogenicity, mutagenicity, reproductive or High Chronic/repeat dose toxicity • oral LOAEL ≤ 10 mg/kg/d[3]; • dermal LOAEL ≤ 2 0 mg/kg/d; • inhalation LOAEC (6 h/d) ≤ 50 ppm/d for gases, ≤ 0.2 mg/L/d for vapours or ≤ 0.02 mg/L/d for dust/mists/fumes[4]	No	
Corrosive (irreversible damage)	Yes	
Respiratory sensitiser	No data found.	
Hazard Band 2		
Harmful chronic/repeat dose toxicity • oral LOAEL > 10 mg/kg and ≤ 100 mg/kg/d • dermal LOAEL > 20 mg/kg/d and ≤ 200 mg/kg/d • inhalation (6-h/d) LOAEC > 50 mg/L ≤ 250 mg/L/d for gases, > 0.2 mg/L ≤ 1 .0 mg/L/d for vapours or > 0.02 mg/L ≤ 0.2 mg/L/d for dust/mists/fumes[4]	No data found.	
Skin Sensitiser	No	
Hazard Band 1		
Acute Toxicity-Harmful • oral LD_{50} > 300 mg/kg ≤ 2000 mg/kg • dermal LD_{50} >1 000 mg/kg ≤ 2000 mg/kg; • inhalation LC_{50} (6 h/d) > 10 mg/L ≤ 20 mg/L for vapours)[4]	No	
Irritant (reversible damage)	Yes	
Hazard Band 0 **All indicators outside criteria listed in Hazards 1-4**		
Physical Hazards		
Flammable potential	No	
Explosive potential	No	
Hazard Evaluation (highest band) not including physical hazards	Hazard Band 3	
Uncertainty analysis /data confidence	12/13 92%%	

* Based on IMAP Framework [NICNAS (2013) Inventory Multi-tiered Assessment and Prioritisation (IMAP) Framework. National Industrial Chemicals Notification and Assessment Scheme. Department of Health and Aging, Canberra].

"[1]Based on list of endocrine disrupting chemicals from the European Commission's Endocrine Disrupters website.

[2] Based on list of neurotoxic chemicals from US Agency for Toxic Substances and Disease Registry (ATSDR).
[3] milligrams per kilogram body mass(mg/kg) or milligrams per kilogram body mas per day (mg/kg/d)

[4] Based on GHS cut-offs for hazard classification. For chronic/repeat dose toxicity, GHS cut-offs are provided as guidance values (i.e. the dose/concentration at or below which significant health effects are observed"). (p 18, NICNAS 2013).

Human Health Guidelines		
Media	**Concentration (mg/m^3; mg/L; mg/kg)**	**Reference**
Occupational Exposure Limits		
Air (OEL)	No data found.	-
8-h TWA	No data found.	-
STEL	No data found.	-
Peak Limitation	No data found.	-
Environmental Exposure		
Air, ambient	No data found.	-
Air, indoor	No data found.	-
Water, potable	0.25 mg/L (for EDTA)	ADWG (2011) – Health Guideline Value
Water, recreational	No data found.	-
Soil, residential	No data found.	-
Soil, commercial/industrial	No data found.	-

Footnotes:

OEL = Occupational Exposure Limit

TWA= 8 h Time-Weighted Average

STEL = (15 min) Short-term Exposure Limit

Qualifying Summary Comments

Trisodium ethylenediaminetetraacetate is an odourless white solid and is water soluble. It rapidly dissociates in water to ethylenediaminetetraacetate (EDTA). It is an organic chelating agent. Chelating agents sequester a variety of polyvalent cations. The toxicity of tri and tetra sodium salts of EDTA are very similar and are dependent on the toxicity of free acid (EDTA). On this basis toxicity information for the acid and tri and tetra sodium salts has been in this profile.

EDTA and its salts are organic acids and can cause severe eye irritation, skin and respiratory irritation in the neat form. Trisodium EDTA has a low order of acute toxicity. On repeat dose exposure by inhalation it can cause upper respiratory tract inflammation. Trisodium EDTA is not classified as a carcinogen, mutagen or reproductive toxicant. On the basis of severe eye irritation it is categorised as Hazard Band 3.

References and Notes

Australian Drinking Water Guidelines (2011). National Health and Medical Research Council. Available at http://www.nhmrc.gov.au/_files_nhmrc/publications/attachments/eh52_aust_drinking_water_guidelines.pdf

ECHA – European Chemicals Agency (2013). Registered Substances List Dossier for Tetrasodium EDTA. Available at http://apps.echa.europa.eu/registered/data/dossiers/DISS-97dbf20f-b6ec-08f3-e044-00144f67d031/AGGR-75dc3626-c376-4e47-9c26-2aba3a64ad60_DISS-97dbf20f-b6ec-08f3-e044-00144f67d031.html#AGGR-75dc3626-c376-4e47-9c26-2aba3a64ad60 Accessed 11/09/13.

European Chemicals Agency. Classification and Labelling Inventory database Search. Available at http://echa.europa.eu/web/guest/information-on-chemicals/cl-inventory-database [Accessed 4 September 2013]

European Commission (EC) (2000) Towards the establishment of a priority list of substances for further evaluation of their role in endocrine disruption, preparation of a candidate list of substances as a basis for priority setting, Final Report (Incorporating corrigenda to final report dated 21 June 2000).

IARC (2013) Agents classified by IARC Monographs Volumes 1- 107. Available at http://monographs.iarc.fr/ENG/Classification/ClassificationsGroupOrder.pdf. [Accessed 5 August 2013.

ICPS (2006). *Tetrasodium ethylenediaminetetraacetate: Summary*. October 2006. International Programme on Chemical Safety and the Commission of the European Communities (IPCS and CEC). Available from http://www.inchem.org/documents/icsc/icsc/eics1688.htm. Accessed on 6 July 2011.

Sciencelab.com, Inc. (2008). *Material Safety Data Sheet: Tetrasodium ethylenediaminetetraacetate*. Available from http://www.chemblink.com/MSDS/MSDSFiles/64-02-8_Science%20Lab.pdf. Accessed on 6 July 2011.

United States Environmental Protection Agency (US EPA, 2013). Aggregated Computational Toxicology Resource (ACToR) database. Available at http://actor.epa.gov/actor/faces/ACToRHome.jsp. [Accessed 4 September 2013]

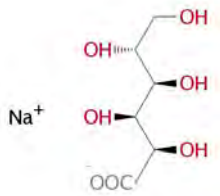
Unites States National Library of Medicine (NLM) Chem ID Plus Lite database. Available at http://chem.sis.nlm.nih.gov/chemidplus/chemidlite.jsp. [Accessed 4 September 2013]. (US NLM (2013a))

Unites States National Library of Medicine (NLM) Drug Information Portal database. Available at http://druginfo.nlm.nih.gov/drugportal/drugportal.jsp. [Accessed 5 September 2013]. (US NLM (2013b))

No data found. - No data found within the limits of the search strategy.

Created by:	MER	Date 4/9/2013
Reviewed and edited by:	JF	Date 11/09/2013

Project number: 127666004
Project name: Hydraulic Stimulation Chemicals Assessment, Southwest Queensland
Client name: Santos Ltd

Name	Sodium gluconate
Synonyms	Sodium D-gluconate,Sodium (2R,3S,4R,5R)-2,3,4,5,6-pentahydroxyhexanoate, sodium pentahydroxy-capronate
CAS number	527-07-1
Molecular formula	$C_6H_{11}NaO_7$
Molecular Structure	

Overview	References
Sodium gluconate is the sodium salt of gluconic acid. Gluconic acid and its mineral salts freely dissociate to the gluconate anion and the respective cations. Glucono-delta-lactone (GDL), the 1,5-inner ester of gluconic acid, is formed from the free acid by the removal of water. On the basis of these spontaneous chemical rearrangements, glucono-delta-lactone, gluconic acid and its sodium, calcium and potassium salts are considered as a category. It is a high solubility in water and occurs as a white or off-white solid. The US FDA considers sodium gluconate to be generally recognized as safe to a limited extent (GRAS/FS). Gluconic acid and its derivatives are naturally occurring substances. Gluconate is a metabolite of glucose oxidation and is excreted in the urine or metabolized. Orally administered gluconate is absorbed rapidly and the majority of it is excreted with the remainder metabolized. Commercially, the gluconates are used as chelating agents in cement set retarding, institutional and household cleaning, personal care products, pharmaceuticals and foodstuffs. Sodium gluconate is an ingredient in some sugar replacement packets and diet soft drinks. Worldwide productions of sodium gluconate is estimated to be 50,000-70,000 tonnes per year.	CHRIP (2008), FDA (2003) OECD (2004).

Human Health Toxicity Summary	Reference
Carcinogenicity - Not classified by IARC	IARC (2013)
Mutagenicity/Genotoxicity - In vitro and in vivo mutagenicity data were negative	OECD (2004)
Reproductive Toxicity - No changes were observed on the reproductive organs in 28 days oral studies with up to 4400 mg/kg bw sodium gluconate (species not specified)	OECD (2004)
Developmental Toxicity/Teratogenicity - NDF	All proposed data sources
Endocrine Disruption - NDF	All proposed data sources
Neurotoxicity - NDF	All proposed data sources

Acute Toxicity (oral, dermal, inhalation) - Although no LD50 data are available for sodium gluconate, similar compound potassium carbonate has an LD50 (oral) of 6,060 mg/kg bw on Wistar rats.	OECD (2004), ECHA (2013)
Chronic/repeat dose toxicity (oral, dermal, inhalation) - Repeated dose toxicity studies of 4 weeks, 6 months, and 24 months were performed. None showed any significant toxicological effects of gluconates.	OECD (2004)
Sensitisation of the skin or respiratory system NDF	All proposed data sources
Corrosion (irreversible and reversible)/irritation of the skin or eye - Not irritating to the eyes or skin.	OECD (2004)
Flammable Potential - Combustible	IPCS (2009)
Explosive Potential - NDF	All proposed data sources

Toxicity Values	Value	Reference
Human Toxicity Data		
Acute Toxicity		
LD_{50}	NDF	-
High Chronic/Repeat Dose Toxicity		
NOAEL, rats (female)	2000 mg/kg bw	OECD (2004)
NOAEL, rats (male)	1000 mg/kg bw	OECD (2004)
NOAEL, Dog (beagle)	500 mg/kg bw	OECD (2004)
Animal Toxicity Data		
Acute Toxicity		
LD_{Lo}		
Rat,crj: CD(SD)	>2000 mg/kg bw	OECD (2004)
Dog, beagle	>2000 mg/kg bw	OECD (2004)
LD_{50}		
	>2000 mg/kg bw	-

Footnotes:
LD_{50} – lethal dose for 50% of experimental population
LC_{50} – lethal air concentration for 50% of experimental population
LOAEL – Lowest Observed Adverse Effect Level
LOAEC – Lowest Observed Adverse Effect Concentration

Human Health Toxicity Ranking*		
	Hazard data	**Comment**
Hazard Band 4		
Carcinogenicity	NO	Not classified by IARC.
Mutagenicity/Genotoxicity	NO	-
Reproductive Toxicity	NO	-
Developmental Toxicity/ Teratogenicity	NO	-
Endocrine Disruption[1]	NO	-
Neurotoxicity[2]	NO	-
Hazard Band 3		
Acute Toxicity (oral, dermal or inhalation) Very Toxic/Toxic • oral LD_{50} ≤ 300 mg/kg[3] • dermal LD_{50} ≤ 1000 mg/kg • inhalation LC_{50} ≤ 10 mg/L[4] (or mg/m^3) (vapour)	NO	-
High Chronic/repeat dose toxicity • oral LOAEL ≤ 10 mg/kg/d[3]; • dermal LOAEL ≤ 2 0 mg/kg/d; • inhalation LOAEC (6 h/d) ≤ 50 ppm/d for gases, ≤ 0.2 mg/L/d for vapours or ≤ 0.02 mg/L/d for dust/mists/fumes[4]	NO	-
Corrosive (irreversible damage)	NO	-
Respiratory sensitiser	NDF	-
Hazard Band 2		
Harmful chronic/repeat dose toxicity • oral LOAEL > 10 mg/kg and ≤ 100 mg/kg/d • dermal LOAEL > 20 mg/kg/d and ≤ 200 mg/kg/d • inhalation (6-h/d) LOAEC > 50 mg/L ≤ 250 mg/L/d for gases, > 0.2 mg/L ≤ 1 .0 mg/L/d for vapours or > 0.02 mg/L ≤ 0.2 mg/L/d for dust/mists/fumes[4]	NO	-
Skin Sensitiser	NO	-
Hazard Band 1		
Acute Toxicity-Harmful • oral LD_{50} > 300 mg/kg ≤ 2000 mg/kg • dermal LD_{50} >1 000 mg/kg ≤ 2000 mg/kg; • inhalation LC_{50} (6 h/d) > 10 mg/L ≤ 20 mg/L for vapours)[4]	NO	-
Irritant (reversible damage)	NO	OECD 2004
Hazard Band 0 **All indicators outside criteria listed in Hazards 1-4**		
Physical Hazards		
Flammable potential	NO	Combustible. IPCS (2009)
Explosive potential	NO	-
Hazard Evaluation (highest band) not including physical hazards	**Band 0**	
Uncertainty analysis /data confidence	12/13 x 100 =	**92%**

* Based on IMAP Framework [NICNAS (2013) Inventory Multi-tiered Assessment and Prioritisation (IMAP) Framework. National Industrial Chemicals Notification and Assessment Scheme. Department of Health and Aging, Canberra].

"[1]Based on list of endocrine disrupting chemicals from the European Commission's Endocrine Disrupters website.

[2] Based on list of neurotoxic chemicals from US Agency for Toxic Substances and Disease Registry (ATSDR).

[3] milligrams per kilogram body mass (mg/kg) or milligrams per kilogram body mass per day (mg/kg/d)

[4] Based on GHS cut-offs for hazard classification. For chronic/repeat dose toxicity, GHS cut-offs are provided as guidance values (i.e. the dose/concentration at or below which significant health effects are observed"). (p 18, NICNAS 2013).

Human Health Guidelines		
Media	**Concentration (mg/m^3; mg/L; mg/kg)**	**Reference**
Occupational Exposure Limits		
Air (OEL)		
8-h TWA	NDF	All proposed data sources
STEL	NDF	All proposed data sources
Peak Limitation	NDF	All proposed data sources
Environmental Exposure		
Air, ambient	NDF	All proposed data sources
Air, indoor	NDF	All proposed data sources
Water, potable	NDF	NEPM (1999; amended 2013)
Water, recreational	NDF	All proposed data sources
Soil, residential	NDF	NEPM (1999; amended 2013)
Soil, commercial/industrial	NDF	NEPM (1999; amended 2013)

Footnotes:

OEL = Occupational Exposure Limit

TWA= 8 h Time-Weighted Average

STEL = (15 min) Short-term Exposure Limit

NDF - No data found within the limits of the search strategy.

Project number: 127666004
Project name: Hydraulic Stimulation Chemicals Assessment, Southwest Queensland
Client name: Santos Ltd

Qualifying Summary Comments

Gluconic acid and its derivatives are naturally occurring substances. Besides being naturally present at a level up to 1% in wine, honey and other foods and drinks, sodium gluconate,is listed as permitted food additive in Europe and the USA. It is a non hazardous substance either following acute or chronic exposure. It is not classified as a mutagen, carcinogen, reproductive, or developmental toxicant.

Created by:	**MER**	Date: **15/08/2013**
Reviewed and edited by:	**JF**	Date: **1209/2013**

References

Chemical Risk Information Platform (CHRIP) [Japan], 2008. Information on Biodegradation and Bioconcentration of the Existing Chemical Substances Database. Available at http://www.safe.nite.go.jp/english/db.html. [Accessed 15 August 2013.]

European Chemicals Agency (ECHA) Classifcation and Labelling Inventory Database. Available at http://echa.europa.eu/web/guest/information-on-chemicals/cl-inventory-database. [Accessed 15 August 2013]

EINECS (European INventory of Existing Commercial chemical Substances). Accessed via European Chemical Substances Information System (ESIS). Available at http://esis.jrc.ec.europa.eu/. [Accessed 14 August 2013.]

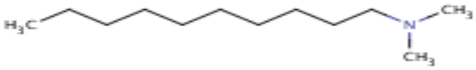
FDA (U.S. Food and Drug Administration) 2013.Food Additive Status. List.Available from http://www.fda.gov/Food/IngredientsPackagingLabeling/FoodAdditivesIngredients/ucm091048.htm, [Accessed 15 August 2013].

IARC (2013) Agents classified by IARC Monographs Volumes 1- 107. Available at http://monographs.iarc.fr/ENG/Classification/ClassificationsGroupOrder.pdf. [Accessed 11 July 2013.]

IPCS (2009). International Chemical Safety Card (ICSC) 1737: Sodium Gluconate. Available at: http://www.inchem.org/documents/icsc/icsc/eics1737.htm.

OECD (2004). Gluconic Acid and Its Derivatives.: SIDS initial assessment report. From INCHEM. Available at http://www.inchem.org/documents/sids/sids/gluconates.pdf

Project number: 127666004
Project name: Hydraulic Stimulation Chemicals Assessment, Southwest Queensland
Client name: Santos Ltd

Name	Decyldimethyl amine (impurity)
Synonyms	Decyldimethylamine, Dimethyl-n-decylamine, N,N-Dimethyl-N-decylamine, N,N-Dimethyldecylamine
CAS number	1120-24-7
Molecular formula	C12-H27-N
Molecular Structure	

Overview	Reference
Decyldimethyl amine is a transparent clear liquid at standard temperature and pressure. The boiling point was found to be 237ºC ± 0.5ºC. The liquid is not considered flammable or explosive. It is used in the manufacturing of bulk chemical (including petroleum products) as an intermediate in chemical synthesis. Available data on the manufacture and use of decyldimethyl amine is relatively limited. Acute toxicity studies have found the acute oral median lethal dosage (LD50) of the decyldimethyl amine was greater than 2000 mg/kg. However, research suggests decyldimethyl amine can cause severe skin burns and eye damage (based on New Zealand White rabbit studies).	ECHA 2013

Human Health Toxicity Summary	Reference
Carcinogenicity Not classified as a carcinogen due to lack of data. Not classified by IARC (not currently evaluated by IARC).	ECHA 2013; IARC 2013
Mutagenicity/Genotoxicity Not classified as a germ cell mutagen by ECHA (conclusive data but not sufficient for classification as a germ cell mutagen).Results of a bacterial gene mutation assay which concluded that the substance did not exhibit any mutagenic activity under the conditions of test.	ECHA 2013
Reproductive Toxicity Not classified as reproductively toxic by ECHA (conclusive data but not sufficient for classification as reproductively toxic).	ECHA 2013

Developmental Toxicity/Teratogenicity NDF.	
Endocrine Disruption Not listed as an endocrine disruptor by European Commission.	EC 2000
Acute Toxicity (oral, dermal, inhalation) ECHA lists the chemical as "Harmful is swallowed" (GHS classification listed: Acute Tox 4. H302) Xn; R22 Harmful if swallowed. The acute toxicity of the decyldimethylamine was investigated in a group of five male and five female Sprague-Dawley rats at a dosage of 2000 mg/kg according to OECD guideline 401. The animals were starved overnight prior to dosing. The test material was administered at a constant volume-dosage of 10 ml/kg in maize oil via gavage. Mortality and signs of reaction to treatment were recorded during a subsequent 14 -day observation period; the surviving animals were killed on the following day. All animals were subjected to necropsy. Only one female rat died during the observation period. Under the conditions of this study, the acute oral median lethal dosage (LD50) of the test material was greater than 2000 mg/kg. ECHA states data are lacking for assessment of acute toxicity via dermal and inhalation pathways.	ECHA 2013
Chronic/repeat dose toxicity (oral, dermal, inhalation) NDF.	
Sensitisation of the skin or respiratory system Not classified as a skin sensitiser by ECHA due to lack of data.	ECHA 2013
Corrosion (irreversible))/irritation (reversible) of the skin or eye Caused severe skin burns and eye damage as reported in a number of animal studies. (GHS classification: Skin Corr. 1B H314). Six New Zealand rabbits were treated with the test substance in a dermal irritation/corrosion study consistent with OECD 404 and EU B.4 guidelines. The test substance produced erythema with a mean score of 2 and edema with a mean score of 2.2. After 4 h of exposure, severe dermal responses were produced. Under the conditions of this study the test material was considered as corrosive to the skin of rabbits. The potential of the substance to cause inflammatory or corrosive changes upon first contact with skin was also assessed by semi-occluded application of 0.5 mL of the test material to the closely-clipped dorsa of three New Zealand White rabbits for four hours. Dermal reactions were assessed 1, 24, 48 and 72 hours after removal of the dressings and on days 7, 10, 13 and 16. Under the conditions of this test the substance was reported as an irritant to skin. The potential of the substance to cause damage to the conjunctivae, iris or cornea was assessed in the New Zealand White rabbits using the OECD Guideline 405. Rabbits were subjected to a single ocular instillation of 0.1mL of the test material. Ocular reactions were assessed 1, 24, 48 and 72 hours after treatment and on Day 8, 15 and 22. Instillation of the test material caused no initial pain response. Under the conditions of this test and the criteria of the EEC, the substance was classified as having the "*risk of serious damage to eyes"*.	ECHA 2013

Physical Hazards	Reference
Flammable Potential Not classified as a flammable liquid.	ECHA 2013
Explosive Potential Not classified as an explosive.	ECHA 2013

Toxicity Values	Value	Reference
Human Toxicity Data		
High Chronic/Repeat dose Toxicity		
Animal Toxicity Data		
Acute Toxicity		
LD_{50}		
Rat, oral (gavage)	> 2000 mg/kg bw	ECHA 2013
Rat, dermal	NDF	
Rabbit, dermal	NDF	
LC_{50}		
Rat	NDF	
High Chronic/Repeat dose Toxicity		
LOAEL	NDF	
LOAEC	NDF	

Footnotes:
LD_{50} – lethal dose for 50% of experimental population
LC_{50} – lethal air concentration for 50% of experimental population
LOAEL – Lowest Observed Adverse Effect Level
LOAEC – Lowest Observed Adverse Effect Concentration
NOAEL – No Observed Adverse Effect Level
Conclusive data: means that the study itself was conclusive in its reported finding, but was not sufficient for classifying the material according to ECHA guidelines.

Human Health Toxicity Ranking*		
	Hazard data	**Comment**
Hazard Band 4		
Carcinogenicity	NDF	IARC 2013;ECHA 2013
Mutagenicity/Genotoxicity	No	ECHA 2013
Reproductive Toxicity	No	ECHA 2013
Developmental Toxicity/ Teratogenicity	NDF	
Endocrine Disruption[1]	No	Not listed as an endocrine disruptor by European Commission, EC 2000
Hazard Band 3		
Acute Toxicity (oral, dermal or inhalation) Very Toxic/Toxic • oral LD_{50} ≤ 300 mg/kg[2] • dermal LD_{50} ≤ 1000 mg/kg • inhalation LC_{50} ≤ 10 mg/L^3 (or mg/m^3) (vapour)	No	GHS classification listed: Acute Tox 4. H302, ECHA 2013
Possible carcinogenicity, mutagenicity, reproductive or High Chronic/repeat dose toxicity • oral LOAEL ≤ 10 mg/kg/d[3]; • dermal LOAEL ≤ 2 0 mg/kg/d; • inhalation LOAEC (6 h/d) ≤ 50 ppm/d for gases, ≤ 0.2 mg/L/d for vapours or ≤ 0.02 mg/L/d for dust/mists/fumes[3]	NDF	
Corrosive (irreversible damage)	Yes	GHS classification listed: Skin Corr. 1B H314, ECHA 2013
Respiratory sensitiser	NDF	
Hazard Band 2		
Harmful chronic/repeat dose toxicity • oral LOAEL > 10 mg/kg and ≤ 100 mg/kg/d • dermal LOAEL > 20 mg/kg/d and ≤ 200 mg/kg/d • inhalation (6-h/d) LOAEC > 50 mg/L ≤ 250 mg/L/d for gases, > 0.2 mg/L ≤ 1 .0 mg/L/d for vapours or > 0.02 mg/L ≤ 0.2 mg/L/d for dust/mists/fumes[3]	NDF	
Skin Sensitiser	No	ECHA 2013
Hazard Band 1		
Acute Toxicity-Harmful • oral LD_{50} > 300 mg/kg ≤ 2000 mg/kg • dermal LD_{50} >1 000 mg/kg ≤ 2000 mg/kg; • inhalation LC_{50} (6 h/d) > 10 mg/L ≤ 20 mg/L for vapours)[3]	No	
Irritant (reversible damage)	Yes	ECHA 2013
Hazard Band 0 **All indicators outside criteria listed in Hazards 1-4**		
Physical Hazards		
Flammable potential	No	
Explosive potential	No	
Hazard Evaluation (highest band) not including physical hazards	**3**	

Uncertainty analysis /data confidence	9/13 x 100 = 69%	**69%**

* Based on IMAP Framework [NICNAS (2013) Inventory Multi-tiered Assessment and Prioritisation (IMAP) Framework. National Industrial Chemicals Notification and Assessment Scheme. Department of Health and Aging, Canberra].

"[1]Based on list of endocrine disrupting chemicals from the European Commission's Endocrine Disrupters website.

[2]milligrams per kilogram body mass(mg/kg) or milligrams per kilogram body mas per day (mg/kg/d)

[3] Based on GHS cut-offs for hazard classification. For chronic/repeat dose toxicity, GHS cut-offs are provided as guidance values (i.e. the dose/concentration at or below which significant health effects are observed"). (p 18, NICNAS 2013).

Human Health Guidelines		
Media	**Concentration (mg/m^3; mg/L; mg/kg)**	**Reference**
Occupational Exposure Limits		
Air (OEL)	NDF	
8-h TWA		
STEL		
Peak Limitation		
Environmental Exposure		
Air, ambient	NDF	
Air, indoor	NDF	
Water, potable	NDF	
Water, recreational	NDF	
Soil, residential	NDF	
Soil, commercial/industrial	NDF	

Footnotes:

OEL = Occupational Exposure Limit

TWA= 8 h Time-Weighted Average

STEL = (15 min) Short-term Exposure Limit

NDF - No data found within the limits of the search strategy.

Qualifying Summary Comments

Across a range of toxicological outcomes decyldimethyl amine exhibits concerns due to skin and eye corrosivity which results in it being placed in Hazard Band 3. Its fate and transport potential is considered similar to dodecyl dimethylamine and subsequently is expected to undergo rapid degradation in agueous systems such that sustained environmental distribution is not expected. Its volatilisation potential suggest the potential for inhalation exposures within confined occupational settings and confined large scale emergency spill settings and these may need to be considered should such settings arise. This is in addition to the dermal and ingestive pathways of exposure for such settings. As this substance is considered an impurity within the fluids the potential for exposures is considered to be substantially reduced provided no concentration processes under any circumstances result during the use of the parent product.

References

European Chemicals Agency (ECHA), 2013. Registered Substances List Dossier for Decyldimethylamine. Available at http://apps.echa.europa.eu/registered/data/dossiers/DISS-9eaede3e-ebf6-2909-e044-00144f67d031/DISS-9eaede3e-ebf6-2909-e044-00144f67d031_DISS-9eaede3e-ebf6-2909-e044-00144f67d031.html [Accessed 29 October 2013].

European Commission (EC) (2000). Towards the establishment of a priority list of substances for further evaluation of their role in endocrine disruption, preparation of a candidate list of substances as a basis for priority setting, Final Report (Incorporating corrigenda to final report dated 21 June 2000). Available at http://www.google.com.au/url?sa=t&rct=j&q=&esrc=s&frm=1&source=web&cd=1&ved=0CCsQFjAA&url=http%3A%2F%2Fec.europa.eu%2Fenvironment%2Farchives%2Fdocum%2Fpdf%2Fbkh_main.pdf&ei=3lGdUuvJHMWAlQWtpoG4Aw&usg=AFQjCNHb22gN8i-m7ibv3ScRCZ205H6X6Q&bvm=bv.57155469,d.dGI [Accessed 29 October 2013].

International Agency for Research on Cancer (IARC), 16 June 2013. Agents Classified by the *IARC Monographs*, Volumes 1–108. Available at http://monographs.iarc.fr/ENG/Classification/index.php. [Accessed 30/10/2013]

Notes

NDF – No data found within the limits of the search strategy

Created by:	MGT	Date: 30/10/2013
Reviewed and edited by:	LT	Date: 08/11/2013 Rev0

Project number: 127666004
Project name: Hydraulic Stimulation Chemicals Assessment, Southwest Queensland
Client name: Santos Ltd

Name	Potassium hydroxide
Synonyms	Potassium hydroxide, caustic potash, potassium lye, potassium hydrate
CAS number	1310-58-3
Molecular formula	HKO
Molecular Structure	

Overview	References
Anhydrous potassium hydroxide consist of white or slightly yellow lumps. It is very soluble in water and is produced largely in the liquid form. It has many industrial and some domestic uses. Industrial uses include potassium carbonate, chemical manufacturing, potassium chemicals, fertilizers, phosphotes, detergents, agricultural chemicals and alkaline batteries. Principal health effects include severe skins burns and eye damage.	IPCS, 2001 HSDB, 2009 ECHA, 2013

Human Health Toxicity Summary	Reference
Carcinogenicity Not classified as carcinogen.	ECHA, 2013
Mutagenicity/Genotoxicity Not classified as genotoxic based on the Ames test (bacterial reverse mutation assay)	ECHA, 2013
Reproductive Toxicity - Not classified as inducing reproductive toxicity - No studies on reproductive toxicity	ECHA, 2013 IPCS, 2001
Developmental Toxicity/Teratogenicity - Not classified as teratogenic - No studies on developmental toxicity	ECHA, 2013 IPCS, 2001
Endocrine Disruption Not Classified as an Endocrine Disruptor	EC, 2000
Acute Toxicity (oral, dermal, inhalation) - Harmful if swallowed: rat study - on the basis of one week observations - showed that: LD 50 for potassium hydroxide = 333 mg/kg (conventional method) and 388 mg/kg (up-and-down method) - Not classified as acute via dermal exposures or inhalation - Reported for oral rat LD50 values 365 mg/kg bw, 273 mg/kg bw and 1230 mg/kg bw	ECHA, 2013 IPCS, 2001
Chronic/repeat dose toxicity (oral, dermal, inhalation) Under normal handling and use conditions (non-irritating) neither the concentration of potassium in the blood nor the pH of the blood will be increased above normal limits and therefore KOH is not expected to cause systemically toxic levels in the blood. The renal excretion of K+ can be elevated and the OH- ion is neutralised by the bicarbonate buffer system in the blood.	IPCS, 2001
Sensitisation of the skin or respiratory system - Not classified as a skin sensitiser based on a guinea pigs study and extensive human	ECHA, 2013

use experience. - Not classified as a respiratory sensitiser based on extensive human use experience. -	IPCS, 2001
Corrosion (irreversible and reversible)/irritation of the skin or eye - Induces severe skin burns and eye damage based on in vitro studies, in vivo studies on rats and rabbits and supported by clinical cases. - Dust formation is unlikely but if aerosols or mist occur they will lead to irritant effects such as coughing and wheezing	ECHA, 2013 IPCS, 2001

Human Health Toxicity Summary	Reference
Flammable Potential Not classified as flammable	ECHA, 2013
Explosive Potential Not classified as explosive	ECHA, 2013

Toxicity Values	Value	Reference
Human Toxicity Data		
Acute Toxicity		
	NDF	
High Chronic/Repeat Dose Toxicity		
LOAEC	NDF	
LOAEL	NDF	
Animal Toxicity Data		
Acute Toxicity		
LD_{50}		
Rat, oral	333 mg/kg (conventional method) and 388 mg/kg (up-and-down method) 365 mg/kg, 273 mg/kg and 1230 mg/kg	ECHA, 2013 IPCS, 2001
Mouse, oral	NDF	
Rabbit, oral	NDF	
Rat, dermal	NDF	
Rabbit, dermal	NDF	
Mouse, dermal	NDF	
LOAEL	NDF	
LOAEC	NDF	
LC_{50}		
Rat	NDF	
High Chronic/Repeat Dose Toxicity		
LOAEL	NDF	
LOAEC	NDF	

Footnotes:
LD_{50} – lethal dose for 50% of experimental population
LC_{50} – lethal air concentration for 50% of experimental population
LOAEL – Lowest Observed Adverse Effect Level
LOAEC – Lowest Observed Adverse Effect Concentration

Human Health Toxicity Ranking*		
	Hazard data	**Comment**
Hazard Band 4		
Carcinogenicity	NO	
Mutagenicity/Genotoxicity	NO	
Reproductive Toxicity	NO	
Developmental Toxicity/ Teratogenicity	NO	
Endocrine Disruption[1]	NDF	
Hazard Band 3		
Acute Toxicity (oral, dermal or inhalation) Very Toxic/Toxic • oral LD_{50} ≤ 300 mg/kg[3] • dermal LD_{50} ≤ 1000 mg/kg • inhalation LC_{50} ≤ 10 mg/L[4] (or mg/m^3) (vapour)	NO	
High Chronic/repeat dose toxicity • oral LOAEL ≤ 10 mg/kg/d[3]; • dermal LOAEL ≤ 2 0 mg/kg/d; • inhalation LOAEC (6 h/d) ≤ 50 ppm/d for gases, ≤ 0.2 mg/L/d for vapours or ≤ 0.02 mg/L/d for dust/mists/fumes[4]	NDF	
Corrosive (irreversible damage)	YES	
Respiratory sensitiser	NO	
Hazard Band 2		
Harmful chronic/repeat dose toxicity • oral LOAEL > 10 mg/kg and ≤ 100 mg/kg/d • dermal LOAEL > 20 mg/kg/d and ≤ 200 mg/kg/d • inhalation (6-h/d) LOAEC > 50 mg/L ≤ 250 mg/L/d for gases, > 0.2 mg/L ≤ 1 .0 mg/L/d for vapours or > 0.02 mg/L ≤ 0.2 mg/L/d for dust/mists/fumes[4]	NDF	
Skin Sensitiser	NO	
Hazard Band 1		
Acute Toxicity-Harmful • oral LD_{50} > 300 mg/kg ≤ 2000 mg/kg • dermal LD_{50} >1 000 mg/kg ≤ 2000 mg/kg; • inhalation LC_{50} (6 h/d) > 10 mg/L ≤ 20 mg/L for vapours)[4]	YES	
Irritant (reversible damage)	YES	If aerosols/mist occur, they will cause direct local effects on respiratory tracts
Hazard Band 0 All indicators outside criteria listed in Hazards 1-4		
Physical Hazards		
Flammable potential	NO	
Explosive potential	NO	
Hazard Evaluation (highest band) not including physical hazards	**Band 3**	
Uncertainty analysis /data confidence	10/13 x 100	**76.9 %**

* Based on IMAP Framework [NICNAS (2013) Inventory Multi-tiered Assessment and Prioritisation (IMAP) Framework. National Industrial Chemicals Notification and Assessment Scheme. Department of Health and Aging, Canberra].

"[1]Based on list of endocrine disrupting chemicals from the European Commission's Endocrine Disrupters website.

[2] Based on list of neurotoxic chemicals from US Agency for Toxic Substances and Disease Registry (ATSDR).

[3] milligrams per kilogram body mas s(mg/kg) or milligrams per kilogram body mas per day (mg/kg/d)

[4] Based on GHS cut-offs for hazard classification. For chronic/repeat dose toxicity, GHS cut-offs are provided as guidance values (i.e. the dose/concentration at or below which significant health effects are observed"). (p 18, NICNAS 2013).

Human Health Guidelines		
Media	**Concentration (mg/m^3; mg/L; mg/kg)**	**Reference**
Occupational Exposure Limits		
Air (OEL)		
8-h TWA	2 mg/ m^3	HSDB, 2000
STEL	2 mg/ m^3	HSDB, 2000
Peak Limitation	2 mg/ m^3	HSDB, 2000
Environmental Exposure		
Air, ambient	0.005 mg/ m^3	DK, 2001
Air, indoor	NDF	
Water, potable	12 mg/L (WHO guidelines for drinking water)	IPCS, 2001
Water, recreational	NDF	
Soil, residential	NDF	
Soil, commercial/industrial	NDF	

Footnotes:

OEL = Occupational Exposure Limit

TWA= 8 h Time-Weighted Average

STEL = (15 min) Short-term Exposure Limit

NDF - No data found within the limits of the search strategy.

Qualifying Summary Comments

Potassium hydroxide either as a solid or aqueous liquid form is a corrosive substance. It can cause severe burns to the eyes, skin or respiratory tract. Systemic effects are unlikely given its severely corrosive nature. Given it causes adverse effects at the site of contact it is important to protect against direct contact with eyes, skin or respiratory tract. Potassium hydroxide is not persistent or bioccumalative in the environment and is unlikely to cause adverse effects to humans from environmental (low) exposure to soil or water at normal pH.

References

Dk delegation SIAM 13 communication (DK 2001)

European Chemicals Agency (ECHA 2013). Registered Chemical Substances Search. Available at http://echa.europa.eu/web/guest/information-on-chemicals/registered-substances. [Accessed 20 August 2013]

European Commission (EC) (2000) Towards the establishment of a priority list of substances for further evaluation of their role in endocrine disruption, preparation of a candidate list of substances as a basis for priority setting, Final Report (Incorporating corrigenda to final report dated 21 June 2000).

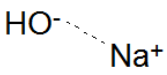
Hazardous Substances Data Bank (HSDB, 2009). Toxicology Data Network (TOXNET) Available at at http://toxnet.nlm.nih.gov/cgi-bin/sis/search/f?./temp/~qkNGcU:1. [Accessed 21 August 2013.]

Hazardous Substances Data Bank, Potassium Hydroxide (HSDB, 2000)

International Programme on Chemical Safety (IPCS 2001), Screening Information Data Set (SIDS)available at http://www.inchem.org/documents/sids/sids/POTASSIUMHYD.pdf . [Accessed 21 August 2013.]

Created by:	JC	Date: 22/08/2013
Reviewed and edited by:	JF	Date: 29/08/2013

Project number: 127666004
Project name: Hydraulic Stimulation Chemicals Assessment, Southwest Queensland
Client name: Santos Ltd

Name	Sodium Hydroxide
Synonyms	Caustic Soda, Sodium Hydrate, Soda hydrate, Lye
CAS number	1310-73-2
Molecular formula	NaOH
Molecular Structure	

Overview	References
Sodium hydroxide is a manufactured substance and at room temperature is a white crystalline odourless solid that absorbs moisture from the air. Sodium hydroxide is extensively used in most industries from food preparation to manufacturing. Major uses include in domestic cleaning products, in the manufacturing of soap, rayon, paper, paper, explosives, dyestuffs, and petroleum products according to ATSDR (2002). In addition, the ASTDR states that sodium hydroxide is also used in 'processing cotton fabric, laundering and bleaching, metal cleaning and processing, oxide coating, electroplating, and electrolytic extracting'. Sodium hydroxide is very corrosive. When dissolved in water or neutralized with acid it liberates substantial heat, which may be sufficient to ignite combustible materials. It is generally used as a solid or a 50% solution.	HSDB (2012) ATSDR (2002)

Human Health Toxicity Summary	Reference
Carcinogenicity IARC and the US EPA have not classified sodium hydroxide for carcinogenicity in humans.	ATSDR (2002)
Mutagenicity/Genotoxicity There are no reliable in vitro and in vivo studies to suggest that NaOH is genotoxic or mutagenic.	OECD (2002)
Reproductive Toxicity OECD (2002) (page 3) states that 'sodium hydroxide will neither reach the foetus nor reach male and female reproductive organs, which shows that there is no risk for toxicity to reproduction'.	OECD (2002)
Developmental Toxicity/Teratogenicity OECD (2002) (page 3) states that 'sodium hydroxide will neither reach the foetus nor reach male and female reproductive organs, which shows that there is no risk for developmental toxicity'.	OECD (2002)
Endocrine Disruption Chemical not listed on the European Commission list of identified possible endocrine disruptors.	BKH (2000)
Neurotoxicity No data found.	
Acute Toxicity (oral, dermal, inhalation) No studies using international/national guidelines in animals are available. OECD (2002) (page 3) reports that 'lethality has been reported for animals at oral doses of 240 mg/kg and 400 mg/kg', however, no reference is made to the type of animal effected. Intentional and accidental ingestion of sodium hydroxide by humans has been reported frequently in the literature with OECD (2002) stating that 'fatal ingestion and fatal dermal exposure has been reported for humans'.	OECD (2002)

In the HSDB a dermal LD_{50} for a rabbit of 1 350 mg/kg and an oral LD_{50} for a rat of 140 mg/kg to 340 mg/kg were stated, although the conditions of the studies in which the results were obtained were not stated.	HSDB (2012)
Chronic/repeat dose toxicity (oral, dermal, inhalation) No studies on animals using international/national guidelines are available on repeated dose toxicity by oral, dermal, inhalation or by other routes. Sodium hydroxide is readily soluble in water and dissociates into ionic parts (i.e. Na^+ and Cl^-). Consequently, sodium hydroxide itself is not considered to be systemically available (OECD,2002). These ions are an important component of biological fluids. Major hazard associated with chronic exposure to sodium hydroxide is development of alkalosis. Dust and vapour exposure are not expected as sodium hydroxide has a negligible vapour pressure, rapidly neutralising in air by carbon dioxide.	OECD (2002)
Sensitisation of the skin or respiratory system In one study sodium hydroxide was applied to the back of male volunteers (human) over a 24 h period (50 µL of solutions containing sodium hydroxide at concentrations of, 0.063%, 0.125%, 0.25%, 0.5% and 1.0%) followed by a further application seven days later (0.125%). The study concluded that sodium hydroxide was not sensitising.	ECHA (2013)
Corrosion (irreversible)/irritation (reversible) effects on the skin or eye Liquid or solid sodium hydroxide is a severe skin irritant. It causes second and third degree burns on short contact and is very injurious to the eyes.	HSDB (2012)
ATSDR states that 'inhalation of low levels of sodium hydroxide as dusts, mists or aerosols may cause irritation of the nose, throat, and respiratory airways', with higher concentrations resulting in swelling or spasms of the upper airway. Inhalation at higher concentrations may also cause inflammation of the lungs and accumulation of fluid in the lungs.	ATSDR (2002)
Long-term exposure to sodium hydroxide via the inhalation pathway may also lead to ulceration of the nasal passage and chronic skin irritation.	ATSDR (2002)
Classified as 'corrosive' and 'causes severe burns'	SafeWork Australia (2013)
Based on human data, concentrations of 0.5% to 4.0% were irritating to the skin, while a concentration of 8.0% was corrosive for the skin of animals.	OECD (2002)

Physical Hazards	Reference
Flammable Potential Not combustible.	HSDB (2012)
Explosive Potential Not explosive.	HSDB (2012)

Toxicity Values	Value	Reference
Human Toxicity Data		
High Chronic/Repeat Dose Toxicity		
LOAEC	NDF	
LOAEL	NDF	
Animal Toxicity Data		
Acute Toxicity		
LD_{50}		
Rat, oral	140 mg/kg to 340 mg/kg	HSDB (2012)
Mouse, oral	NDF	
Rabbit, oral	NDF	
Oral (animal not specified)	240 mg/kg	OECD (2002)
Oral (animal not specified)	400 mg/kg	OECD (2002)
Rat, dermal	NDF	
Rabbit, dermal	1 350 mg/kg	HSDB (2012)
Mouse, dermal	NDF	
LC_{50}		
Rat	NDF	
High Chronic/Repeat Dose Toxicity		
LOAEL	NDF	
LOAEC	NDF	

Footnotes:
LD_{50} – lethal dose for 50% of experimental population
LC_{50} – lethal air concentration for 50% of experimental population
LOAEL – Lowest Observed Adverse Effect Level
LOAEC – Lowest Observed Adverse Effect Concentration
NDF – no data found within the limits of the search strategy

Human Health Toxicity Ranking*		
	Hazard data	**Comment**
Hazard Band 4		
Carcinogenicity (IARC Group 1 or 2A)	No	
Mutagenicity/Genotoxicity (GHS Category 1A and 1B)	No	
Reproductive Toxicity/Developmental toxicity (GHS Category 1, 1A and 1B)	No	
Endocrine Disruption[1]	No	
Hazard Band 3		
Carcinogenicity (IARC Group 2B)	No	
Mutagenicity/Genotoxicity (GHS Category 2)	No	
Reproductive Toxicity/Developmental toxicity (GHS Category 2)	No	
Acute Toxicity (oral, dermal or inhalation) Very Toxic/Toxic • oral LD_{50} ≤ 300 mg/kg [3] • dermal LD_{50} ≤ 1000 mg/kg inhalation LC_{50} ≤ 10 mg/L [4] (vapour)	140 mg/kg o 340 mg/kg 240 mg/kg and 400 mg/kg	Rat, oral LD_{50} (HSDB, 2012) Animal not specified (OECD, 2002)
Possible carcinogenicity, mutagenicity, reproductive or High Chronic/repeat dose toxicity • oral LOAEL ≤ 10 mg/kg/d [3]; • dermal LOAEL ≤ 2 0 mg/kg/d; • inhalation LOAEC (6 h/d) ≤ 50 ppm/d for gases, ≤ 0.2 mg/L/d for vapours or ≤ 0.02 mg/L/d for dust/mists/fumes [4]	No	Not systemically available OECD (2002)
Corrosive (irreversible effect)	Yes	SafeWork Australia (2013)
Respiratory sensitiser	No	ECHA (2013)
Hazard Band 2		
Harmful chronic/repeat dose toxicity • oral LOAEL > 10 mg/kg and ≤ 100 mg/kg/d • dermal LOAEL > 20 mg/kg/d and ≤ 200 mg/kg/d • inhalation (6-h/d) LOAEC > 50 mg/L ≤ 250 mg/L/d for gases, > 0.2 mg/L ≤ 1 .0 mg/L/d for vapours or > 0.02 mg/L ≤ 0.2 mg/L/d for dust/mists/fumes [4]	No	Not systemically available OECD (2002)
Skin Sensitiser	No	ECHA (2013)
Hazard Band 1		
Acute Toxicity-Harmful • oral LD_{50} > 300 mg/kg ≤ 2000 mg/kg • dermal LD_{50} >1 000 mg/kg ≤ 2000 mg/kg; • inhalation LC_{50} (6 h/d) > 10 mg/L ≤ 20 mg/L for vapours) [4]	1,350 mg/kg	Rabbit, dermal LD_{50} (HSDB, 2012)
Irritant (reversible effect)	Yes	OECD (2002)
Hazard Band 0 **All indicators outside criteria listed in Hazards 1 - 4**	No	
Physical Hazards		
Flammable potential	No	
Explosive potential	No	
Hazard Evaluation (highest band) not including physical hazards	3	Based on acute toxicity and corrosive
Uncertainty analysis /data confidence (out of 12 parameters)	100%	

* Based on IMAP Framework [NICNAS (2013) Inventory Multi-tiered Assessment and Prioritisation (IMAP) Framework. National Industrial Chemicals Notification and Assessment Scheme. Department of Health and Aging, Canberra].

"[1]*Based on list of endocrine disrupting chemicals from the European Commission's Endocrine Disrupters website.*

[2] *Based on list of neurotoxic chemicals from US Agency for Toxic Substances and Disease Registry (ATSDR).*

[3] *milligrams per kilogram body mass (mg/kg) or milligrams per kilogram body mass per day (mg/kg/d)*

[4] *Based on GHS cut-offs for hazard classification. For chronic/repeat dose toxicity, GHS cut-offs are provided as guidance values (i.e. the dose/concentration at or below which significant health effects are observed)". (p 18, NICNAS 2013).*

Human Health Guidelines		
Media	**Concentration (mg/m^3; mg/L; mg/kg)**	**Reference**
Occupational Exposure Limits		
Air (OEL)		
8-h TWA		
STEL	NDF	
Peak Limitation	2 mg/m^3	SafeWork Australia (2011)
Environmental Exposure		
Air, ambient	NDF	
Air, indoor	NDF	
Water, potable	pH 6.5-8.5	pH aesthetic, no health value (ADWG, 2011)
Water, recreational	NDF	
Soil, residential	NDF	
Soil, commercial/industrial	NDF	

Footnotes:
OEL = Occupational Exposure Limit
TWA= 8-h Time-Weighted Average
STEL = (15 min) Short-term Exposure Limit
NDF – no data found within the limits of the search strategy

Summary Concluding Comments

Sodium hydroxide has been assigned to a Hazard Band 3. It is a highly corrosive substance and very dangerous to humans in high concentrations. From an environmental perspective, effects on water alkalinity and direct effects on plants and animal tissues are a concern. These factors are important with respect to acute occupational exposure and acute environmental exposures where exposure to dusts and concentrated solutions may result.

References

ADWG 2011, National Water Quality Management Strategy, *Australian Drinking Water Guidelines 6*, Australian Government, National Health and Medical Research Council, National Resource Management Ministerial Council.

ATSDR 2002, ToxFAQs™ for *Sodium Hydroxide*. Agency for Toxic Substances and Disease Registry. US Department of Health and Human Services, Public Health Service. Available at: http://www.atsdr.cdc.gov/toxfaqs/tf.asp?id=248&tid=45. [Accessed 20 December 2013]

BKH 2000, BKH Consulting Engineers. *Towards the establishment of a priority list of substances for further evaluation of their role in endocrine disruption: - preparation of a candidate list of substances as a basis for priority setting*. Final report

(incorporating corrigenda to final report dated 21 June 2000), Annex 10: List of 564 substances with their selection criteria. Available at http://ec.europa.eu/environment/archives/docum/pdf/bkh_main.pdf [Accessed 11/12/2013]

ECHA 2013, European Chemical Agency, 2007 – 2013.

Available at: http://apps.echa.europa.eu/registered/data/dossiers/DISS-9ea1ebb9-dbf1-0959-e044-00144f67d031/AGGR-c93b3c36-0c13-4475-a356-cede4a7e7c1e_DISS-9ea1ebb9-dbf1-0959-e044-00144f67d031.html#section_1.1. [Accessed 11/12/2013]

HSDB 2012, Hazardous Substances Database (HSDB). *Sodium Hydroxide*. Hazardous Substances Data Bank Number 229, reviewed 19/01/2012. Toxicology Data Network (TOXNET). Available at http://toxnet.nlm.nih.gov/cgi-bin/sis/search/f?./temp/~JKlwbL:1. [Accessed 11/12/2013].

IARC 2011, International Agency for Research on Cancer (IARC). Available at: http://monographs.iarc.fr/ENG/Classification/index.php. [(database accessed on 5 May 2011].

IPCS (INCHEM) 2005, International Programme on Chemical Safety (IPCS). Joint FAO/WHO Expert Commission on Food Additives (JECFA), (last updated 2005) [Accessed 11/12/2013].

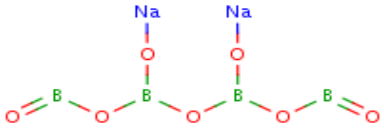
OECD 2002, *OECD SIDS Initial Assessment Report for SIAM 14: Sodium Hydroxide*, March 2002. Available at: http://www.inchem.org/documents/sids/sids/NAHYDROX.pdf [Accessed 11/12/2013]

SafeWork Australia 2011, Hazardous Substance Information System (HSIS). Available at: http://hsis.safeworkaustralia.gov.au/. [Accessed June 2011].

SafeWork Australia 2013, Hazardous Substance Information System (HSIS): *Sodium Hydroxide*. Available at: http://hsis.safeworkaustralia.gov.au/HazardousSubstance/Details?hazardousSubstanceID=876 [Accessed 12/12/2013]

Created by:	JB	23/06/2011
	CM	11/12/2013 (Rev3)
Reviewed and edited by:	LT	02/07/2011 (Rev0) 09/08/2012 (Rev1)
	PDM	09/01/2014 (Rev3)

Project number: 127666004
Project name: Hydraulic Stimulation Chemicals Assessment, Southwest Queensland
Client name: Santos Ltd

Name	Borax (SURROGATE FOR Sodium tetraborate 1330-43-4)
Synonyms	Borax, sodium tetraborate decahydrate, sodium pyroborate
CAS number	1303-96-4 (surrogate for 1330-43-4)
Molecular formula	$B_4Na_2O_7.10H_20$
Molecular Structure	

Overview	References
Sodium tetraborate is a naturally occurring mineral distributed widely in the environment. Commonly known as borax, it occurs in arid regions and was deposited by evaporation of salt lakes in the Tertiary Period. Sodium tetraborate is a white crystalline solid with no odour and an alkaline taste. It is differentiated by the crystal water content and ranges from the anhydrous form to the decahydrate which is referred to as borax.	HSDB (2010)
Industrial uses of sodium tetraborate in the United States of America include glass and ceramics (70%), soaps, bleaches, and detergents (4%), fire retardants (2%), and agriculture (2%). Other uses, including metallurgy, nuclear applications, as an addition to enamels and glazes, and in ingredients for cosmetics or medical preparations which make up the remaining 19%.	ATSDR (2010)
Borates are relatively soluble in water, and readily hydrolysed to form boric acid. Boron in aqueous solution may also be adsorbed by soils and sediments, with adsorption-desorption reactions expected to be the only significant mechanism that influences the fate of boron in water. The extent of boron adsorption depends on the pH of the water and the chemical composition of the soil, with the greatest adsorption generally observed at pH 7.5–9.0.	ATSDR (2010); Rai et al. (1986); Keren & Mezuman (1981); Keren et al. (1981)
Human exposure to sodium tetraborate may occur through ingestion of boron in food and water, or through use of pesticides containing boron compounds; inhalation of boron-containing powders or dusts, or the use of boron in cosmetics or medical preparations.	ATSDR (2010)
Boron concentrations in ambient non-occupational air samples in the United States of America have been reported to range from $<5x10^{-7}$ to $8x10^{-5}$ mg boron/m^3, with an average concentration of $2x10^{-5}$ mg boron/m^3. Workers in other industries, including manufacture of fiberglass and other glass products, cleaning and laundry products, fertilizers, pesticides, and cosmetics, may also be exposed to boron compounds. Mean dust concentrations ranging from 3.3 to 18 mg particulates/m^3 were measured in air samples from U.S. facilities where borax was packaged and shipped.	ATSDR (2010)

The primary health effect associated with inhalation exposure of humans to boron is acute respiratory irritation. Acute-duration exposures of mining and processing workers to 0.44–3.1 mg boron/m^3 (5.7–14.6 mg particulates/m^3) as sodium borate dusts have been associated with mild irritation of the eyes, throat, and nose, as well as with cough and breathlessness.	ATSDR (2010)
Oral exposure animal studies have clearly identified the reproductive system and developing	ATSDR

fetus as the most sensitive targets of boron toxicity. Adverse developmental effects have been identified for acute-and intermediate-duration exposures. Human case reports have reported that boron can be lethal following short-term oral exposure at high doses, although the dose estimation can be quite imprecise and variability in human responses to acute exposure is quite large.	(2010)
The primary health effects associated with dermal exposure are irritation of the eyes and reversible skin changes. Case reports of human occupational exposures have suggested that acute dermal exposure to boron as borax may cause localized hair loss from the scalp.	ATSDR (2010)
No epidemiology studies have identified an association between boron exposure and the development of cancer. The International Agency for Research on Cancer (IARC) has not assessed the carcinogenic potential of boron, sodium tetraborate or other borates. The United States Environment Protection Agency (USEPA) has stated that boron and associated compounds are not classifiable as to their carcinogenic potential on the basis of inadequate data.	IARC (2013); IRIS (2004)

Human Health Toxicity Summary	Reference
Carcinogenicity Inadequate data for classification ('Boron and compounds') (USEPA). Not classified (IARC).	IRIS (2004); IARC(2013)
Mutagenicity/Genotoxicity Negative results have been reported from studies in bacteria, mammalian cells and mice *in vivo*.	IRIS (2004)
Reproductive Toxicity Disodium tetraborate is classified as a presumed human reproductive toxicant based on animal studies (Repr. 1B H360). Oral exposure to the substance may damage fertility. Testes are a sensitive target of boron toxicity in rats and mice (oral studies). Testicular effects from these studies have included reduced organ weight and organ:body weight ratio, atrophy, degeneration of the spermatogenic epithelium, impaired spermatogenesis, reduced fertility, and sterility.	ECHA (2013) Weir and Fisher, 1972; Seal and Weeth, 1980; NTP, 1987; Fail et al., 1991 (in IRIS, 2004)
Developmental Toxicity/Teratogenicity Disodium tetraborate is classified as a presumed human reproductive toxicant based on animal studies (Repr. 1B H360). Oral exposure to the substance may damage the unborn child. Foetuses from rats (Sprague Dawley) exposed to boric acid in their feed had reduced foetal body weight, short and wavy ribs; effects disappeared during the postnatal period. A LOAEL for developmental toxicity of 76 mg/kg/day was determined. Boric acid administered to rabbits (New Zealand White) by gavage was found to be toxic to dams and cause foetal resorption and cardiac or great vessel malformations in surviving foetuses. A LOAEL for maternal and developmental toxicity of 250 mg/kg/day was determined.	ECHA (2013)
Endocrine Disruption Changes in testicular characteristics following exposure to boric-acid have suggested the involvement of an endocrine mechanism, however, boron and borates are not listed as priority Endocrine Disrupting substances by the European Commission.	EC (2000), Weir and Fisher, 1972 (in HSDB, 2013)
Neurotoxicity	

NDF	
Acute Toxicity (oral, dermal, inhalation) Acute *oral* exposure of humans to boron and its soluble salts (including sodium tetraborate) have been lethal at sufficiently high doses. The minimal lethal dose of ingested boron (as boric acid) was reported to be 2–3 g in infants, 5–6 g in children, and 15–20 g in adults. Adverse developmental effects have been identified for acute-duration oral exposures in mice and rats. Acute *dermal* exposure of humans to sodium tetraborate may cause localized hair loss from the scalp. In animals, exposure to boron dust and aqueous solution applied to the eyes has resulted in conjunctivitis, mild irritancy of the epithelium and superficial stroma. Acute *inhalational* exposure of humans to boron can cause acute respiratory irritation and increased nasal secretions.	ATSDR (2010)
Chronic/repeat dose toxicity (oral, dermal, inhalation) Chronic *oral* exposure of humans to borate salts in drinking water (9–25 mg boron/L) found no evidence of reproductive effects. Testicular atrophy has been observed in rats exposed to 81 mg boron/kg/day and mice exposed to 201 mg boron/kg/day for 2 years. Several systemic effects have also been observed in chronic animal studies, including haematological effects, desquamated skin and chronic inflammation of the liver. Chronic *dermal* exposure of industrial workers to sodium tetraborate dust has been documented to cause chronic eczema. Chronic *inhalational* exposure of humans to sodium tetraborate dust has been documented to cause symptoms of persistent respiratory irritation meeting the definition of chronic simple bronchitis.	ATSDR (2010); Garabrant et al. (1984); International Labour Office (1983)
Sensitisation of the skin or respiratory system Not classified as a skin or respiratory sensitiser by ECHA. *In vivo* Buehler tests (OECD guideline 406) carried out on male/female guinea pigs (Hartley) concluded boric acid was not a skin sensitiser. The dose applied epicutaneously (occlusive) was 0.4 g 95% w/w. Chronic *dermal* exposure of industrial workers to sodium tetraborate dust has been documented to cause chronic eczema.	ECHA (2013) ATSDR (2010)
Corrosion (irreversible and reversible)/irritation of the skin or eye Not classified as corrosive/irritating to the skin by ECHA. Disodium tetraborate (anhydrous, pentahydrate, decahydrate) is classified as an eye irritant (Eye Irrit. 2 H319). Eye irritation is caused by the glassy nature of the crystals of substance and not a chemical effect of irritation. Disodium tetraborate decahydrate is used as a buffer in eyewashes. Not corrosive. Irritant to the skin and mucous membranes of the eyes, nose and other parts of the respiratory tract.	ECHA (2013) ACGIH (2001); in HSDB (2013)

Human Health Toxicity Summary	Reference
Flammable Potential No.	HSDB (2013)
Explosive Potential No.	HSDB (2013)

Toxicity Values	Value	Reference
Human Toxicity Data		
Acute Toxicity		
LD_{50}	NDF	-
LC_{50}	NDF	-
High Chronic/Repeat Dose Toxicity		
LOAEC	1.8 mg/m^3	Garabrant et al. (1984)
Animal Toxicity Data		
Acute Toxicity		
LD_{50}		
Rat, oral	396 – 5,660 mg/kg	USEPA (1988); O'Neill (ed) (2001)
Rat, dermal	NDF	-
Rabbit, dermal	>10,000 mg/kg	Tomlin (ed) (2003-2004)
LC_{50}		
Rat	>2 mg/m^3/4 hrs	Bingham et al. (2001)
High Chronic/Repeat Dose Toxicity		
LOAEL	28.5 mg B/kg	Heindel et al. (1992); Price et al.(1990)
LOAEL	13.6 – 25.3 mg B/kg	Heindel et al. (1992); Price et al.(1996)
LOAEL	76 mg/kg/day	Oral, developmental toxicity, rats ECHA (2013)
NOAEL	55 mg/kg/day	Oral, developmental toxicity, rats ECHA (2013)
LOAEL	250 mg/kg/day	Oral, developmental and maternal toxicity, rabbits ECHA (2013)
NOAEL	125 mg/kg/day	Oral, developmental and maternal toxicity, rabbits ECHA (2013)

Footnotes:
LD_{50} – lethal dose for 50% of experimental population
LC_{50} – lethal air concentration for 50% of experimental population
LOAEL – Lowest Observed Adverse Effect Level
LOAEC – Lowest Observed Adverse Effect Concentration
NDF – no data found within the limits of the search strategy

Human Health Toxicity Ranking*		
	Hazard data	**Comment**
Hazard Band 4		
Carcinogenicity (IARC Group 1 or 2A)	NDF	
Mutagenicity/Genotoxicity (GHS Category 1A and 1B)	No	ECHA (2013); IRIS (2004)
Reproductive Toxicity/Developmental toxicity (GHS Category 1, 1A and 1B)	Yes	ECHA (2013), category 1B
Endocrine Disruption[1]	No	EC (2000)
Hazard Band 3		
Carcinogenicity (IARC Group 2B)	NDF	
Mutagenicity/Genotoxicity (GHS Category 2)	No	ECHA (2013); IRIS (2004)
Reproductive Toxicity/Developmental toxicity (GHS Category 2)	No	ECHA (2013)
Acute Toxicity (oral, dermal or inhalation) Very Toxic/Toxic • oral LD_{50} ≤ 300 mg/kg [3] • dermal LD_{50} ≤ 1000 mg/kg • inhalation LC_{50} ≤ 10 mg/L [4] (or mg/m^3) (vapour)	No	ATSDR (2010)
Possible carcinogenicity, mutagenicity, reproductive or High Chronic/repeat dose toxicity • oral LOAEL ≤ 10 mg/kg/d [3]; • dermal LOAEL ≤ 20 mg/kg/d; • inhalation LOAEC (6 h/d) ≤ 50 ppm/d for gases, ≤ 0.2 mg/L/d for vapours or ≤ 0.02 mg/L/d for dust/mists/fumes [4]	No	ECHA (2013); ATSDR (2010); Garabrant et al. (1984); International Labour Office (1983)
Corrosive (irreversible effect)	No	ECHA (2013)
Respiratory sensitiser	No	ECHA (2013)
Hazard Band 2		
Harmful chronic/repeat dose toxicity • oral LOAEL > 10 mg/kg and ≤ 100 mg/kg/d • dermal LOAEL > 20 mg/kg/d and ≤ 200 mg/kg/d • inhalation (6 h/d) LOAEC > 50 mg/L ≤ 250 mg/L/d for gases, > 0.2 mg/L ≤ 1 .0 mg/L/d for vapours or > 0.02 mg/L ≤ 0.2 mg/L/d for dust/mists/fumes [4]	Yes	Based on decreased fetal body weight (Heindel et al., 1992; Price et al., 1996) Occupational exposure to sodium borate dust (Garabrant et al., 1984)
Skin Sensitiser	No	ECHA (2013)
Hazard Band 1		
Acute Toxicity-Harmful • oral LD_{50} > 300 mg/kg ≤ 2,000 mg/kg • dermal LD_{50} >1,000 mg/kg ≤ 2,000 mg/kg; • inhalation LC_{50} (6 h/d) > 10 mg/L ≤ 20 mg/L for vapours) [4]	No	USEPA (1988); O'Neill (ed) (2001)
Irritant (reversible effect)	Yes	ECHA (2013)
Hazard Band 0 **All indicators outside criteria listed in Hazards 1-4**		
Physical Hazards		
Flammable potential	No	HSDB (2013)
Explosive potential	No	HSDB (2013)

Hazard Evaluation (highest band) not including physical hazards	Band 4	Based on reproductive and developmental toxicity
Uncertainty analysis /data confidence (out of 12 parameters)	11/12	**91%**

*Based on IMAP Framework [NICNAS (2013) Inventory Multi-tiered Assessment and Prioritisation (IMAP) Framework. National Industrial Chemicals Notification and Assessment Scheme. Department of Health and Aging, Canberra].

"[1]Based on list of endocrine disrupting chemicals from the European Commission's Endocrine Disrupters website.

[2] Based on list of neurotoxic chemicals from US Agency for Toxic Substances and Disease Registry (ATSDR).

[3] milligrams per kilogram body mass (mg/kg) or milligrams per kilogram body mass per day (mg/kg/d)

[4] Based on GHS cut-offs for hazard classification. For chronic/repeat dose toxicity, GHS cut-offs are provided as guidance values (i.e. the dose/concentration at or below which significant health effects are observed)". (p 18, NICNAS 2013).

Human Health Guidelines		
Media	**Concentration (mg/m^3; mg/L; mg/kg)**	**Reference**
Occupational Exposure Limits		
Air (OEL)		
8-h TWA	5 mg/m^3 (sodium tetraborate)	HSIS (2005)
STEL	6 mg/m^3 (sodium tetraborate)	ACGIH (2006) (in ATSDR, 2010)
Peak Limitation	NDF	All proposed data sources
Environmental Exposure		
Air, ambient	NDF	All proposed data sources
Air, indoor	0.021 mg/m^3 (boron and borates) – **residential** air 0.088 mg/m^3 (boron and borates) – **industrial** air	USEPA Region 9 RSLs (2012)
Water, potable	4 mg/L (boron)	NEPM (1999; amended 2013)
Water, recreational	NDF	All proposed data sources
Soil, residential	4,500 mg/kg (boron); Setting A – low density residential 40,000 mg/kg (boron); Setting B – high density residential	NEPM (1999; amended 2013)
Soil, commercial/industrial	300,000 mg/kg (boron); Setting D – commercial/industrial	NEPM (1999; amended 2013)

Footnotes:

OEL = Occupational Exposure Limit

TWA= 8 h Time-Weighted Average

STEL = (15 min) Short-term Exposure Limit

NDF - No data found within the limits of the search strategy.

QualifyingSummary Comments

Boric acid is an inorganic, white, odourless, crystalline solid. Its primary uses (along with sodium salts of boron (primarily borax, or disodium tetraborate decahydrate)) are in industrial processes such as the manufacture of glass, as a fire retardant, in laundry additives, in fertilisers and in herbicides. Low concentrations of simple inorganic borates (e.g. boric acid, disodium tetraborate pentahydrate, boric oxide and disodium octaborate tetrahydrate) will predominately exist as un-dissociated boric acid in aqueous solutions at physiological and acidic pH. Sodium tetraborate exhibits a Hazard Band Rating of 4 based on its reproductive toxicity potential in animal studies. In addition, anhydrous boric acid and aqueous solutions have been reported as being irritating to the eye. It is not flammable and explosive but as a powder it may result in contact and inhalation exposures in occupational settings which can lead to adverse respiratory,dermal and ocular effects. In the environmental setting its solubility and resultant persistence as the metal in various forms combined with its identified toxicity warrants closer evaluation of frequency of use, masses of chemical used and potential distribution in water, soils and sediments.

References

ACGIH (2001). American Conference of Governmental Industrial Hygienists. Documentation of Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices for 2001. Cincinnati, OH.

ACGIH (2006). American Conference of Governmental Industrial Hygienists. Boron. Threshold limit values for chemical substances and physical agents and biological exposure indices. Cincinnati, OH: American Conference of Governmental Industrial Hygienists, 14-15.

ATSDR (2010). Agency for Toxic Substances and Disease Registry. Toxicological Profile for Boron. Available at: http://www.atsdr.cdc.gov/toxprofiles/tp.asp?id=453&tid=80. [Accessed 23 May 2013]

Bingham, E., Cohrssen, B., Powell, C.H. (2001). Patty's Toxicology Volumes 1-9 5th ed. John Wiley & Sons. New York, N.Y., p. V3 p.533.

EC 2000, *Towards the establishment of a priority list of substances for further evaluation of their role in endocrine disruption: - preparation of a candidate list of substances as a basis for priority setting*. Final report (incorporating corrigenda to final report dated 21 June 2000), Annex 10: List of 564 substances with their selection criteria. Prepared by BKH Consulting Engineers in association with TNO Nutrition and Food Research, The Netherlands for European Commission. Available at http://ec.europa.eu/environment/archives/docum/pdf/bkh_main.pdf [Accessed15/01/2014]

European Chemicals Agency (ECHA) (2013), European Chemicals Agency Registered Chemical Substances Search, Available at: http://echa.europa.eu/web/guest/information-on-chemicals/registered-substances [Accessed 15/01/ 2014]

Fail, PA; George, JD; Seely, JC; Grizzle, TB; Heindel, JJ. (1991). Reproductive toxicity of boric acid in Swiss (CD-1) mice: Assessment using the continuous breeding protocol. Fund Appl Toxicol 17:225-239.

Garabrant, DH; Bernstein, L; Peters, JM; Smith, TJ. (1984) Respiratory and eye irritation from boron oxide and boric acid dusts. J Occup Med 26:584-586.

Heindel, JJ; Price, CJ; Field, EA; et al. (1992). Developmental toxicity of boric acid in mice and rats. Fund Appl Toxicol 18:266-277 (in IRIS, 2004).
HSDB (2013). Hazardous Substances Data Bank. Available at: http://toxnet.nlm.nih.gov/cgi-bin/sis/search/f?./temp/~Cumxru:1 [Accessed 21 May 2013]

HSIS (2005). Hazardous Substances Information System. Available at: http://hsis.safeworkaustralia.gov.au/ExposureStandards/Details?exposureStandardID=66 [Accessed 22 May 2013]

International Labor Office. Encyclopedia of Occupational Health and Safety. Vols. I&II. Geneva, Switzerland: International Labour Office, 1983. p. 320.

IRIS (2004). Integrated Risk Information System. Toxicological Profile for Boron and Compounds. Available at: http://www.epa.gov/iris/subst/0410.htm [Accessed 21 May 13]

Keren, R., Mezuman, U. (1981). Boron adsorption by clay minerals using a phenomenological equation. Clays Clay Miner 29:198-204.

Keren, R., Gast, R.G., Bar-Yosef, B. (1981). pH-dependent boron adsorption by Na-montmorillonite. Soil Sci Soc Am J 45:45-48.

National Environment Protection (Assessment of Site Contamination) Measure 1999 (NEPM, 1999 - amended).

NTP (1987). National Toxicology Program. Toxicology and Carcinogenesis Studies of Boric Acid (CAS No. 10043-35-3) in B6C3F1 Mice (feed studies). NTP Tech. Rep. Ser. No. 324. U.S. DHHS, PHS, NIH, Research Triangle Park, NC.

O'Neil, M.J. (ed.) (2001). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. 13th Edition, Whitehouse Station, NJ: Merck and Co., Inc., p. 1537.

Price, C.J., Field, E.A., Marr, M.C., Myers, C.B., Morrissey, R.E., Schwetz, B.A. (1990) Final report on the Developmental Toxicity of Boric Acid (CAS No. 10043-35-3) in Sprague Dawley Rats. NTP Report No. 90-105 (and Report Supplement No. 90-105A). National Toxicology Program, U.S. DHHS, PHS, NIH, Research Triangle Park, NC, May 1.

Price, CJ; Strong, PL; Marr, MC; Myers, CB; Murray, FJ. (1996). Developmental toxicity NOAEL and postnatal recovery in rats fed boric acid during gestation. Fund Appl Toxicol 32:179-193 (in IRIS, 2004).

Rai, D., Zachara, J.M., Schwab, A.P. et al. (1986). Chemical attenuation rates, coefficients, and constants in leachate migration. Vol. 1. A critical review. Palo Alto, CA: Electric Power Research Institute, Research Project 2198-1.

Seal, BS; Weeth, HJ. (1980). Effect of boron in drinking water on the male laboratory rat. Bull Environ Contam Toxicol 25:782-789.

Silaev, A.A. (1984). Experimental determination of the maximum permissible concentration of sodium perborate in workplace air. Gig. Tr. Prof. Zabol. 6 : 44. Sprague RW. (1972). The Ecological Significance of Boron. US Borax Research Corporation, Anaheim CA : 58.

Tomlin, C.D.S., ed. Borax (1303-96-4). In: The e-Pesticide Manual, 13th Edition Version 3.0 (2003-04). Surrey UK, British Crop Protection Council.

USEPA (1988). United States Environment Protection Agency. Health Advisory for Boron (Draft) p 5.

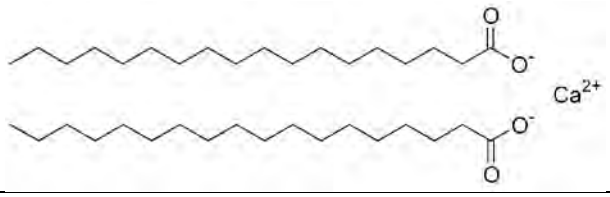
USEPA (2012). United States Environment Protection Agency. Region 9: Regional Screening Levels. Available at: http://www.epa.gov/region9/superfund/prg/ [Accessed 22 May 13]

Waggott A. (1969). An investigation of the potential problem of increasing boron concentrations in rivers and water courses. Water Res 3:749-765.

Weir, RJ; Fisher, RS. (1972). Toxicologic studies on borax and boric acid. Toxicol Appl Pharmacol 23:351-364.

Created by:	MH	Date: 9/01/2014
Reviewed:	LT	Date: 16/01/2014

Project number: 127666004
Project name: Hydraulic Stimulation Chemicals Assessment, Southwest Queensland
Client name: Santos Ltd

Name	Octadecanoic acid calcium salt
Synonyms	Calcium stearate, calcium distearate, stearic acid calcium salt
CAS number	1592-23-0
Molecular formula	C18H36O2.1/2Ca
Molecular Structure	

Overview	Reference
Octadecanoic acid calcium salt is a salt of the stearic acid. Stearic acid salts (stearates) are white to yellow powder or wax-like substances. Stearic acid and its salts are fatty acids with natural occurrence in some animals and vegetable fats and oils. Steric acid is produced by hydrogenating vegetable oils. Stearic acid and its salts are used in cosmetics, pharmaceuticals, food additives, waterproofing agents, plastic stabilizers, emulsifiers, and rubber lubricants and dusting agents. Octadecanoic acid calcium salt is classified *generally recognized as safe* (GRAS) for human consumption by the Food and Drug Administration. The properties and toxicity data for stearic acid have been utilised in this profile when no information was available for its calcium salt.	SIDS, 2012 US NLM, 2013 FDA, 2013

Human Health Toxicity Summary	Reference
Carcinogenicity Not as a carcinogenic substance.	IARC, 2013
Mutagenicity/Genotoxicity Not classified as mutagenic.	ECHA, 2013
Reproductive Toxicity Not classified as toxic to reproduction.	ECHA, 2013
Developmental Toxicity/Teratogenicity Not classified as toxic to development	ECHA, 2013
Endocrine Disruption Not listed as an endocrine disruptor	EC, 2000
Acute Toxicity (oral, dermal, inhalation) Not classified as acute toxicity hazard.	ECHA, 2013
Chronic/repeat dose toxicity (oral, dermal, inhalation) Not classified as specific target organ toxicant.	ECHA, 2013
Sensitisation of the skin or respiratory system Not classified as a skin sensitizer. Data lacking regarding respiratory sensitization.	ECHA, 2013
Corrosion (irreversible and reversible)/irritation of the skin or eye Not classified as corrosive or irritant to the skin or eye.	ECHA, 2013

Physical Hazards	Reference
Flammable Potential Not classified as flammable	ECHA, 2013
Explosive Potential Not classified as explosive	ECHA, 2013

Toxicity Values	Value	Reference
Human Toxicity Data		
Acute Toxicity		
	No data found (NDF)	
High Chronic/Repeat dose Toxicity		
	NDF	
Animal Toxicity Data		
Acute Toxicity		
LD_{50}		
Rat, oral	> 5000 mg/kg	ECHA, 2013
Rat, dermal	NDF	
Rabbit, dermal	> 2000 mg/kg	ECHA, 2013
LOAEL	NDF	
LOAEC	NDF	
LC_{50}		
Rat	0.1621 mg/L air (read across: octanoic acid)	ECHA, 2013
High Chronic/Repeat dose Toxicity		
LOAEL	NDF	
LOAEC	NDF	
NOAEL	1000 mg/kg bw/day (read across: docosanoic acid)	ECHA, 2013

Footnotes:
LD_{50} – lethal dose for 50% of experimental population
LC_{50} – lethal air concentration for 50% of experimental population
LOAEL – Lowest Observed Adverse Effect Level
LOAEC – Lowest Observed Adverse Effect Concentration
NOAEL – No Observed Adverse Effect Level

Human Health Toxicity Ranking*		
	Hazard data	**Comment**
Hazard Band 4		
Carcinogenicity	No	
Mutagenicity/Genotoxicity	No	
Reproductive Toxicity	No	
Developmental Toxicity/ Teratogenicity	No	
Endocrine Disruption[1]	No	
Hazard Band 3		
Acute Toxicity (oral, dermal or inhalation) Very Toxic/Toxic • oral LD_{50} ≤ 300 mg/kg[2] • dermal LD_{50} ≤ 1000 mg/kg • inhalation LC_{50} ≤ 10 mg/L^3 (or mg/m^3) (vapour)	No	
Possible carcinogenicity, mutagenicity, reproductive or High Chronic/repeat dose toxicity • oral LOAEL ≤ 10 mg/kg/d[3]; • dermal LOAEL ≤ 2 0 mg/kg/d; • inhalation LOAEC (6 h/d) ≤ 50 ppm/d for gases, ≤ 0.2 mg/L/d for vapours or ≤ 0.02 mg/L/d for dust/mists/fumes[3]	No	
Corrosive (irreversible damage)	No	
Respiratory sensitiser	NDF	
Hazard Band 2		
Harmful chronic/repeat dose toxicity • oral LOAEL > 10 mg/kg and ≤ 100 mg/kg/d • dermal LOAEL > 20 mg/kg/d and ≤ 200 mg/kg/d • inhalation (6-h/d) LOAEC > 50 mg/L ≤ 250 mg/L/d for gases, > 0.2 mg/L ≤ 1 .0 mg/L/d for vapours or > 0.02 mg/L ≤ 0.2 mg/L/d for dust/mists/fumes[3]	No	
Skin Sensitiser	No	
Hazard Band 1		
Acute Toxicity-Harmful • oral LD_{50} > 300 mg/kg ≤ 2000 mg/kg • dermal LD_{50} >1 000 mg/kg ≤ 2000 mg/kg; • inhalation LC_{50} (6 h/d) > 10 mg/L ≤ 20 mg/L for vapours)[3]	No	
Irritant (reversible damage)	No	
Hazard Band 0 **All indicators outside criteria listed in Hazards 1-4**		
Physical Hazards		
Flammable potential	No	
Explosive potential	No	
Hazard Evaluation (highest band) not including physical hazards	Hazard Band 0	
Uncertainty analysis /data confidence	12/13	**92%**

* Based on IMAP Framework [NICNAS (2013) Inventory Multi-tiered Assessment and Prioritisation (IMAP) Framework. National Industrial Chemicals Notification and Assessment Scheme. Department of Health and Aging, Canberra].

"[1]Based on list of endocrine disrupting chemicals from the European Commission's Endocrine Disrupters website.

[2]milligrams per kilogram body mass(mg/kg) or milligrams per kilogram body mas per day (mg/kg/d)

[3] Based on GHS cut-offs for hazard classification. For chronic/repeat dose toxicity, GHS cut-offs are provided as guidance values (i.e. the dose/concentration at or below which significant health effects are observed"). (p 18, NICNAS 2013).

Human Health Guidelines		
Media	**Concentration (mg/m^3; mg/L; mg/kg)**	**Reference**
Occupational Exposure Limits		
Air (OEL)		
8-h TWA	10 mg/m^3 (octadecanoic acid calcium salt)	IPCS, 2003
STEL (Excursion limit recommendation)	>30 mg/m^3 (for no more than 30min through work day)	HSDB, 2011
Peak Limitation	50 mg/m^3 (for no more than 30min through work day)	HSDB, 2011
Environmental Exposure		
Air, ambient	35 µg/m^3	Ontario's AAQC, 2012
Air, indoor	NDF	
Water, potable	NDF	ADWG, 2011
Water, recreational	NDF	NEPM, 1999 - amended
Soil, residential	NDF	NEPM, 1999 - amended
Soil, commercial/industrial	NDF	NEPM, 1999 - amended

Footnotes:

OEL = Occupational Exposure Limit

TWA= 8 h Time-Weighted Average

STEL = (15 min) Short-term Exposure Limit

NDF - No data found within the limits of the search strategy.

Qualifying Summary Comments

Octadecanoic acid calcium salt has a low hazard profile to human health. It is not classified as a hazardous substance and deemed to be safe for human consumption.

References and Notes

Australian Drinking Water Guidelines (ADWG, 2011). National Health and Medical Research Council. Available from http://www.nhmrc.gov.au/_files_nhmrc/publications/attachments/eh52_aust_drinking_water_guidelines.pdf

European Chemicals Agency (ECHA 2013). Registered Chemical Substances Search. Available at http://echa.europa.eu/web/guest/information-on-chemicals/registered-substances. [Accessed 10 October 2013] (ECHA 2013)

European Commission (EC, 2000) Towards the establishment of a priority list of substances for further evaluation of their role in endocrine disruption, preparation of a candidate list of substances as a basis for priority setting, Final Report (Incorporating corrigenda to final report dated 21 June 2000).

Food and Drug Administration (FDA, 2013) Generally Recognised As Safe (GRAS) Substances Database. Available at http://www.fda.gov/Food/IngredientsPackagingLabeling/GRAS/SCOGS/ucm261238.htm [Accessed 10 October 2013].

Hazardous Substances Data Bank (HSDB, 2011) Toxicology Data Network (TOXNET). Available at http://toxnet.nlm.nih.gov/cgi-bin/sis/search. [Accessed 10 October 2013].

International Agency for Research on Cancer (IARC, 2013) Agents classified by IARC Monographs, Volumes 1-108. Available at http://monographs.iarc.fr/ENG/Classification/ClassificationsGroupOrder.pdf

International Program on Chemical Safety (IPCS, 2003) *Calcium Stearate* summary. Available at http://www.inchem.org/documents/icsc/icsc/eics1506.htm [Accessed 9 October 2013].

National Environment Protection (Assessment of Site Contamination) Measure 1999 (NEPM, 1999 - amended).

Ontario's Ambient Air Quality Criteria (Ontario's AAQC, 2012). Available at http://www.ene.gov.on.ca/stdprodconsume/groups/lr/@ene/@resources/documents/resource/std01_079182.pdf

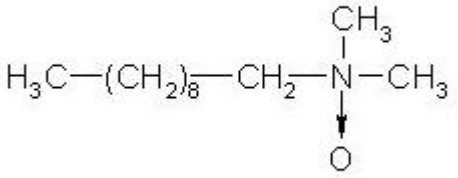
Organisation for Economic Cooperation and Development (OECD) Existing Chemicals Screening Information Dataset (SIDS, 2012). Available at http://webnet.oecd.org/Hpv/UI/SIDS_Details.aspx?id=7D49842A-206F-41A3-B76A-904C11EF4CF8. [Accessed 10 October 2013].

United States National Library of Medicine (US NLM, 2013) Haz-Map Database. Available at http://hazmap.nlm.nih.gov/search?search_query=calcium+stearate. [Accessed 10 October 2013].

NDF – No data found within the limits of the search strategy

Created by:	JC	Date: 10/10/2013
Reviewed and edited by:	JF	Date 08/11/2013

Project number: 127666004
Project name: Hydraulic Stimulation Chemicals Assessment, Southwest Queensland
Client name: Santos Ltd

Name	Decyl-dimethyl amine oxide
Synonyms	N,N-Dimethyl-1-decanamine-N-oxide N,N-Dimethyldecylamine oxide 1-Decanamine,N,N-dimethyl-,N-oxide Capric dimethyl amine oxide DDOA Decylamine oxide
CAS number	2605-79-0
Molecular formula	C12H27NO
Molecular Structure	

Overview	Reference
Decyl-dimethyl amine oxide is a mono constituent organic surfactant that has been used in washing and cleaning products (including solvent-based products), cosmetics and personal care products. It is also used in laboratory chemicals, metal working fluids, polishes and wax blends, water treatment chemicals and pesticides. It is most often found in a mixture in solid (powder) or liquid form. It is a solid at 20°C, is readily biodegradable and very soluble in water (>10000 mg/L) In Europe, annual use has been reported as 100 - 1,000 tonnes. It is recognised as resulting in serious eye damage (Eye Damage 1 H318: serious eye damage/ eye irritation) following contact and is harmful if swallowed (Acute Toxicity 4 H302). Protective gloves/clothing/face/eye protection is required when handling decyl-dimethyl amine oxide. Decyl-dimethyl amine oxide has been reported as being hazardous to the aquatic environment for both acute and long term exposures and release into the environment should be avoided. Based on its rapid aqueous degradation potential exposures to humans following environmental introduction will be limited.	ECHA (2013); HSDB (2009)

Human Health Toxicity Summary	Reference
Carcinogenicity Not on the IARC International Agency for Research on Cancer Carcinogen list.	IARC (2013)
Mutagenicity/Genotoxicity Not classified as mutagenic. ECHA has not reported this substance to be a mutagen.	ECHA (2013)
Reproductive Toxicity Not classified as reproductively toxic.	ECHA (2013)
Developmental Toxicity/Teratogenicity	ECHA

Not classified as a developmentally toxic by ECHA.	(2013)
Endocrine Disruption Not classified as an endocrine disrupter by ECHA.	ECHA (2013)
Acute Toxicity (oral, dermal, inhalation) **Oral** Acute Toxicity 4 (GHS Acute toxicity cat. 4 LD 50 = >300 <2000 mg/kg for oral pathways) H302- Harmful if swallowed. **Dermal** Not classified as dermally acutely toxic, category 5 GHS. **Inhalation** NDF.	ECHA (2013) ECHA (2013)
Chronic/repeat dose toxicity (oral, dermal, inhalation) No classed as chronically toxic. Conclusive but not sufficient for classification as chronic toxic under GHS.	ECHA (2013)
Sensitisation of the skin or respiratory system Not classified as a skin sensitiser. NDF for respiratory sensitiser.	ECHA (2013)
Corrosion (irreversible and reversible)/irritation of the skin or eye Eye Damage 1 H318: Causes serious irreversible eye damage.	ECHA (2013)

Physical Hazards	Reference
Flammable Potential Not classified as a flammable substance.	ECHA (2013)
Explosive Potential Not classified as an explosive substance.	ECHA (2013)

Toxicity Values	Value	Reference
Human Toxicity Data		
Acute Toxicity		
	NDF	
High Chronic/Repeat dose Toxicity		
NOAEL	**Dermal** Workers-1100 mg/kg bw/day General Population- 1100 mg/kg bw/day **Oral** Workers- 88 mg/kg	ECHA, 2013
Animal Toxicity Data		
Acute Toxicity		
LD_{50}		
Rat, oral	>300 <2000 mg/kg bw	ECHA 2013
Rat, dermal	>2000 mg/kg bw	ECHA 2013
Rabbit, dermal	>2000 mg/kg bw	ECHA 2013
LOAEL	NDF	
LOAEC	NDF	
LC_{50}		
Rat	NDF	
High Chronic/Repeat dose Toxicity		
NOAEL (Oral, rat)	40 mg/kg bw/day (study based on using amines, C_{12-18} (even numbered)-alkyldimethyl, N-	ECHA (2013)

	oxides)	
LOAEL	NDF	ECHA (2013)
LOAEC	NDF	
NOAEL (Dermal, mouse)	NDF	ECHA (2013)
LOAEL(Dermal, mouse)	0.27mg per application (2 cm X 3 cm patch on skin), per day, 5 applications per week	ECHA (2013)
LOAEC (Dermal, mouse)	NDF	
LOAEC	NDF	

Footnotes:
NDF- No data found within the limits of this search/study
LD_{50} – lethal dose for 50% of experimental population
LC_{50} – lethal air concentration for 50% of experimental population
LOAEL – Lowest Observed Adverse Effect Level
LOAEC – Lowest Observed Adverse Effect Concentration
NOAEL – No Observed Adverse Effect Level

Project number: 127666004
Project name: Hydraulic Stimulation Chemicals Assessment, Southwest Queensland
Client name: Santos Ltd

Human Health Toxicity Ranking*		
	Hazard data	**Comment**
Hazard Band 4		
Carcinogenicity	NDF	
Mutagenicity/Genotoxicity	No	
Reproductive Toxicity	No	
Developmental Toxicity/ Teratogenicity	No	
Endocrine Disruption[1]	NDF	
Hazard Band 3		
Acute Toxicity (oral, dermal or inhalation) Very Toxic/Toxic • oral LD_{50} ≤ 300 mg/kg[2] • dermal LD_{50} ≤ 1000 mg/kg • inhalation LC_{50} ≤ 10 mg/L[3] (or mg/m[3]) (vapour)	No	
Possible carcinogenicity, mutagenicity, reproductive or High Chronic/repeat dose toxicity • oral LOAEL ≤ 10 mg/kg/d[3]; • dermal LOAEL ≤ 2 0 mg/kg/d; • inhalation LOAEC (6 h/d) ≤ 50 ppm/d for gases, ≤ 0.2 mg/L/d for vapours or ≤ 0.02 mg/L/d for dust/mists/fumes[3]	No	
Corrosive (irreversible damage)	Yes	Serious Eye Damage (ECHA (2013))
Respiratory sensitiser	NDF	
Hazard Band 2		
Harmful chronic/repeat dose toxicity • oral LOAEL > 10 mg/kg and ≤ 100 mg/kg/d • dermal LOAEL > 20 mg/kg/d and ≤ 200 mg/kg/d • inhalation (6-h/d) LOAEC > 50 mg/L ≤ 250 mg/L/d for gases, > 0.2 mg/L ≤ 1 .0 mg/L/d for vapours or > 0.02 mg/L ≤ 0.2 mg/L/d for dust/mists/fumes[3]	No	
Skin Sensitiser	No	
Hazard Band 1		
Acute Toxicity-Harmful • oral LD_{50} > 300 mg/kg ≤ 2000 mg/kg • dermal LD_{50} >1 000 mg/kg ≤ 2000 mg/kg; • inhalation LC_{50} (6 h/d) > 10 mg/L ≤ 20 mg/L for vapours)[3]	Yes	ECHA (2013)
Irritant (reversible damage)	NDF	
Hazard Band 0 **All indicators outside criteria listed in Hazards 1-4**		
Physical Hazards		
Flammable potential	No	
Explosive potential	No	
Hazard Evaluation (highest band) not including physical hazards	**Band 3**	
Uncertainty analysis /data confidence	8/13	**62%**

* Based on IMAP Framework [NICNAS (2013) Inventory Multi-tiered Assessment and Prioritisation (IMAP) Framework. National Industrial Chemicals Notification and Assessment Scheme. Department of Health and Aging, Canberra].

"[1]Based on list of endocrine disrupting chemicals from the European Commission's Endocrine Disrupters website.

[2]milligrams per kilogram body mass(mg/kg) or milligrams per kilogram body mas per day (mg/kg/d)

[3] Based on GHS cut-offs for hazard classification. For chronic/repeat dose toxicity, GHS cut-offs are provided as guidance values (i.e. the dose/concentration at or below which significant health effects are observed"). (p 18, NICNAS 2013).

Human Health Guidelines		
Media	**Concentration (mg/m^3; mg/L; mg/kg)**	**Reference**
Occupational Exposure Limits		
Air (OEL)	NDF	
8-h TWA	NDF	
STEL	NDF	
Peak Limitation	NDF	
Environmental Exposure		
Air, ambient	NDF	
Air, indoor	NDF	
Water, potable	NDF	
Water, recreational	NDF	
Soil, residential	NDF	
Soil, commercial/industrial	NDF	

Footnotes:

OEL = Occupational Exposure Limit

TWA= 8 h Time-Weighted Average

STEL = (15 min) Short-term Exposure Limit

NDF - No data found within the limits of the search strategy.

Qualifying Summary Comments

Decyl-dimethyl amine oxide is a colourless liquid at standard temperature and pressure. It is not classified as a, mutagen or reproductive toxicant but exhibits corrosive action to the eyes with moderate oral acute toxicity. On the basis of the corrosivity it is placed in Hazard Band 3. A broad range of toxicological data has been investigated for this substance providing some confidence in the hazard assessment undertaken. When diluted in water and distributed in the subsurface it will degrade rapidly. It has limited volatility to present as an inhalation hazard. On this basis the main concern relates to direct contact with skin and eyes with the management focus restricted to occupational exposures from direct contact with pure product and public emergency spill settings.

References and Notes

ECHA (2013), European Chemicals Agency, Registered Chemical Substances Search. Available at http://echa.europa.eu/web/guest/information-on-chemicals/registered-substances. [Accessed 29 October 2013]

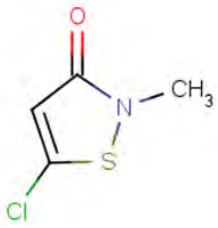
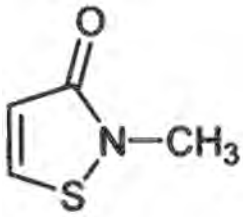
EC (2000), European Commission. Towards the establishment of a priority list of substances for further evaluation of their role in endocrine disruption, preparation of a candidate list of substances as a basis for priority setting, Final Report (Incorporating corrigenda to final report dated 21 June 2000).

HSDB (2013) Hazardous Substances Data Bank. Toxicology Data Network (TOXNET) available at http://toxnet.nlm.nih.gov/ [Accessed 30 October 2013]

IARC (2013), International Agency for Research on Cancer, agents classified by IARC Monographs, Volumes 1-108. Available at http://monographs.iarc.fr/ENG/Classification/ClassificationsGroupOrder.pdf.

Created by:	AES	Date: 30/10/2013
Reviewed and edited by:	LT	Date: 11/06/2013 Rev0

Project number: 127666004
Project name: Hydraulic Stimulation Chemicals Assessment, Southwest Queensland
Client name: Santos Ltd

Name	5-chloro-2-methyl-4-isothiazin-3-one & 2-methyl-4-isothiazin-3-one	
Synonyms	CMIT, 3(2H)-Isothiazolone, 5-chloro-2-methyl, Methylchloroisothiazolinone	MIT, 3-Isothiazolone, 2-methyl,Methylisothiazolinone, N-Methylisothiazolin-3-one.
CAS number	26172-55-4	2682-20-4
Molecular formula	C_4H_4ClNOS (5-chloro-2-methyl-4-isothiazin-3-one)	C4H5NOS (2-methyl-4-isothiazin-3-one)
Molecular Structure		

Overview	References
NOTE THAT BOTH OF THE ABOVE HAVE BEEN CONSIDERED COLLECTIVELY. CMIT/MIT are liquid chemicals that are clear to yellow in colour. Freezing point is -5℃, and boiling point is >100℃. Isothiazoline derivatives are effective biocides (antiseptic agents, preservatives, bactericides, slimicides, and fungicides). The biggest application is in the paint industry especially marine antifouling agent. 5-chloro-2-methyl-4-isothiazolin-3-one (CMIT), is used as a biodiesel biocide and is a high performance, broad spectrum antimicrobial agent based on isothiazolone chemistry. CMIT/MIT is very effective at very low concentrations in controlling microorganisms causing microbial induced spoilage. No other preservatives control a wider range of microorganisms over a wide range of pH at such low levels. CMIT/MIT are also used in adhesives, cutting oils, water systems, cosmetics, household goods and wound protectant for pruning cuts. They are also used as pulp and wood impregnating agents as well as in leather, fur and polymer process. CMIT/MIT is rapidly absorbed and metabolised following ingestion and do not bioaccumulate in tissues. CMI/MI are eliminated as metabolites which are rapidly eliminated in urine.	SHP 2013, SPE 2013, EU SCCS 2009

Human Health Toxicity Summary	Reference
Carcinogenicity IARC has not evaluated the evidence for the carcinogenicity of 5-chloro-2-methyl-4-isothiazin-3-one 2-myl-4-isothiazin-3-one.	IARC, 2013
Mutagenicity/Genotoxicity MIT was mutagenic when evaluated in some in vitro test systems (bacterial mutagenicity assay (Ames test), mouse lymphoma gene mutation assay with or without metabolic activation) but not in in vivo (sex-linked recessive lethal test, unscheduled DNA synthesis and micronucleus studies).	EU SCCS 2009
Reproductive Toxicity Rats were dosed for two generation with CMI/MI in drinking water at 0 (control), 0 (magnesium salt control), 30, 100 or 300 ppm active ingredient (a.i.). For the P1 generation, this was	

equivalent to 0, 2.8-4.4; 8.5-11.8, and 22.7-28.0 mg a.i./kg bw/day; and in the P2 generation 0, 4.3-5.5, 13.4-16.0, and 35.7-39.1 mg a.i./kg bw/day. There were no treatment related effects on survival, food consumption or overt signs of toxicity. A decrease in bodyweight gain was noted initially in the P1 generation. This was thought to be linked to reduced water consumption since significant dose-related reduction in water consumption was seen at all concentrations in both the P1 and P2 generations, during the premating, gestation and lactation stages. Treatment-related histopathological changes were seen in the stomach in the P1 and P2 generation at the 100 and 300ppm a.i. The oestrus cycle in P1 or P2 females at any treatment level was comparable with the controls, as was the sperm motility, morphology, testicular sperm count or caudal epididymal reserves of P1 or P2 males. All other endpoints (gestation index, gestation length, number of pups per litter or treatment-related gross findings in F1 or F2 pups) were similar to those in the controls in either generation. The study authors considered that rats exposed to CMI/MI in the drinking water through two generations had a No Observed Adverse Effect Level (NOAEL) of 30 ppm a.i. (2.8-4.4 mg/kg/day in the P1 animals; 4.3-5.5 mg/kg/day in the P2 animals) for parental animal toxicity, based on the gastric irritation of stomach at higher doses. The No Observed Effect Level (NOEL) for reproductive toxicity was 300 ppm a.i. (22.7-28.0 mg/kg/day in the P1 animals; 35.7-39.1 mg/kg/day in the P2 animals), the highest dose tested. There were no effects on fertility or foetal development at any dose level.	EU SCCS 2009
Developmental Toxicity/Teratogenicity CMIT/MIT did not cause developmental toxicity at doses lower than those required to cause maternal toxicity in four developmental toxicity studies in rats. The NOAEL for developmental toxicity was greater than 15 mg a.i./kg.	SCCS 2009
Endocrine Disruption Not listed as an endocrine disruptor by European Commission.	EC,2000
Neurotoxicity No data found.	
Acute Toxicity (oral, dermal, inhalation) Ingestion – corrosive, can cause burns to gastro-intestinal tract. Other effects include nausea, vomiting and stomach pain. GHS classification, category 2 (Acute toxicity:oral). A reference supporting this classification is *Nordic Chemicals Group Health effects of selected chemicals 2.* The test species were rabbits, the LD50 30mg/kg. GHS classification, category 2 (Acute toxicity:dermal). A reference supporting this classification is *Nordic Chemicals Group Health effects of selected chemicals 2.* The test species were rabbits, the LD50 87mg/kg. GHS classification, category 2 (Acute toxicity:inhalation). A reference supporting this classification is *Nordic Chemicals Group Health effects of selected chemicals 2.* The test species were rats, the LD50 0.2-1.4mg/l.	AET, 2011 NZEPA - HSNO CCID,2013
Chronic/repeat dose toxicity (oral, dermal, inhalation) Test species were rats. Original administered dose was 17.2mg/kg/day. Resulted in neoplastic and non-neoplastic proliferative liver lesions. LOEL of 17.2mg/kg/day. No further information found to support the study. A 90 day dietary study was undertaken on dogs. Dose concentration, 840ppm isothiazoline. Resulted in irritation, however no pathological findings were observed. A 30 month skin painting study was undertaken on mice. Dose concentration, 400ppm isothiazoline three times per week. No increased tumour frequency over control.	USEPA from QSAR AET, 2011

A 90 day dermal study was undertaken on rabbits. Dose concentration, 0.4 mg/kg isothiazoline. Resulted in irritation, however no pathological effects were observed.	
Sensitisation of the skin or respiratory system GHS classification, category 1 (skin sensitisation). The test species were guinea pigs and the result was sensitising.	NZEPA - HSNO CCID,2013
Corrosion (irreversible)/irritation (reversible) effects on the skin or eye Skin and eye contact - causes burns. GHS classification, category 1B (skin corrosion/irritation). The test species were rabbits, test substance CAS Number was 55965-84-9. The result was corrosive at 0.6% and greater. Irritation cut off for the test was at 0.06% and greater (GHS category 2). GHS classification, category 1 (serious eye damage/eye irritation). The test species were rabbits, test substance Cas. Number was 55965-84-9. The result was corrosive at 0.6% and greater. Irritation cut off for the test was at 0.06% and greater (GHS category 2B). Inhalation – corrosive to respiratory system. No further information provided.	AET, 2011 NZEPA - HSNO CCID,2013

Physical Hazards	Reference
Flammable Potential No data found	
Explosive Potential No data found	

Toxicity Values	Value	Reference
Human Toxicity Data		
High Chronic/Repeat Dose Toxicity		
LOAEC	No data found	
LOAEL	No data found	
Animal Toxicity Data		
Acute Toxicity		
LD_{50}		
Quail, oral	85mg/kg	Bobwhite quail, 21-day oral, Accepta MSDS (2011)
Rabbit, oral	30mg/kg	NZEPA - HSNO CCID,2013
Rat, dermal	87mg/kg	NZEPA - HSNO CCID,2013
Rat, inhalation	0.2-1.4mg/L	NZEPA - HSNO CCID,2013
Mouse, dermal	No data found	
LC_{50}		
Quail/Duck, oral	>560ppm	Bobwhite Quail and Pekin Duck, 8-day dietary, Aceepta MSDS (2011)
High Chronic/Repeat Dose Toxicity		
LOAEL	No data found	
LOAEC	No data found	
LOEL, rats	17.2 mg/kg/day	Exposure pathway unknown, EU SCCS 2009
NOAEL, rats, oral	30ppm	Parental toxicity, EU SCCS 2009
NOAEL, rats,	>15 mg a.i./kg.	Development toxicity, EU SCCS 2009
NOEL, rats, oral	300ppm	Reproductive toxicity, EU SCCS 2009

Footnotes:
LD_{50} – lethal dose for 50% of experimental population
LC_{50} – lethal air concentration for 50% of experimental population
LOAEL – Lowest Observed Adverse Effect Level
LOAEC – Lowest Observed Adverse Effect Concentration
NOAEL - No Observed Adverse Effect Level
NOEL - No Observed Effect Level

Human Health Toxicity Ranking*		
	Hazard data	**Comment**
Hazard Band 4		
Carcinogenicity (IARC Group 1 or 2A)	No	EU SCCS 2009
Mutagenicity/Genotoxicity (GHS Category 1A and 1B)	No	
Reproductive Toxicity/Developmental toxicity (GHS Category 1, 1A and 1B)	No	
Endocrine Disruption[1]	No	Not listed as an endocrine disruptor by European Commission.EC,2000
Hazard Band 3		
Carcinogenicity (IARC Group 2B)	No	EU SCCS 2009
Mutagenicity/Genotoxicity (GHS Category 2)	No	
Reproductive Toxicity/Developmental toxicity (GHS Category 2)	No	
Acute Toxicity (oral, dermal or inhalation) Very Toxic/Toxic • oral $LD_{50} \leq 300$ mg/kg[3] • dermal $LD_{50} \leq 1000$ mg/kg inhalation $LC_{50} \leq 10$ mg/L[4] (or mg/m[3]) (vapour)	Yes	Rabbit, oral = 30mg/kg Rat, dermal = 87mg/kg Rat, inhalation = 0.2-1.4mg/kg NZEPA - HSNO CCID,2013
Possible carcinogenicity, mutagenicity, reproductive or High Chronic/repeat dose toxicity • oral LOAEL ≤ 10 mg/kg/d[3]; • dermal LOAEL ≤ 2 0 mg/kg/d; • inhalation LOAEC (6 h/d) ≤ 50 ppm/d for gases, ≤ 0.2 mg/L/d for vapours or ≤ 0.02 mg/L/d for dust/mists/fumes[4]	No	
Corrosive (irreversible effect)	Yes	GHS classification, category 1B (skin corrosion/irritation). GHS classification, category 1 (serious eye damage/eye irritation). NZEPA - HSNO CCID,2013
Respiratory sensitiser	No	Not classified by Aceepta MSDS, 2011
Hazard Band 2		
Harmful chronic/repeat dose toxicity • oral LOAEL > 10 mg/kg and ≤ 100 mg/kg/d • dermal LOAEL > 20 mg/kg/d and ≤ 200 mg/kg/d • inhalation (6-h/d) LOAEC > 50 mg/L ≤ 250 mg/L/d for gases, > 0.2 mg/L ≤ 1 .0 mg/L/d for vapours or > 0.02 mg/L ≤ 0.2 mg/L/d for dust/mists/fumes[4]	yes	LOEL of 17.2mg/kg/day, USEPA from QSAR
Skin Sensitiser	Yes	GHS classification, category 1 (skin sensitisation). NZEPA - HSNO CCID,2013
Hazard Band 1		
Acute Toxicity-Harmful • oral $LD_{50} > 300$ mg/kg ≤ 2000 mg/kg	No	Rabbit, oral = 30mg/kg

• dermal LD_{50} >1 000 mg/kg ≤ 2000 mg/kg; • inhalation LC_{50} (6 h/d) > 10 mg/L ≤ 20 mg/L for vapours)[4]		Rat, dermal = 87mg/kg Rat, inhalation = 0.2-1.4mg/kg NZEPA - HSNO CCID,2013
Irritant (reversible effect)	Yes	Rabbits, GHS category 2 (Skin irritant). Rabbits, GHS category 2B (eye irritant). NZEPA - HSNO CCID,2013
Hazard Band 0 **All indicators outside criteria listed in Hazards 1-4**		
Physical Hazards		
Flammable potential	No data found	
Explosive potential	No data found	
Hazard Evaluation (highest band) not including physical hazards	Hazard Band 3	
Uncertainty analysis /data confidence (out of 12 parameters)	12/12	**100%**

* Based on IMAP Framework [NICNAS (2013) Inventory Multi-tiered Assessment and Prioritisation (IMAP) Framework. National Industrial Chemicals Notification and Assessment Scheme. Department of Health and Aging, Canberra].

"[1]Based on list of endocrine disrupting chemicals from the European Commission's Endocrine Disrupters website.

[2] Neurotoxicity based on REACH assessments.

[3] milligrams per kilogram body mass(mg/kg) or milligrams per kilogram body mas per day (mg/kg/d)

[4] Based on GHS cut-offs for hazard classification. For chronic/repeat dose toxicity, GHS cut-offs are provided as guidance values (i.e. the dose/concentration at or below which significant health effects are observed"). (p 18, NICNAS 2013).

Human Health Guidelines		
Media	**Concentration (mg/m^3; mg/L; mg/kg)**	**Reference**
Occupational Exposure Limits		
Air (OEL)	No data found	
8-h TWA	No data found	
STEL	No data found	
Peak Limitation	No data found	
Environmental Exposure		
Air, ambient	No data found	
Air, indoor	No data found	
Water, potable	No data found	
Water, recreational	No data found	
Soil, residential	No data found	
Soil, commercial/industrial	No data found	

Footnotes:

OEL = Occupational Exposure Limit

TWA= 8 h Time-Weighted Average

STEL = (15 min) Short-term Exposure Limit

Qualifying Summary Comments

The Isothiazoline derivatives are highly reactive compounds that are biologically active ans are thus used as biocides. They are categorized as acutely toxic and are skin sensitisers however they are not considered mutagenic, carcinogenic or reproductive toxicants. The moderate toxicity level of concern for this substance is more focused towards acute occupational and large scale environmental accidental releases.

References and Notes

Advanced Environmental Technologies (AET), Accepta 2893, Material Safety Data Sheet, 0.5% isothiazolin – non-oxidising biocide (2011), Available at: <http://www.accepta.com/images/product-safetydata/MSDS_Accepta%20Ltd_Accepta%202893.pdf> [Accessed 28 November 2013].

NDF - No data found within the limits of the search strategy.

European Commission (EC) (2000). Towards the establishment of a priority list of substances for further evaluation of their role in endocrine disruption, preparation of a candidate list of substances as a basis for priority setting, Final Report (Incorporating corrigenda to final report dated 21 June 2000).

European Commission, Scientific Committee on Consumer Safety (EU SCCS), Opinion on the mixture of 5-chloro-2-methylisothiazolin-3(2H)-one and 2-methylisothiazolin-3(2H)-one (2009), Available at: <http://ec.europa.eu/health/scientific_committees/consumer_safety/docs/sccs_o_009.pdf>, [Accessed 2 December 2013].

International Agency for Research on Cancer (IARC), 16 June 2013. Agents Classified by the *IARC Monographs*, Volumes 1–108. Available at http://monographs.iarc.fr/ENG/Classification/index.php. [Accessed 26 November 2013].

New Zealand Environment Protection Authority (NZEPA) - New Zealand Hazardous Substances and New Organisms (HSNO) Chemical Classification Information Database (CCID), 4-Isothiazolin-3-one, 5-chloro-2-methyl-. Available at: http://www.epa.govt.nz/search-databases/Pages/ccid-details.aspx?SubstanceID=1973 [Accessed 28 November 2013].

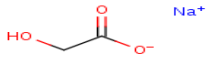
Sino Harvest Products (SHP), *Biocide: CMIT/MIT*, Available at: <http://www.sinoharvest.com/products/CMIT-MIT.shtml> [Accessed 28 November 2013].

SPE Chemicals CO.,Ltd. *Biocides: Biocide CMIT/MIT is antimicrobial agents and effective in controlling microorganisms causing microbial induced spoilage,* Available at: <http://spechemicals.en.alibaba.com/product/478463622212263531/CMIT_MIT_biocide_is_antimicrobial_agents_and_effective_in_controlling_microorganisms_causing_microbial_induced_spoilage.html> [Accessed 28 November 2013].

US EPA (1998) Reregistration Eligibility Decision (RED) Methylisothiazolinone (1998), Available at: <http://www.epa.gov/oppsrrd1/REDs/3092.pdf>, [Accessed 2 December 2013].

Created by:	CS	Date: 28/11/2013
Reviewed by:	JF	Date 02/12/13

Project number: 127666004
Project name: Hydraulic Stimulation Chemicals Assessment, Southwest Queensland
Client name: Santos Ltd

Name	Sodium Glycolate (Impurity)
Synonyms	Sodium Hydroxyacetic Acid
CAS number	2836-32-0
Molecular formula	$NaOOCCH_2OH$
Molecular Structure	
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Overview	References
Sodium glycolate is a crystalline colourless powder. This chemical belongs to the group of alpha-hydroxy acids (AHAs) and is the sodium salt of glycolic acid. As it readily dissociates to glycolic acid the properties and toxicity data for glycolic acid have been utilised. Glycolic acid is soluble in water or organic solvents like acetone but not lipophilic (fat soluble) and it is stable . AHAs uses include mild exfoliants, pH adjusters and skin-conditioning agents. Glycolic acid is also used in food packaging applications. Glycolic acid is naturally present in a variety of fruits, vegetables, meats, and beverages at concentrations up to 50 mg/kg. Principal health effects of glycolic acid include skin burns and high damage. Moreover, glycolic acid is harmful if inhaled. Sodium glycolate is harmful if swallowed.	Anderson, 1998 ECHA, 2013 EFSA 2008

Human Health Toxicity Summary	Reference
Carcinogenicity A number of carcinogenicity studies in both rats and mice and by both oral and dermal routes have not identified any substance related tumour formation. On this basis it is not classifiable as a carcinogenic substance. One of these studies was conducted for a cosmetic formulation containing 4% or 10% glycolic acid (pH 3.5) or 2% or 4% salicylic acid (pH 4) in combination with ultraviolet light. Only photocarcinogenesis was investigated. Oral feeding studies with the primary metabolite in both rats and mice were negative for carcinogenic effects.	ECHA, 2013
Mutagenicity/Genotoxicity - The genotoxicity potential of glycolic acid has recently been evaluated by the European Food Safety Agency. Glycolic acid was considered non genotoxic based on negative results in mutagenicity and chromosome aberrations in mammaline cells and whole animal mammalian mutagenicity test results (micronucleus assay). - Glycollic acid is not classified as mutagenic	EFSA 2008 ECHA, 2013 Andersen, 1998
Reproductive Toxicity A single generation reproductive toxicity study was conducted in which four groups of rats were dosed at various levels with glycolic acid. Males and females were pair housed for mating and the females observed through gestation and F1 (offspring) and P (parental) generations observed during lactation.	Andersen, 1998 ECHA, 2013

The NOEL for reproductive toxicity was 600 mg/kg bw/day, based on the absence of treatment related effects on reproductive function. The NOEL for reproductive organ pathology in both the P1 generation and the F1 weanlings was 600 mg/kg bw/day, based on the absence of gross pathological changes.	
Developmental Toxicity/Teratogenicity - A developmental toxicity study with rats given 75, 150, 300 and 600 mg/kg bw by oral gavage for 14 days (day 7-21 of gestation) was conducted. Developmental changes were evident in the 300 mg/kg bw/day group as a slight, non-significant, increase in the incidence of skeletal malformations (fused ribs and fused vertebrae in 2 fetuses from 2 litters). There were no indications of developmental toxicity at either the 150 or 75 mg/kg bw/day dose levels. The study authors conclude that the results indicate that glycolic acid is not likely to be uniquely toxic to the rat conceptus, developmental effects were only apparent at maternally toxic doses. On this basis it is not classifiable as a developmental toxicant.	Andersen, 1998 ECHA, 2013
Endocrine Disruption Not listed as an endocrine disruptor.	EC, 2000
Acute Toxicity (oral, dermal, inhalation) - Oral doses greater than 500 mg/kg of a 9.8% buffer solution of sodium glycolate and glycolic acid lead death (cat study). - Based on a rat study, inhalation of glycolic acid can cause death.	Andersen, 1998
Chronic/repeat dose toxicity (oral, dermal, inhalation) - One rat study showed that long term oral administration of high doses of sodium glycolate (2000 mg/kg/day) resulted in deaths caused by calcium oxalate crystals damaging renal and urinary bladder - One rabbit studies showed that long term oral administration of sodium glycolate resulted in increased oxalate content in the kidney.	Andersen, 1998
Sensitisation of the skin or respiratory system Based on a guinea pig study, sodium glycolate is not a skin sensitiser.	Andersen, 1998
Corrosion (irreversible and reversible)/irritation of the skin or eye - Glycollic acid can cause severe skin burns and eye damage	ECHA, 2013
Flammable Potential Non flammable solid. The flammability of the solid form of glycolic acid (glycolic acid >99%) was investigated according to flammable solid test method EC A10. The test substance did not ignite during the full 2 minutes of heating.	ECHA, 2013
Explosive Potential Glycolic acid 70% solution was not found to be sensitive to thermal or impact stimuli (i.e. non explosive) when a 70% glycolic acid solution was tested using EU Method A.14 (Explosive properties).	ECHA, 2013

Toxicity Values	Value	Reference
Human Toxicity Data		
Acute Toxicity		
	NDF	
High Chronic/Repeat Dose Toxicity		
LOAEC	NDF	
LOAEL	NDF	
Animal Toxicity Data		
Acute Toxicity		
LD_{50}		
Rat, oral	1443 - 2469 mg/kg with a median of 2040 caused renal tubular oxalosis, but cytotoxicity was the cause of renal failure rather than simple mechanical obstruction of the tubular lumina by oxalate crystals.	ECHA, 2013
Mouse, oral	NDF	
Rabbit, oral	NDF	
Rat, dermal	NDF	
Rabbit, dermal	NDF	
Mouse, dermal	NDF	
LOAEL	NDF	
LOAEC	NDF	
LC_{50}		
Rat (inhalation)	Glycolic acid 70% solution: >5.2 mg/L (female); 3.6 mg/L (male). Clinical signs included signs of respiratory irritation (gasping, hunched posture, nasal and ocular discharge).	ECHA, 2013
Mice (inhalation)	NDF	
High Chronic/Repeat Dose Toxicity		
LOAEL	NDF	
LOAEC	NDF	
NOAEL (oral, 90 day male and female rats)	150 mg/kg (males) renal oxalate crystal nephropathy 600 mg/kg (females) (highest dose tested)	ECHA, 2013

Footnotes:
LD_{50} – lethal dose for 50% of experimental population
LC_{50} – lethal air concentration for 50% of experimental population
LOAEL – Lowest Observed Adverse Effect Level
LOAEC – Lowest Observed Adverse Effect Concentration
NOAEL – No Observed Adverse Effect Level

Human Health Toxicity Ranking*		
	Hazard data	**Comment**
Hazard Band 4		
Carcinogenicity	NO	
Mutagenicity/Genotoxicity	NO	
Reproductive Toxicity	NO	
Developmental Toxicity/ Teratogenicity	NO	
Endocrine Disruption[1]	NO	
Hazard Band 3		
Acute Toxicity (oral, dermal or inhalation) Very Toxic/Toxic • oral LD_{50} ≤ 300 mg/kg[3] • dermal LD_{50} ≤ 1000 mg/kg • inhalation LC_{50} ≤ 10 mg/L[4] (or mg/m^3) (vapour)	NO	
Possible carcinogenicity, mutagenicity, reproductive or High Chronic/repeat dose toxicity • oral LOAEL ≤ 10 mg/kg/d[3]; • dermal LOAEL ≤ 2 0 mg/kg/d; • inhalation LOAEC (6 h/d) ≤ 50 ppm/d for gases, ≤ 0.2 mg/L/d for vapours or ≤ 0.02 mg/L/d for dust/mists/fumes[4]	NO	
Corrosive (irreversible damage)	YES	
Respiratory sensitiser	NDF	
Hazard Band 2		
Harmful chronic/repeat dose toxicity • oral LOAEL > 10 mg/kg and ≤ 100 mg/kg/d • dermal LOAEL > 20 mg/kg/d and ≤ 200 mg/kg/d • inhalation (6-h/d) LOAEC > 50 mg/L ≤ 250 mg/L/d for gases, > 0.2 mg/L ≤ 1 .0 mg/L/d for vapours or > 0.02 mg/L ≤ 0.2 mg/L/d for dust/mists/fumes[4]	NO	
Skin Sensitiser	NO	
Hazard Band 1		
Acute Toxicity-Harmful • oral LD_{50} > 300 mg/kg ≤ 2000 mg/kg • dermal LD_{50} >1 000 mg/kg ≤ 2000 mg/kg; • inhalation LC_{50} (6 h/d) > 10 mg/L ≤ 20 mg/L for vapours)[4]	YES	
Irritant (reversible damage)	YES	
Hazard Band 0 All indicators outside criteria listed in Hazards 1-4		
Physical Hazards		
Flammable potential	NO	
Explosive potential	NO	
Hazard Evaluation (highest band) not including physical hazards	**Band 3**	
Uncertainty analysis /data confidence	12/13	**92%**

* Based on IMAP Framework [NICNAS (2013) Inventory Multi-tiered Assessment and Prioritisation (IMAP) Framework. National Industrial Chemicals Notification and Assessment Scheme. Department of Health and Aging, Canberra].

"[1] *Based on list of endocrine disrupting chemicals from the European Commission's Endocrine Disrupters website.*

[2] *Based on list of neurotoxic chemicals from US Agency for Toxic Substances and Disease Registry (ATSDR).*

[3] *milligrams per kilogram body mas s(mg/kg) or milligrams per kilogram body mas per day (mg/kg/d)*

[4] *Based on GHS cut-offs for hazard classification. For chronic/repeat dose toxicity, GHS cut-offs are provided as guidance values (i.e. the dose/concentration at or below which significant health effects are observed"). (p 18, NICNAS 2013).*

Human Health Guidelines		
Media	**Concentration (mg/m^3; mg/L; mg/kg)**	**Reference**
Occupational Exposure Limits		
Air (OEL)		
8-h TWA	10 mg/m^3 (glycolic acid 99% solution)	Anderson, 1998
STEL	NDF	
Peak Limitation	NDF	
Environmental Exposure		
Air, ambient	NDF	
Air, indoor	NDF	
Water, potable	NDF	
Water, recreational	NDF	
Soil, residential	NDF	
Soil, commercial/industrial	NDF	

Footnotes:

OEL = Occupational Exposure Limit

TWA= 8 h Time-Weighted Average

STEL = (15 min) Short-term Exposure Limit

NDF - No data found within the limits of the search strategy.

Qualifying Summary Comments

Sodium glycolate readily dissociates to glycolic acid thus the health effects of these compounds are equivalent.

The acute toxicity associated with sodium glycolate is principally related to corrosion of skin and eyes and respiratory tract. Sodium glycolate is harmful when swallowed and when inhaled. The systemic, single or repeat dose toxicity of sodium glycolate is due to the formation of oxalate crystals in the kidney resulting in renal tubule inflammation and potential kidney failure . The no observed adverse effect level in 90 day oral rat study was 150 mg/kg/d. Sodium glycolate is not genotoxic, carcinogenic or a reproductive/developmental toxicant.

Sodium glycolate falls into the Hazard Band 3 category. The primary effect of exposure via usual occupational routes is considered to be irritation of the eyes and skin, and inhalation. Therefore, it is import to protect against direct contact with eyes and skin and prevent inhalation.

References

Anderson, F.A. 1998. Final Report On the Safety Assessment of Glycolic Acid, Ammonium, Calcium, Potassium, and Sodium Glycolates, Methyl, Ethyl, Propyl, and Butyl Glycolates, and Lactic Acid, Ammonium, Calcium, Potassium, Sodium, and Tea-Lactates, Methyl, Ethyl, Isopropyl, and Butyl Lactates, and Lauryl, Myristyl, and Cetyl Lactates. *International Journal of Toxicology.*

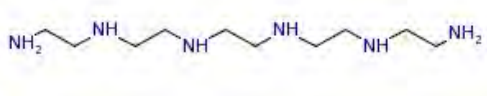
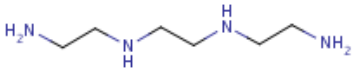
European Chemicals Agency (ECHA, 2013). Registered Chemical Substances Search. Available at http://echa.europa.eu/web/guest/information-on-chemicals/registered-substances. [Accessed 30 August 2013]

European Commission (EC) (2000) Towards the establishment of a priority list of substances for further evaluation of their role in endocrine disruption, preparation of a candidate list of substances as a basis for priority setting, Final Report (Incorporating corrigenda to final report dated 21 June 2000).

EFSA (2008). Opinion of the Scientific Panel on food additives, flavourings, processing aids and materials in contact with food (AFC) on a request related to 18th list of substances for food contact materials. The EFSA Journal (2008) 628-633, 1-19 European Food Safety Authority, 2008

Created by:	JC	Date: 30/08/2013
Reviewed and edited by:	JF	05/09/2013

Project number: 127666004
Project name: Hydraulic Stimulation Chemicals Assessment, Southwest Queensland
Client name: Santos Ltd

Name	Pentaethylenehexamine
Synonyms	PEHA, 3,6,9,12-tetraazatetradecamethylenediamine, 3,6,9,12-Tetraazatetradecane-1,14-diamine, 3,6,9,12-Tetraazatetradecametilendiamina
CAS number	4067-16-7
Molecular formula	$C_{10}H_{28}N_6$ $HN(CH_2CH_2NHCH_2CH_2NHCH_2CH_2NH_2)_2$
Molecular Structure	Pentaethylenehexamine (PEHA):  Triethylenetetramine (TETA; CAS #112-24-3): 

Overview	Reference
Pentaethylenehexamine (PEHA) is a yellow viscous and odourless organic clear liquid with a molecular weight of 232.37. At 20°C the density of Pentaethylenehexamine is 1.003 g/cm^3 and its water solubility > 500 g/l. The flash point of the substance is 183°C and the freezing point is -70°C PEHA has a boiling point of 380 °C and a melting point of -35 to -26 °C. The production of PEHA and other ethyleneamines is via the ethylene dichloride (EDC) process. At high pressure and moderate temperature, EDC is reacted with an excess of ammonia. The resulting ethyleneamine hydrochloride solution is neutralized with caustic soda generating a mixture of ethyleneamines. PEHA is then separated from the other ethyleneamines by distillation. A less common method for the generation of PEHA and other ethyleneamines involves reacting ethylene oxide and ammonia to form monoethanolamine, which is added to ammonia to generate ethylenediamine (EDA) and higher ethyleneamines. PEHA has a wide number of applications across numerous industries. It is a hardener used with epoxy resins that have both industrial and consumer applications including agricultural chemicals, fungicides, bactericides, wood preservatives, chelating agents, surfactants, mineral processing aids, and polymers. It is an intermediate in the synthesis of several substances/products including coatings and auxiliaries, coolants, lubricants, and antifreezes, plastics and auxiliaries, auxiliaries for the recovery and processing of oil, coal, and natural gas, auxiliaries for the construction industry and pharmaceuticals. PEHA has also widespread use in the manufacture of lubricating oil and fuel additives. Studies/data are lacking for the toxicity evaluation of PEHA. Instead most of the human health toxicity summaries below are based upon read across interpretations from studies undertaken on triethylenetetramine. Triethylenetetramine, also known as TETA, (molecular formula $C_6H_{15}N_4$), is a yellow, moderately viscous liquid. It is completely soluble in water and is also soluble in alcohols and acids. TETA has a smaller molecular structure than PEHA with a molecular weight of 146.24 and a density of 0.9818 at 20°C.Its boiling point is 266-267°C at 760 mm HG and melting point is 12°C.	ECHA (2013) NCI (date unknown)

Human Health Toxicity Summary	Reference
Carcinogenicity	

Based on the GHS classification 'Pentaethylenehexamine' is not classifiable as to its carcinogenicity to humans. A search on the International Agency for Research on Cancer (IARC) website did not reveal any information on Pentaethylenehexamine. *Notes:* The carcinogenicity classification for pentaethylenehexamine is based on a read across study using triethylenetetramine (TETA). The dermal carcinogenic potential of TETA was assessed by applying 25 µl of a 5% (v/v) solution in deionized water to the backs of 50 male mice three times a week until the death of the animals. No treatment-related skin tumours were observed and therefore TETA was not carcinogenic when applied to the skin of mice.	ECHA (2013)
Mutagenicity/Genotoxicity Not classified as a mutagenic/genotoxic chemical. *Notes:* The genetic toxicity classification for pentaethylenehexamine is based on a read across key in-vivo study using TETA. TETA was evaluated for potential clastogenic (chromosome-damaging) activity with the in-vivo micronucleus test system using both female and male mice. Test results showed that TETA was not an active agent in producing treatment-related increases in micronuclei in male and female mice. However, in an in-vitro study TETA was tested for potential mutagenic activity using the Salmonella/microsome bacterial mutagenicity assay (Ames test). Due to growth inhibition TETA was considered to be mutagenic in this in-vitro bacterial study but the genetic toxicity classification was based on the above in vivo study in mice.	ECHA (2013)
Reproductive Toxicity Not classified as having reproductive toxicity effects.	ECHA (2013)
Developmental Toxicity/Teratogenicity No information found.	All proposed data sources
Endocrine Disruption Pentaethylenehexamine has not been included in the European Commission's Endocrine Disrupters Priority List.	ECED (2013)
Acute Toxicity (oral, dermal, inhalation) Classified as having acute oral and dermal toxic effects. Pentaethylenehexamine is harmful if swallowed (Oral Acute Toxicity 4 H302) or when in contact with skin (Dermal Acute Toxicity 4 H3120). For the inhalation pathway data is lacking. *Notes:* TETA was used as a surrogate to infer the oral and dermal toxicity of pentaethylenehexamine. TETA was administered orally to 5 female and 5 male rats at doses of 800, 1250, 1600 or 2000 mg/kg with a subsequent observation of 14 days. An acute oral LD50 of 1861.9 (1383.5 - 2505.7) mg/kg was reported for male rats, 1591.4 (1283.5 - 1973.3) mg/kg for female rats and 1716.2 (1446.5 - 2036.1) mg/kg for the combined sexes. TETA was applied to the skin of New Zealand White rabbits at concentrations of 1000, 2000 and 3000 mg/kg with a 14 day observation period. Based on the observations the acute dermal LD50 in males was determined to be 1720 (1082.9-2732.0) mg/kg and for the combined sexes 1465.4 (1074.6-1998.3) mg/kg, respectively. The data generated for the acute dermal LD50 in females did not lend itself to the statistical method employed and therefore an LD50 for female rabbits was not determined.	ECHA (2013)
Chronic/repeat dose toxicity (oral, dermal, inhalation)	ECHA

Classified as having chronic oral toxic effects. No data available for the chronic dermal and inhalation pathways. *Notes:* The oral repeat dose toxicity is based on the key read across study involving triethylenetetramine dihydrochloride (trientine-2HCl, TJA-250), a copper chelating agent used to treat Wilson's disease. Trientine-2HCl was administered orally to four male and female rats for 4 or 8 weeks at dosages of 0, 100, 350 or 1200 mg/kg/day or to 12 female and male rats for 26 weeks at dosages of 50, 175 or 600 mg/kg/day. Study results showed death and irreversible toxic changes in the lung. Based on this a NOAEL of 50 mg/kg was concluded for the female rats and a LOAEL of 50 mg/kg for the male rats. However, the chronic repeat study was non-GLP compliant as at least 20 animals (ten female and ten male) should have been used instead of 12.	(2013)
Sensitisation of the skin or respiratory system Pentaethylenehexamine may cause an allergic skin reaction (Skin Sensitiser 1 H317). Data is lacking for the respiratory system sensitisation. *Notes:* A group of nine alkyleneamines were investigated for their potential to induce skin sensitisation and to cross-react with one another to elicit a hypersensitivity response. The sensitising potency was inversely correlated with the number of amine units. Cyclic amines had a lower sensitising potency than the corresponding olefinic amines. The results suggest that there was a direct correlation of the potencies to cause sensitisation and cross-sensitisation in this family of alkyleneamines. From the results of this study it was concluded that PEHA is a skin sensitiser. The second skin sensitisation study involved skin application of TETA to guinea pigs at a dose of 0.3 ml/site area. At the first reading (24 hours after), 18/20 animals showed skin reactions and at the second reading (48 hours after), 19/20 animals were positive. It was therefore concluded that TETA is a skin sensitiser. Although specific studies addressing respiratory system sensitisation were lacking it has been noted that ethyleneamines alongside their ability of producing chemical burns and skin rashes, also have the ability to produce asthma-like symptoms.	ECHA (2013) NCI (date unknown)
Corrosion (irreversible and reversible)/irritation of the skin or eye Causes severe skin burns (Skin Corrosion1B H314). Causes serious eye damage (Eye Damage 1 H318). *Notes:* TETA was applied undiluted directly on the intact and abraded skin sites of 3 male and 3 female New Zealand White rabbits. It was applied at a concentration of 0.5 mL/ site (6 m²) for 3 minutes, 60 minutes, 4hours or 24 hours. Necrosis was observed after a 3 minute exposure. The animals that had been exposed for 60 minutes, 4 hours, or 24 hours scored 4 (necrosis) for erythema and oedema immediately after unwrapping. Severe erythema and severe oedema remained present in all animals at all observation periods during the study (up to 14 days). In an eye experiment involving direct contact of undiluted PEHA it was reported that PEHA might be slightly painful and would likely produce considerable conjunctivitis including a possible burn of the soft tissues. However, based on read across with TETA it cannot be excluded that PEHA is corrosive to the eye as well. TETA was applied undiluted to the eye of one female rabbit for 1 second. Vocalisation occurred immediately after test article administration. Due to the extreme ocular scores observed, the study was terminated.	ECHA (2013)

Physical Hazards	Reference
Flammable Potential No information found.	All proposed

	data sources
Explosive Potential No information found.	All proposed data sources

Toxicity Values	Value	Reference
Human Toxicity Data		
Acute Toxicity		
	No data found.	All proposed data sources
High Chronic/Repeat dose Toxicity		
Animal Toxicity Data		
Acute Toxicity		
LD_{50}		
Rat, oral	1861.9 mg/kg (male; based on TETA study) 1591.4 mg/kg (female; based on TETA study) 1716.2 (combined sexes; based on TETA study)	ECHA (2013)
Rat, dermal	No data found.	All proposed data sources
Rabbit, dermal	1720 mg/kg (male; based on TETA study) 1465.4 (combined sexes; based on TETA study)	ECHA (2013)
LOAEL	No data found.	All proposed data sources
LOAEC	No data found.	All proposed data sources
LC_{50}		
Rat	No data found.	All proposed data sources
High Chronic/Repeat dose Toxicity		
LOAEL	50 mg/kg oral pathway (male rats; based on triethylenetetramine dihydrochloride)	ECHA (2013)
LOAEC	No data found.	All proposed data sources

Footnotes:
LD_{50} – lethal dose for 50% of experimental population
LC_{50} – lethal air concentration for 50% of experimental population
LOAEL – Lowest Observed Adverse Effect Level
LOAEC – Lowest Observed Adverse Effect Concentration
NOAEL – No Observed Adverse Effect Level

Human Health Toxicity Ranking*		
	Hazard data	**Comment**
Hazard Band 4		
Carcinogenicity	NO	Based on a dermal study using TETA.
Mutagenicity/Genotoxicity	NO	Based on an in-vivo study using TETA. Mutagenic effects noted for an in-vitro Salmonella/microsome bacterial study using TETA.
Reproductive Toxicity	NO	
Developmental Toxicity/ Teratogenicity	No data found.	
Endocrine Disruption[1]	NO	
Hazard Band 3		
Acute Toxicity (oral, dermal or inhalation) Very Toxic/Toxic • oral LD_{50} ≤ 300 mg/kg[2] • dermal LD_{50} ≤ 1000 mg/kg • inhalation LC_{50} ≤ 10 mg/L[3] (or mg/m^3) (vapour)	NO	No data on inhalation.
Possible carcinogenicity, mutagenicity, reproductive or High Chronic/repeat dose toxicity • oral LOAEL ≤ 10 mg/kg/d[3]; • dermal LOAEL ≤ 2 0 mg/kg/d; • inhalation LOAEC (6 h/d) ≤ 50 ppm/d for gases, ≤ 0.2 mg/L/d for vapours or ≤ 0.02 mg/L/d for dust/mists/fumes[3]	NO	
Corrosive (irreversible damage)	YES	Causes severe skin burns and serious eye damage.
Respiratory sensitiser	No data found.	It has been noted that ethyleneamines have the ability to cause asthma-like symptoms.
Hazard Band 2		
Harmful chronic/repeat dose toxicity • oral LOAEL > 10 mg/kg and ≤ 100 mg/kg/d • dermal LOAEL > 20 mg/kg/d and ≤ 200 mg/kg/d • inhalation (6-h/d) LOAEC > 50 mg/L ≤ 250 mg/L/d for gases, > 0.2 mg/L ≤ 1 .0 mg/L/d for vapours or > 0.02 mg/L ≤ 0.2 mg/L/d for dust/mists/fumes[3]	YES	Oral LOAEL 50mg/kg
Skin Sensitiser	YES	
Hazard Band 1		
Acute Toxicity-Harmful • oral LD_{50} > 300 mg/kg ≤ 2000 mg/kg • dermal LD_{50} >1 000 mg/kg ≤ 2000 mg/kg; • inhalation LC_{50} (6 h/d) > 10 mg/L ≤ 20 mg/L for vapours)[3]	YES	
Irritant (reversible damage)	NO	
Hazard Band 0		

All indicators outside criteria listed in Hazards 1-4		
Physical Hazards		
Flammable potential	No data found.	
Explosive potential	No data found.	
Hazard Evaluation (highest band) not including physical hazards	**Hazard Band 3**	
Uncertainty analysis /data confidence	11/13	**85%**

* Based on IMAP Framework [NICNAS (2013) Inventory Multi-tiered Assessment and Prioritisation (IMAP) Framework. National Industrial Chemicals Notification and Assessment Scheme. Department of Health and Aging, Canberra].

"[1]Based on list of endocrine disrupting chemicals from the European Commission's Endocrine Disrupters website.

[2]milligrams per kilogram body mass(mg/kg) or milligrams per kilogram body mas per day (mg/kg/d)

[3] Based on GHS cut-offs for hazard classification. For chronic/repeat dose toxicity, GHS cut-offs are provided as guidance values (i.e. the dose/concentration at or below which significant health effects are observed"). (p 18, NICNAS 2013).

Human Health Guidelines		
Media	**Concentration (mg/m^3; mg/L; mg/kg)**	**Reference**
Occupational Exposure Limits		
Air (OEL)		
8-h TWA	No data found.	All proposed data sources
STEL	No data found.	All proposed data sources
Peak Limitation	No data found.	All proposed data sources
Environmental Exposure		
Air, ambient	No data found.	All proposed data sources
Air, indoor	No data found.	All proposed data sources
Water, potable	No data found.	All proposed data sources
Water, recreational	No data found.	All proposed data sources
Soil, residential	No data found.	All proposed data sources
Soil, commercial/industrial	No data found.	All proposed data sources

Footnotes:

OEL = Occupational Exposure Limit

TWA= 8 h Time-Weighted Average

STEL = (15 min) Short-term Exposure Limit

NDF - No data found within the limits of the search strategy.

Qualifying Summary Comments

Pentaethylenehexamine (PEHA) is a yellow, viscous and clear liquid with a molecular weight of 232.37. It is an odourless organic substance that is highly soluble in water. As studies on the toxicity evaluation of PEHA are lacking the human health toxicity summaries are mainly based upon read across interpretations from its surrogate triethylenetetramine (TETA).

PEHA is not classifiable as to its carcinogenicity to humans or to its mutagenicity/genotoxicity based upon mice studies using TETA. Furthermore, it is not classified as having reproductive toxicity effects and is not considered an endocrine disrupter. No information was found on developmental toxicity/teratogenicity. In terms of acute toxicity PEHA is harmful if swallowed or when in contact with skin. No data was available for the evaluation of inhalation acute toxicity. Chronic/repeat data was lacking for TETA although irreversible toxic changes in the lung have been noted for an oral repeat dose study using triethylenetetramine dihydrochloride. PEHA may cause an allergic skin reaction with an absence of data for the respiratory system sensitisation, although it has been noted that ethyleneamines have the ability to cause asthma-like symptoms. Due PEHA's corrosion classifications with to its ability to cause severe skin burns and serious eye damage it has been categorised as hazard band 3.

References and Notes

ECED (2013) European Commission's Endocrine Disrupters Priority List. Available at http://ec.europa.eu/environment/chemicals/endocrine/strategy/substances_en.htm#priority_list [Accessed 25 October 2013]

ECHA (2013) (European Chemicals Agency) Registered Substances List. Available at http://apps.echa.europa.eu/registered/data/dossiers/DISS-97d78db5-dceb-1601-e044-00144f67d031/AGGR-501d8767-a2fe-4a21-891a-7cc59c5ec4ba_DISS-97d78db5-dceb-1601-e044-00144f67d031.html#L-edc932aa-49bf-4532-a5c1-2cc1d52264ce [Accessed 24 October 2013]

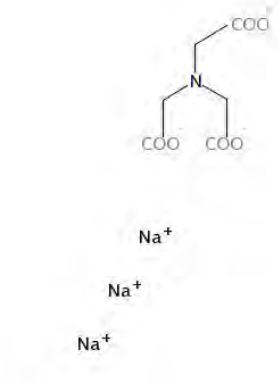
HSDB (2002). 'Triethylenetetramine'. Hazardous Substance Data Bank (HSDB), U.S. National Library of Medicine. Available at http://toxnet.nlm.nih.gov/cgi-bin/sis/search/f?./temp/~V4ZvQU:1 [Accessed 28 October 2013]

NCI (date unknown) Prepared for NCI to support chemical nomination by Technical Resources International, Inc. under contract no. N02-CB-07007 (10/05; 3/06). Available at http://ntp.niehs.nih.gov/ntp/htdocs/Chem_Background/ExSumPdf/4067-16-7_508.pdf [Accessed 25 October 2013]

NDF – No data found within the limits of the search strategy

Created by:	JH	Date: 28/10/13
Reviewed and edited by:	JF	Date 08/11/13

Project number: 127666004
Project name: Hydraulic Stimulation Chemicals Assessment, Southwest Queensland
Client name: Santos Ltd

Name	Trisodium nitrilotriacetate (impurity)
Synonyms	Trisodium 2,2',2''-nitrilotriacetate, Nitrilotriacetic acid trisodium salt, NTA trisodium salt, NTA, trisodium salt, trisodium nitrilotriacetate, trisodium NTA
CAS number	5064-31-3
Molecular formula	$C_6H_9NO_6 \cdot 3Na$
Molecular Structure	

Overview	References
Trisodium nitrilotriacetate is a water-soluble, white organic crystalline powder. Parent compound nitrilotriacetic acid is used as a chelating and sequestering agent, a builder in synthetic detergents, an eluting agent, a boiler feedwater additive, in water and textile treatment, in metal plating and cleaning and in pulp and paper processing. Based on the results of animal toxicity studies the toxicity of nitrilotriacetate and its sodium salts is equivalent. Repeated oral administration of nitrilotriacetate results in toxicity of the urinary system (kidney, bladder and ureter). The toxicity is due to its chelating properties resulting in binding to metals within the body.	ECHA (2013a), IARC

Human Health Toxicity Summary	Reference
Carcinogenicity Not classified by IARC as a standalone chemical, however nitrilotriacetic acid and its salts are possibly carcinogenic to humans (Group 2B), as there is sufficient evidence in experimental animals for the carcinogenicity of nitrilotriacetic acid and its salts. Suspected of causing cancer from oral route of exposure. Limited evidence of carcinogenic effect. The trisodium salt was tested for carcinogenicity in mice and rats by oral administration. When administered in the diet as the monohydrate, it induced haematopoietic tumours in male mice and benign and malignant tumours of the urinary system (kidney, ureter and bladder) in rats of each sex. When administered in drinking-water to male rats, it induced renal tubular adenomas and adenocarcinomas. The carcinogenicity of nitrilotriacetic acid and its salts is due to chronic inflammation. It is thought to be secondary to its chelating effects.	IARC (1999). ECHA (2013a), ECHA (2013b)
Mutagenicity/Genotoxicity	ECHA (2013a)

Conclusive but not sufficient for classification. Nitrilotriacetic acid and its disodium and trisodium salts were not genotoxic in experimental systems in vivo, except that the acid induced aneuploidy in mouse germ cells. Neither the acid nor its salts were genotoxic in mammalian cells in vitro and they were not mutagenic to bacteria.	IARC (1999)
Reproductive Toxicity Conclusive but not sufficient for classification. One reproductive study indicated no deleterious effects on reproduction in rats. In a second rat study, it caused a slight trend towards post-natal growth retardation but no other effects.	ECHA (2013a)
Developmental Toxicity/Teratogenicity No significant effects on embryonic development of rats at dose levels up to 450 mg/kg/d. No delirious effect on the development of the foetuses was observed in rabbits receiving doses up to 250 mg/kg/d. In a rat study, it was not teratogenic when applied via drinking water in concentrations up to 20 mg/kg/d. In a mice study, there were no observed significant embryotoxic effects and produced no increases in malformations at 300 mg/kg/day.	ECHA (2013a)
Endocrine Disruption Not listed as an endocrine disruptor.	EC (2000)
Neurotoxicity No data found.	
Acute Toxicity (oral, dermal, inhalation) Harmful if swallowed. Toxicity via dermal and inhalation route conclusive but not sufficient for classification. Rats that died during toxicity studies reported gastrointestinal and lung effects. No abnormalities in the organs were detected in the sacrificed rats. In mice and rats, toxic symptoms included ataxia, tremors, hypopnea, hypothermia tremors, muscular incoordination, unthrifty coat, faecal and urinary staining, decreased food consumption, overall weakness and mortality only in first 24 hours upon application. No mortality was observed in rat inhalation studies after treatment with NTA. No symptoms of systemic toxicity were observed in dermal rabbit studies. In a volunteer human study, no clinical signs were observed after consumption of a 10 mg dose. The chemical was poorly absorbed and rapidly excreted by the human subjects.	ECHA (2013a)
Chronic/repeat dose toxicity (oral, dermal, inhalation) Conclusive but not sufficient for classification. In chronic oral rat studies, rats exhibited kidney toxicity, reduced food consumption and significant lower body weight gain. A chronic dermal rabbit study resulted in no observed effects aside from mild skin irritation.	ECHA (2013a)
Sensitisation of the skin or respiratory system Conclusive but not sufficient for classification. Not sensitising to skin in guinea pig studies. Not sensitising to skin in a volunteer human study (three applications per week for three weeks at 40% concentration).	ECHA (2013a)
Corrosion (irreversible and reversible)/irritation of the skin or eye Causes serious eye irritation. Evidence for skin irritation is conclusive but not sufficient for classification. Non-irritating when applied as finely ground powder or as 10 % aqueous solution to intact skin of male and female rabbits. A mild irritant when applied as 25 % aqueous solution to intact skin of male and female rabbits. Non-irritating at 50% in a skin sensitizing study conducted in 20 guinea pigs. Slightly irritating to irritating on rabbit skin at varying concentrations, and non-irritating in two rabbit studies Slightly irritating to highly irritating in rabbit eyes.	ECHA (2013a)

Physical Hazards	Reference
Flammable Potential Not classified as a flammable solid. The self-ignition temperature was determined to be > 200°C. Not highly flammable or easily ignitable. Combustible under specific conditions and decomposes on burning producing toxic and irritating fumes including nitrogen oxides.	ECHA (2013a)
Explosive Potential Not classified as an explosive. Explosive in one experiment and non-explosive in another. When explosive, the ignition temperature of a cloud of the sample dust was 561 °C.	ECHA (2013a)

Toxicity Values	Value	Reference
Human Toxicity Data		
Acute Toxicity		
	No data found.	-
High Chronic/Repeat Dose Toxicity		
	No data found.	-
Animal Toxicity Data		
Acute Toxicity		
LD_{50}		
Rat, oral	1740 mg/kg	ECHA (2013a)
Rat, oral	3500 mg/kg	ECHA (2013a)
Rat, oral (male)	1250 mg/kg	ECHA (2013a)
Rat, oral	3715 mg/kg	ECHA (2013a)
Rat, oral	3900 mg/kg	ECHA (2013a)
Rat, oral (male)	2000 mg/kg	ECHA (2013a)
Rat, oral	2595 mg/kg	ECHA (2013a)
Rat, oral (female)	1000 mg/kg	ECHA (2013a)
Rat, oral	1450 mg/kg	ECHA (2013a)
Rat, oral	2100 mg/kg	ECHA (2013a)
Mouse, oral	300 mg/kg	ECHA (2013a)
Mouse, oral	680 mg/kg	ECHA (2013a)
Rabbit, oral	No data found.	-
Rat, dermal	No data found.	-
Rabbit, dermal	No data found.	-
Mouse, dermal	No data found.	-
LC_{50}		
Rat	No data found.	-
High Chronic/Repeat Dose Toxicity		
LOAEC (monkey, inhalation)	0.34 mg/l	ECHA (2013a)
LOAEL (rat, oral)	0.15 %	ECHA (2013a)
LOAEL (rat, oral)	187 mg/kg bw/day	ECHA (2013a)
LOAEL (rat, oral)	200 mg/kg/day	ECHA (2013a)
LOAEL (rat, oral)	1309 mg/kg bw/day	ECHA (2013a)
LOAEL (rat, oral)	2%	ECHA (2013a)
LOAEL (rat, oral)	350 mg/kg bw/day	ECHA (2013a)
LOAEL (dog, oral)	90 - 168 mg/kg bw/day	ECHA (2013a)
LOAEL (rat, oral)	9 mg/kg bw/day	ECHA (2013a)
LOAEL (rat, oral)	500 mg/kg/day	ECHA (2013a)
LOAEL (rat, oral)	150 - 560 mg/kg bw/day	ECHA (2013a)
LOAEL (rat, oral)	110 mg/kg bw/day	ECHA (2013a)
LOAEL (rat, oral)	500 mg/kg bw/day	ECHA (2013a)

Footnotes:
LD_{50} – lethal dose for 50% of experimental population
LC_{50} – lethal air concentration for 50% of experimental population
LOAEL – Lowest Observed Adverse Effect Level
LOAEC – Lowest Observed Adverse Effect Concentration
Conclusive data: means that the study itself was conclusive in its reported finding, but was not sufficient for classifying the material according to ECHA guidelines.

Human Health Toxicity Ranking*		
	Hazard data	**Comment**
Hazard Band 4		
Carcinogenicity	No	-
Mutagenicity/Genotoxicity	No	IARC 1999
Reproductive Toxicity	No	
Developmental Toxicity/ Teratogenicity	No	
Endocrine Disruption[1]	No	
Hazard Band 3		
Acute Toxicity (oral, dermal or inhalation) Very Toxic/Toxic • oral LD_{50} ≤ 300 mg/kg[3] • dermal LD_{50} ≤ 1000 mg/kg • inhalation LC_{50} ≤ 10 mg/L[4] (or mg/m^3) (vapour)	No	
Possible carcinogenicity, mutagenicity, reproductive or High Chronic/repeat dose toxicity • oral LOAEL ≤ 10 mg/kg/d[3]; • dermal LOAEL ≤ 2 0 mg/kg/d; • inhalation LOAEC (6 h/d) ≤ 50 ppm/d for gases, ≤ 0.2 mg/L/d for vapours or ≤ 0.02 mg/L/d for dust/mists/fumes[4]	Yes	Nitrilotriacetic acid and its salts are possibly carcinogenic to humans (Group 2B)
Corrosive (irreversible damage)	Yes	
Respiratory sensitiser	No data found.	
Hazard Band 2		
Harmful chronic/repeat dose toxicity • oral LOAEL > 10 mg/kg and ≤ 100 mg/kg/d • dermal LOAEL > 20 mg/kg/d and ≤ 200 mg/kg/d • inhalation (6-h/d) LOAEC > 50 mg/L ≤ 250 mg/L/d for gases, > 0.2 mg/L ≤ 1 .0 mg/L/d for vapours or > 0.02 mg/L ≤ 0.2 mg/L/d for dust/mists/fumes[4]	Yes	
Skin Sensitiser	No	
Hazard Band 1		
Acute Toxicity-Harmful • oral LD_{50} > 300 mg/kg ≤ 2000 mg/kg • dermal LD_{50} >1 000 mg/kg ≤ 2000 mg/kg; • inhalation LC_{50} (6 h/d) > 10 mg/L ≤ 20 mg/L for vapours)[4]	Yes	
Irritant (reversible damage)	Yes	
Hazard Band 0 **All indicators outside criteria listed in Hazards 1-4**		
Physical Hazards		
Flammable potential	No	
Explosive potential	No	
Hazard Evaluation (highest band) not including physical hazards	Hazard Band 3	
Uncertainty analysis /data confidence	12/13 = 92%	

* Based on IMAP Framework [NICNAS (2013) Inventory Multi-tiered Assessment and Prioritisation (IMAP) Framework. National Industrial Chemicals Notification and Assessment Scheme. Department of Health and Aging, Canberra].

"[1]Based on list of endocrine disrupting chemicals from the European Commission's Endocrine Disrupters website.

[2] Based on list of neurotoxic chemicals from US Agency for Toxic Substances and Disease Registry (ATSDR).

[3] milligrams per kilogram body mass(mg/kg) or milligrams per kilogram body mas per day (mg/kg/d)

[4] Based on GHS cut-offs for hazard classification. For chronic/repeat dose toxicity, GHS cut-offs are provided as guidance values (i.e. the dose/concentration at or below which significant health effects are observed"). (p 18, NICNAS 2013).

Human Health Guidelines		
Media	**Concentration (mg/m^3; mg/L; mg/kg)**	**Reference**
Occupational Exposure Limits		
Air (OEL)	No data found.	-
8-h TWA	No data found.	-
STEL	No data found.	-
Peak Limitation	No data found.	-
Environmental Exposure		
Air, ambient	No data found.	-
Air, indoor	No data found.	-
Water, potable	The World Health Organization has established an international drinking-water guideline for parent compound nitrilotriacetic acid of 200 g/L.	-
Water, recreational	No data found.	-
Soil, residential	No data found.	-
Soil, commercial/industrial	No data found.	-

Footnotes:

OEL = Occupational Exposure Limit

TWA= 8 h Time-Weighted Average

STEL = (15 min) Short-term Exposure Limit

Qualifying Summary Comments

Trisodium nitrilotriacetate is a water-soluble, white organic crystalline powder. It is a chelating and sequestering agent, a builder in synthetic detergents, an eluting agent, a boiler feedwater additive, in water and textile treatment, in metal plating and cleaning and in pulp and paper processing.

Trisodium nitrilotriacetate can result in severe eye irritation and is harmful if swallowed.

Repeated exposure to high doses in drinking water, feed or bolus administration in rats and mice has resulted in toxicity to the urinary system as well as a range of tumours. These effects are largely attributable to to its chelating properties resulting in interactions with internal zinc and calcium related bodily processes. It is not classifiable a genotoxic, a reproductive or developmental toxicant. Overall a hazard band of 3 was assigned based on possible carcinogenic potential and inhalation repeat dose toxicity.

References and Notes

European Chemicals Agency. Registered Chemical Substances Search. Available at http://echa.europa.eu/web/guest/information-on-chemicals/registered-substances. [Accessed 8 August 2013] (ECHA 2013a)

European Chemicals Agency. Classification and Labelling Inventory database Search. Available at http://echa.europa.eu/web/guest/information-on-chemicals/cl-inventory-database. [Accessed 8 August 2013] (ECHA 2013b)

European Commission (EC) (2000) Towards the establishment of a priority list of substances for further evaluation of their role in endocrine disruption, preparation of a candidate list of substances as a basis for priority setting, Final Report (Incorporating corrigenda to final report dated 21 June 2000).

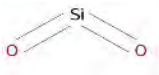
IARC (2013) Agents classified by IARC Monographs Volumes 1- 107. Available at http://monographs.iarc.fr/ENG/Classification/ClassificationsGroupOrder.pdf. [Accessed 5 August 2013.]

IARC.(1999). Nitrilotriacetic acid and its salts. IARC Monographs on the Evaluation of Carcinogenic Risks to Humans, Volume 73, Some Chemicals that Cause Tumours of the Kidney or Urinary Bladder in Rodents and Some Other Substances. Summary of Data Reported and Evaluation. Iinternational Agency for Research on Cancer (IARC). Lyon France
Available at http://monographs.iarc.fr/ENG/Monographs/vol73/mono73-19.pdf

No data found. - No data found within the limits of the search strategy.

Created by:	MER	Date 4/9/2013
Reviewed and edited by:	JF	Date 11/09/2013

Project number: 127666004
Project name: Hydraulic Stimulation Chemicals Assessment, Southwest Queensland
Client name: Santos Ltd

Name	Silica, amorphous - fumed
Synonyms	Silica, amorphous, fumed, crystalline free; Fumed silica, crystalline free; Pyrogenic colloidal silica; Synthetic amorphous silica, fumed; silicon dioxide
CAS number	7631-86-9 (112945-52-5 pyrogenic silica)*
Molecular formula	O_2-Si
Molecular structure	

* Refer to figure 1 at the end of this document.

Overview	References
Silica, amorphous – fumed belongs to a sub-class of silica called synthetic amorphous silica (SAS) which is part of the overarching group of silica (CAS No 7631-86-9); refer to figure 1 at the end of this document for diagram of relationship. Silica amorphous-fumed, also known as pyrogenic silica, is registered under the specific CAS No 112945-52-5.	ECETOC (2006)
SAS (including silica gels) are white, fluffy and/or powdery amorphous forms of silicon dioxide (silica, SiO_2). It has a molecular mass of 60.08 g/mol, a density of 2.2 at 20ºC and a melting point of approximately 1 700 ºC.	
Important quantities of synthetic amorphous silica are produced as pyrogenic (fumed) silica and wet process silica (precipitated silica and silica gels) which are used, notably, for reinforcing elastomers, for thickening resins, paints and toothpaste, and as free-flow additives. Exposure to synthetic amorphous silica may occur during its production and use. Synthetic amorphous silica may also be ingested as a minor constituent (< 2%) of a variety of food products where it serves as an anti-caking agent, and as an excipient in some pharmaceutical preparations. Silica fume (CAS No 69012-64-2) which is a by-product from electrical furnace is another form of amorphous silica.	IARC (1997)
Commercialised since the 1950s, SAS are used in a wide variety of industrial applications and they are usually tailor-made to meet the users' requirements. Main uses of SAS include reinforcement and thickening agent in various systems such as elastomers, resins, inks and water for instance. Due to their high porosity, SAS is also used as an adsorbing agent. Due to their inert nature, SAS are also used in consumers' products such as cosmetics, pharmaceuticals and foods.	ECETOC (2006)
SAS have been studied less than crystalline silica. They are generally less toxic than crystalline silica and are cleared more rapidly from the lung. Furthermore, amorphous silica is chemically and biologically inert when ingested in any of its many physical forms. This explains why overall it is not considered as hazardous to humans.	IARC (1997)
The human health toxicity information discussed below is based on SAS, not specifically on silica, amorphous - fumed.	

Human Health Toxicity Summary	Reference
Carcinogenicity IARC rating for silica, amorphous (CAS No 7631-86-9): Group 3 (Amorphous silica *is not classifiable as to its carcinogenicity to humans)*	IARC (2013)
Mutagenicity/Genotoxicity UNEP reported a study where pyrogenic SAS (Aerosil 200) was used in one sub-chronic inhalation study where rats were exposed to a mean dust concentration of 50 mg/m^3 for 13 wk. The study also included crystalline silica. Alveolar type-II cells were isolated from the bronchoalveolar lavage fluid and subjected to the HPRT gene-mutation assay *in vitro*. The cells were cultured for 14 d to 21 d in	UNEP (2004)

selective medium prior to fixation. No increase in 6TG-resistant mutant vs. control where noted after exposure to the pyrogenic SAS, while the mutant frequency have significantly increased after exposure to crystalline silica.	
Reproductive Toxicity UNEP cited a study where the reproductive toxicity properties of fumed silica were assessed in rats. In this one-generation study, animals were fed pyrogenic SAS (Aerosol) at a dose of 500 mg/kg/d for a premating period of 4.5 months with continued exposure up to 6 months. Five pregnant test females and four pregnant untreated controls females (delivery respectively 45 pups and 37 pups) were included in this study. While no adverse effects were observed, it was reported that the study had some shortcomings regarding the low number of pregnant animals used and that the mating ratio was too low according to current standards.	UNEP (2004)
Developmental Toxicity/Teratogenicity According to UNEP, the potential for developmental effects of SAS were assessed in a comprehensive and reliable testing program where various animal species (rat, mouse, rabbit, and hamster) were administered SAS orally at doses up to 1 600 mg/kg/d. No significant signs of maternal or developmental toxic effects were observed in any species tested. Abnormalities noted in soft or skeletal tissues of the test groups were comparable to the frequencies occurring in the control groups. The types of SAS used were not specified in the UNEP report.	UNEP (2004)
Endocrine Disruption Not listed as an endocrine disruptor.	EC (2000)
Neurotoxicity NDF.	
Acute Toxicity (oral, dermal or inhalation) Oral According to the studies reported in the UNEP report, various forms of SAS administered orally (gavage or in diet) did not cause mortality at the highest doses tested. Oral LD_{50} values by gavage ranged from > 3 100 mg/kg to > 20 000 mg/kg in rats and mice. An oral LD_{50} > 10 000 mg/kg was established for rats given SAS in the diet for 24 h. **Dermal** LD_{50} > 5 000 mg/kg was established for rabbits administered aqueous pastes of precipitated SAS and Na-Al silicates to the intact and abraded skin for 24 h under occlusive conditions. **Inhalation** No adverse effects were observed after 4-h exposure of rats to pyrogenic SAS (Aerosol 200) at an average dust concentration of 139 mg/m^3. In another study, rats survived exposure to an average concentration of 2 080 mg/m^3 pyrogenic SAS (Cab-O-Sil M5). Clinical symptoms included nasal discharge during exposure, crusty eyes and nose in few animals and alopecia post-exposure. It was noted that acute inhalation studies performed with dry dusts were hindered by the inability to achieve the recommended highest test concentration of 5 mg/L. No information about control groups was given. UNEP reports LC_{50} in the range of > 0.14 mg/L to > 2.0 mg/L (maximum concentrations technically feasible) for SAS). It appears that the LC_{50} values are based on the rats study aforementioned.	UNEP (2004)
Chronic/repeat dose toxicity (oral, dermal, inhalation) **Oral** None of the oral repeated dose studies reported by UNEP were performed with a pyrogenic SAS. However, an overall oral NOAEL of 2 500 mg/kg/d was established for rats based on studies carried out with different SAS. **Dermal** According to UNEP, long-term exposure to SAS may produce skin dryness. **Inhalation**	UNEP (2004)

UNEP reports that no evidence of pneumoconiosis or silicosis was observed in occupational exposures to SAS. Other disorders of the respiratory tract could not be correlated with exposure to SAS alone. However, the available epidemiological data base on workers is too limited to be able to draw firm conclusions. UNEP cites a study where rats were exposed to pyrogenic SAS at (1.3, 5.9 and 31) mg/m^3 for 13 wk. The results showed mild reversible pro-inflammatory cell proliferation but no pathologically relevant tissue change. At mid-concentration, adverse effects such as stimulation of collagen production, increase in lung weight, incipient interstitial fibrosis and slight focal atrophy in the olfactory epithelium were observed. All these effects were reversible following discontinuation of exposure. A NOAEL of 1.3 mg/m^3 and a LOAEL of 5.9 mg/m^3 were established. UNEP assessed this study as comprehensive, fully reliable and valid.	
Sensitisation of the skin or respiratory system According to UNEP, there are no experimental data available on sensitisation. There is no evidence of skin sensitisation in workers over decades of practical experience.	UNEP (2004)
Corrosion (irreversible)/irritation (reversible) effects on the skin or eye **Effects on skin** UNEP states that based on experimental data, SAS is not irritating to rabbit skin. However, it is noted that cases of dryness or degenerative eczema of the skin in workers with chronic contact have been reported by occupational physicians. When tested on the rabbit eye as a powder, SAS showed no or only weak and non-permanent irritating effects on the conjunctivae but neither the iris nor the cornea were affected.	UNEP (2004)

Physical Hazards	Reference
Flammable Potential Non-flammable	UNEP (2004)
Explosive Potential Non-explosive	UNEP (2004)

Toxicity Values	Value	Reference
Human Toxicity Data		
High Chronic/Repeat Dose Toxicity		
LOAEC	NDF	
LOAEL	NDF	
Animal Toxicity Data		
Acute Toxicity		
LD_{50}		
Rat, oral (gavage)	> 3 100 to > 20 000 mg/kg (aqueous suspension and gel SAS)	UNEP (2004)
Mouse, oral	> 3 100 to > 20 000 mg/kg (aqueous suspension and gel SAS)	UNEP (2004)
Rabbit, oral	NDF	
Rat, dermal	NDF	
Rabbit, dermal	> 5 000 mg/kg (precipitated SAS)	UNEP (2004)
Mouse, dermal	NDF	
LC_{50}		
Rat	> 0.14 - > 2.0 mg/l (pyrogenic and precipitated SAS; maximum concentrations technical feasible)	UNEP (2004)
High Chronic/Repeat Dose Toxicity		
NOAEL (rat, oral)	2 500 mg/kg/d	UNEP (2004)
LOAEC	5.9 mg/m^3 (precipitated and gel SAS)	UNEP (2004)

Footnotes:
LD_{50} – lethal dose for 50% of experimental population
LC_{50} – lethal air concentration for 50% of experimental population
LOAEL – Lowest Observed Adverse Effect Level
LOAEC – Lowest Observed Adverse Effect Concentration
NDF – no data found within the limits of the search strategy

Human Health Toxicity Ranking*		
	Hazard data	**Comment**
Hazard Band 4		
Carcinogenicity (IARC Group 1 or 2A)	No	IARC Group 3 – not classifiable as to its carcinogenicity to humans) (IARC 2013)
Mutagenicity/Genotoxicity (GHS Category 1A and 1B)	No	UNEP, 2004
Reproductive Toxicity/Developmental toxicity (GHS Category 1, 1A and 1B)	No	Based on a study with some limitations (UNEP, 2004)
Endocrine Disruption[1]	No	EC, 2000
Hazard Band 3		
Carcinogenicity (IARC Group 2B)	No	IARC Group 3 – not classifiable as to its carcinogenicity to humans) (IARC 2013)
Mutagenicity/Genotoxicity (GHS Category 2)	No	UNEP, 2004
Reproductive Toxicity/Developmental toxicity (GHS Category 2)	No	Based on a study with some limitations (UNEP, 2004)
Acute Toxicity (oral, dermal or inhalation) Very Toxic/Toxic • oral LD_{50} ≤ 300 mg/kg [3] • dermal LD_{50} ≤ 1 000 mg/kg • inhalation LC_{50} ≤ 10 mg/L [4] (vapour)	No	Oral LD_{50} (rat and mouse,) > 3 100 mg/kg to > 20 000 mg/kg (aqueous suspension and gel SAS) (UNEP 2004) LC_{50} (rat) > 0.14 mg/L- > 2.0 mg/l (pyrogenic and precipitated SAS; maximum concentrations technical feasible)
Possible carcinogenicity, mutagenicity, reproductive or High Chronic/repeat dose toxicity • oral LOAEL ≤ 10 mg/kg/d [3]; • dermal LOAEL ≤ 2 0 mg/kg/d; • inhalation LOAEC (6 h/d) ≤ 50 ppm/d for gases, ≤ 0.2 mg/L/d for vapours or ≤ 0.02 mg/L/d for dust/mists/fumes [4]	No	LOAEC rat = 5.9 mg/m^3 (precipitated and gel SAS) (UNEP 2004)
Corrosive (irreversible effect)	No	UNEP (2004)
Respiratory sensitiser	NDF	
Hazard Band 2		
Harmful chronic/repeat dose toxicity • oral LOAEL > 10 mg/kg and ≤ 100 mg/kg/d • dermal LOAEL > 20 mg/kg/d and ≤ 200 mg/kg/d	No	LOAEC (rat) 5.9 mg/m^3 (precipitated and gel SAS)

• inhalation (6-h/d) LOAEC > 50 mg/L ≤ 250 mg/L/d for gases, > 0.2 mg/L ≤ 1.0 mg/L/d for vapours or > 0.02 mg/L ≤ 0.2 mg/L/d for dust/mists/fumes [4]		(UNEP 2004)
Skin Sensitiser	NDF	
Hazard Band 1		
Acute Toxicity-Harmful • oral LD_{50} > 300 mg/kg ≤ 2 000 mg/kg • dermal LD_{50} >1 000 mg/kg ≤ 2 000 mg/kg; • inhalation LC_{50} (6 h/d) > 10 mg/L ≤ 20 mg/L for vapours)[4]	No	UNEP (2004)
Irritant (reversible effect)	No	UNEP (2004)
Hazard Band 0 **All indicators outside criteria listed in Hazards 1-4**		
Physical Hazards		
Flammable potential	No	UNEP (2004)
Explosive potential	No	UNEP (2004)
Hazard Evaluation (highest band) not including physical hazards	**0**	
Uncertainty analysis /data confidence (out of 12 parameters)	**10/12**	**83%**

* Based on IMAP Framework [NICNAS (2013) Inventory Multi-tiered Assessment and Prioritisation (IMAP) Framework. National Industrial Chemicals Notification and Assessment Scheme. Department of Health and Aging, Canberra].

"[1] *Based on list of endocrine disrupting chemicals from the European Commission's Endocrine Disrupters website.*

[2] *Based on list of neurotoxic chemicals from US Agency for Toxic Substances and Disease Registry (ATSDR).*

[3] *milligrams per kilogram body mass (mg/kg) or milligrams per kilogram body mass per day (mg/kg/d)*

[4] *Based on GHS cut-offs for hazard classification. For chronic/repeat dose toxicity, GHS cut-offs are provided as guidance values (i.e. the dose/concentration at or below which significant health effects are observed)". (p 18, NICNAS 2013).*

Human Health Guidelines		
Media	**Concentration (mg/m^3; mg/L; mg/kg)**	**Reference**
Occupational Exposure Limits		
Air (OEL)		
8-h TWA	10 mg/m^3	HSIS (2013)
STEL	NDF	
Peak Limitation	NDF	
Environmental Exposure		
Air, ambient	NDF	
Air, indoor	NDF	
Water, potable	NDF	
Water, recreational	NDF	
Soil, residential	NDF	
Soil, commercial/industrial	NDF	

Footnotes:

OEL = Occupational Exposure Limit

TWA= 8-h Time-Weighted Average

STEL = (15 min) Short-term Exposure Limit

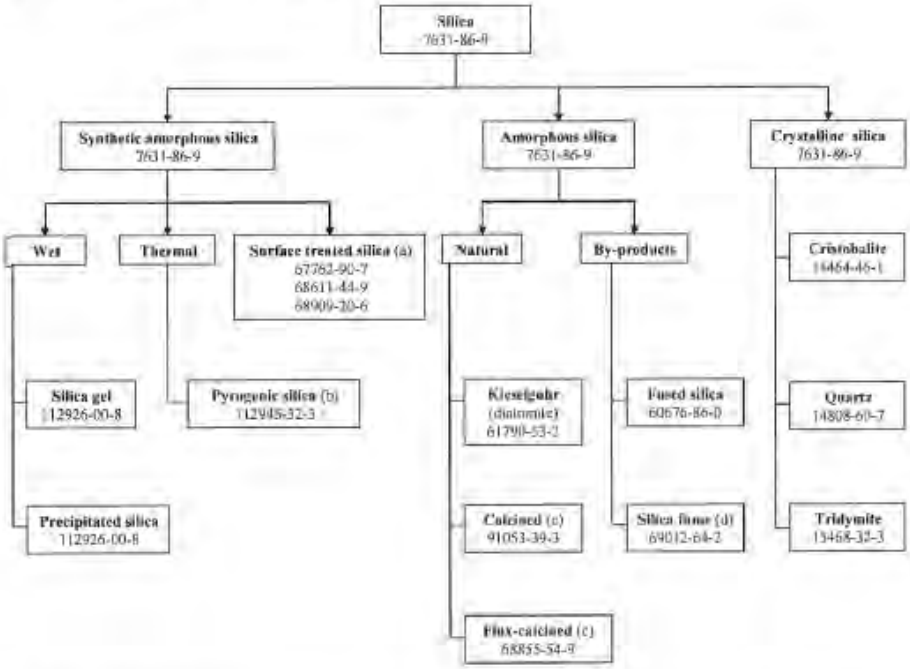
NDF – no data found within the limits of the search strategy

Qualifying Summary Comments

Silica, amorphous-fumed gel is a type of synthetic amorphous silica (SAS). Amorphous silica has been studied less than crystalline silica as it is generally less toxic than crystalline silica and is cleared more rapidly from the lung. Although effects on the lung have been observed at high concentrations these have been reversible following cessation of exposure. Amorphous silica is chemically and biologically inert when ingested in any of its many physical forms such as amorphous siliceous earth (diatomaceous earth, diatomite, kieselguhr) or colloidal silica gels and is not classifiable as to its carcinogenicity to humans. SAS does neither have acute or chronic health effects when administered by oral, dermal and inhalational routes nor have reproductive, development/teratogenicity or mutagenicity/genotoxicity effects. SAS is not classified as a skin sensitiser nor does it cause irritation of the skin or eye. For these reasons it is categorized as Hazard Band 0.

Safe Work Australia has listed amorphous silica as a hazardous substance under the respective legislation and developed an exposure standard for amorphous silica dust which is the generic standard for dusts. Due to its low solubility, amorphous silica in aqueous solution and as introduced during chemical stimulation activities would settle into soils and sediments and become indistinguishable from those materials. The principal hazard is subsequently the generation of dusts under occupational settings which would require management.

Figure 1: Different polymorphs of silica with CAS numbers



(a) All forms of SAS can be surface-treated either physically or chemically; most common treating agents are organosilicon compounds (Appendix B: Table B.2)
(b) Pyrogenic silica is also known as fumed silica in the English speaking countries
(c) Partial transformation into cristobalite
(d) By-product from electrical furnace

2.2 EC classification and labelling

SAS is not classifiable according to the Dangerous Substances Directive 67/548/EEC (EC, 1993).

Surface-treated substances are exempt from notification under the EC Directive (EC, 2002), including the three surface-treated SASs listed in the European Inventory of Existing Commercial Chemical Substances (EINECS): silane, dichlorodimethyl-reaction products with silica (271-893-4), silane, hexamethyldisilazane-reaction product with silica (272-697-1), and silane, octyltrimethoxy-reaction product with silica (296-597-2).

References

EC (European Commission) 2000, *Towards the establishment of a priority list of substances for further evaluation of their role in endocrine disruption Final Report (Incorporating corrigenda to final report dated 21 June 2000) – Annex 10: List of 564 substances with their selection criteria*, Available at: http://ec.europa.eu/environment/archives/docum/pdf/bkh_annex_10.pdf, Accessed 14 January 2014.

ECETOC (European Centre for Ecotoxicology and Toxicology of Chemicals) 2005, *Report No. 51 Synthetic Amorphous Silica (CAS No. 7631-86-9)*, Available at http://members.ecetoc.org/Documents/Document/JACC%20051.pdf, Accessed 14 January 2014.

HSIS (Hazardous Substances Information System) 2013, *HSIS Database – Exposure Standards*, Safe Work Australia, Available at http://hsis.safeworkaustralia.gov.au/ExposureStandards, Accessed 14 January 2014.

IARC (International Agency for Research on Cancer) 1997, *International Programme on Chemical Safety Database - IARC Summary & Evaluation: Silica,* Available at: http://www.inchem.org/documents/iarc/vol68/silica.html, Accessed 14 January 2014.

IARC (International Agency for Research on Cancer) 2013, *Agents Classified by the IARC Monographs*, Volumes 1–109, Available at: http://monographs.iarc.fr/ENG/Classification/ClassificationsCASOrder.pdf, Accessed 14 January 2014.

UNEP (United Nations Environment Programme) 2004, *Synthetic Amorphous Silica and Silicates - SIDS (Screening Information Dataset) Initial Assessment Report*, UNEP Publications, Available at: http://www.chem.unep.ch/irptc/sids/OECDSIDS/Silicates.pdf, Accessed 14 January 2014.

Updated by:	JC	14/01/2014
Reviewed by:	PDM	14/01/2014 Rev 1
Reviewed by:	PDM	15/01/2014 Rev 2

Project number: 127666004
Project name: Hydraulic Stimulation Chemicals Assessment, Southwest Queensland
Client name: Santos Ltd

Name	Hydrochloric acid
Synonyms	Anhydrous hydrochloric acid, Chlorohydric acid, Hydrochloric acid gas, Hydrogen chloride, Muriatic acid
CAS number	7647-01-0
Molecular formula	HCl
Molecular Structure	H-Cl

Overview	References
Hydrogen chloride the gas, and hydrogen chloride the aqueous acid (hydrochloric acid), have the same CAS Registry number. Since the gas becomes the acid in aqueous systems and volatilization of the gas can occur from aqueous systems, it is often difficult to determine which is being considered in a specific item in the literature. If released to water, hydrogen chloride dissociates readily to chloride and hydronium ions, decreasing the pH of the water. There are few detailed studies reported following human exposures. Hydrogen chloride vapour is irritant to mucous membranes and is so severe that workers evacuate from the work place shortly after detecting its odour. A relation between concentrations from accidental exposure and health effects has not been reported in detail.	HSDB (2011)
The solution in water is a strong acid which reacts with bases and is corrosive. It reacts violently with oxidants forming toxic gas (chlorine). Hydrochloric acid attacks many metals in the presence of water forming flammable/explosive gas (hydrogen).	IPCS (2000)
Hydrochloric acid is one of the most widely used industrial chemicals, for example: • Pickling and cleaning steel and other metals. • Production of various inorganic and organic chemicals. • Food processing. • Cleaning of industrial equipment. • Extraction of metals. Hydrochloric acid levels in ambient air usually do not exceed 0.01 mg/m^3. Long-term or repeated exposures may have effects on the lungs, resulting in chronic bronchitis and effects on the teeth, resulting in erosion.	UNEP (2002)

Human Health Toxicity Summary	Reference
Carcinogenicity Not classified as a carcinogenic substance by ECHA. IARC Group 3, hydrochloric acid is not classifiable as to its carcinogenicity to humans	ECHA (2013) IARC (2013)
Mutagenicity/genotoxicity Not classified as mutagenic by ECHA. In single studies, HCl induced mutation and chromosomal aberrations in mammalian cells and induced chromosomal aberrations in insects and in plants. It did not induce mutation in bacteria. For genetic toxicity, a negative result has been shown in the Ames test. A positive result, which is	ECHA (2013) UNEP(2002)

considered to be an artefact due to the low pH, has been obtained in a chromosome aberration test using Hamster ovary cells. Positive results were obtained in a Sex Linked Recessive Lethal study with *D. melanogaster*. There are no mammalian studies on *in vivo* mutagenicity with hydrogen chloride.	
Reproductive Toxicity According to UNEP, no reliable studies have been reported regarding toxicity to reproduction in animals after oral, dermal or inhalation exposure to hydrogen chloride/hydrochloric acid. Although no reliable studies on reproductive toxicity are reported in the UNEP assessment report, it states that in another study not specifically designed to assess reproductive toxicity (repeated dose inhalation study) no effects on the gonads were observed in mice up to 50 ppm. According to the author, this study was assessed as compliant with FDA-GLP (Food and Drugs Administration – Good Laboratory Practice).	UNEP (2002)
Developmental Toxicity/Teratogenicity UNEP suggests in an assessment report that no reliable studies have been reported regarding developmental toxicity in animals after oral, dermal or inhalation exposure to hydrogen chloride/hydrochloric acid. However, it states that as hydronium ions and chloride ions are normal constituents in the body fluid of animal species, low concentrations of hydrogen chloride gas/mist or solution do not seem to cause adverse effects to animals, provided the gas or acid concentrations do not exceed the capacity for buffering systems in the body to neutralise them. In addition, the UNEP report states that hydrochloric acid plays an important role in digestion, being secreted by the cells of gastric glands in the stomach and that orally administered sulfuric acid, which results in pH change in the stomach as well, did not cause developmental toxicity to laboratory animals. The report concludes that consequently, low concentrations of hydrogen chloride/hydrochloric acid which can be tolerated by the body with respect to irritant and corrosive effects are unlikely to have developmental toxicity.	UNEP (2002)
Endocrine Disruption Not listed as an endocrine disruptor.	EC (2000)
Neurotoxicity No data available.	
Acute toxicity (Oral, Dermal or Inhalation) According to ECHA, data are lacking about the acute toxicity of hydrochloric acid by oral and dermal routes. However, based on the GHS classification ECHA states that hydrochloric acid (> 10% w/w) may cause respiratory irritation of the lungs and respiratory system by inhalation. ECHA reported a study where the acute toxicity of hydrochloric acid by inhalation was assessed in rats exposed to various concentrations of the substance as a gas or aerosol (percentage of HCl not specified), for exposure periods of 5 min or 30 min. For the gas, the LC_{50} was equivalent to 61.1 mg/L and 7.0 mg/L for 5 min and 30 min exposures, respectively. HSIS also classifies hydrochloric acid of concentration > 5% as toxic via inhalation IPCS reports that effects of short-term exposure include pneumonitis and lung oedema caused by inhalation of high concentrations of the gas. This may result in reactive airways dysfunction syndrome (RADS). The effects may be delayed.	ECHA (2013) HSIS (2013) IPCS (2000)
Chronic/repeat dose toxicity (oral, dermal, inhalation) According to UNEP, there are no repeated dose dermal studies available for hydrogen chloride/hydrochloric acid and the oral studies found have low reliability scores. However, it is noted in the report that hydrogen chloride/hydrochloric acid caused adverse effects at the site of	UNEP (2002)

contact at high concentration (actual doses not provided) and that solutions of lower concentration that might not cause skin irritation, are not expected to be absorbed from the skin and not expected to be available systemically in the body. Based on a study cited in the UNEP report, because the cells of the gastric glands secrete hydrochloric acid (with pH as low as 0.87) into the stomach cavity, small volumes or lower concentrations of ingested hydrochloric acid are not known to cause systemic effects. The UNEP report cites another study where the repeat dose toxicity of hydrochloric acid via inhalation was assessed with rats and mice exposed to hydrogen chloride gas at concentrations of (0, 15, 30 and 75) mg/m^3 or (0, 10, 20 and 50) ppm for 90 d, 6 h/d, 5 d/week. At the highest dose, a decrease in body weight gain and food consumption was observed in male and female mice, while a decrease in liver weight was noted in male mice only. Decrease in food consumption and body weight was also noted at the highest dose in rats. Urinalysis, haematology and serum chemistry did not show significant difference between test and control animals. A NOAEL for repeated dose inhalation toxicity of 20 ppm (30 mg/m^3) was established for rats and mice. This NOAEL is assumed to be based on decrease in food consumption and body weight. IPCS states that long-term exposure effects might include chronic bronchitis and teeth erosion.	Ganong (2011) as cited in UNEP (2002) UNEP (2002) IPCS (2000)
Sensitisation of the skin or respiratory system Not classified as a skin sensitizer by ECHA. Data lacking regarding the sensitisation of the respiratory system.	ECHA (2013)
Corrosion (irreversible)/irritation (reversible) effects on the skin or eye Hydrochloric acid causes severe skin burns and eye damage. ECHA cites a study where the corrosive/irritating properties of hydrochloric acid to the skin were assessed in rabbits. The dorsal and lateral parts of the animals were clipped 15 h to 24 h prior to exposure. Hydrochloric acid aqueous solution (37%) was applied in occluded and semi-occluded patches of 0.5 mL to the areas of the animals for one or four hours. The study concludes that hydrochloric acid aqueous solution at 37% caused corrosion to the rabbit skin under occlusive and semi-occlusive conditions. ECHA deems this study to be reliable with restrictions as it followed the OECD but not the GHS guidelines and no control group was used. To assess the corrosive property of hydrochloric acid to the eye, ECHA cites another rabbit study where a single dose of 0.1 mL of hydrochloric acid aqueous solution at 0% and 10% was instilled in one eye of each rabbit and the vehicle instilled in the other eye (the untreated eye serving as control). The eyes were then observed 4 h, 24 h, 48 h, 72h and 96 h post-treatment. Irreversible damage of the eyes were observed.	ECHA (2013)

Physical Hazards	Reference
Flammable Potential Non-flammable. Extreme heat or contact with metals can release explosive hydrogen gas	UNEP (2002)
Explosive Potential Non-explosive. Extreme heat or contact with metals can release explosive hydrogen gas	UNEP (2002)

Toxicity Values	Value	Reference
Human Toxicity Data		
High Chronic/Repeat Dose Toxicity		
LOAEC	NDF	
LOAEL	NDF	
Animal Toxicity Data		
Acute Toxicity		
LD_{50}		
Rat, oral	NDF	
Mouse, oral	NDF	
Rabbit, oral	NDF	
Rat, dermal	NDF	
Rabbit, dermal	NDF	
Mouse, dermal	NDF	
LC_{50}		
Rat (gas, 5 min exposure)	61.1 mg/L	ECHA (2013)
Rat (gas, 30 min exposure)	7.0 mg/L	ECHA (2013)
High Chronic/Repeat Dose Toxicity		
LOAEL	NDF	
LOAEC	NDF	
NOAEC (rats and mice)	30 mg/m^3	UNEP (2002)

Footnotes:
LD_{50} – lethal dose for 50% of experimental population
LC_{50} – lethal air concentration for 50% of experimental population
LOAEL – Lowest Observed Adverse Effect Level
LOAEC – Lowest Observed Adverse Effect Concentration
NDF – no data found within the limits of the search strategy

Human Health Toxicity Ranking*		
	Hazard data	**Comment**
Hazard Band 4		
Carcinogenicity (IARC Group 1 or 2A)	No	IARC Group 3 (IARC 2013)
Mutagenicity/Genotoxicity (GHS Category 1A and 1B)	No	ECHA (2013)
Reproductive Toxicity/Developmental toxicity (GHS Category 1, 1A and 1B)	NDF	The data found has a low reliability score (UNEP 2002)
Endocrine Disruption[1]	No	EC (2000)
Hazard Band 3		
Carcinogenicity (IARC Group 2B)	No	IARC Group 3 (IARC 2013)
Mutagenicity/Genotoxicity (GHS Category 2)	No	ECHA (2013)
Reproductive Toxicity/Developmental toxicity (GHS Category 2)	NDF	The data found has a low reliability score (UNEP 2002)
Acute Toxicity (oral, dermal or inhalation) Very Toxic/Toxic • oral $LD_{50} \leq 300$ mg/kg [2] • dermal $LD_{50} \leq 1000$ mg/kg inhalation $LC_{50} \leq 10$ mg/L [3] (vapour)	Yes	LC_{50}: 61.1 mg/L (5 min) and 7.0 mg/L (30 min) (ECHA, 2013). Toxic by inhalation (HSIS)
Possible carcinogenicity, mutagenicity, reproductive or High Chronic/repeat dose toxicity • oral LOAEL ≤ 10 mg/kg/d [2]; • dermal LOAEL ≤ 2 0 mg/kg/d; inhalation LOAEC (6 h/d) ≤ 50 ppm/d for gases, ≤ 0.2 mg/L/d for vapours or ≤ 0.02 mg/L/d for dust/mists/fumes [3]	NDF	NOAEC for rats 30 mg/m^3 (20 ppm) (UNEP 2002) no LOAEC given.
Corrosive (irreversible effect)	Yes	ECHA (2013)
Respiratory sensitiser	NDF	
Hazard Band 2		
Harmful chronic/repeat dose toxicity • oral LOAEL > 10 mg/kg and ≤ 100 mg/kg/d • dermal LOAEL > 20 mg/kg/d and ≤ 200 mg/kg/d • inhalation (6-h/d) LOAEC > 50 mg/L ≤ 250 mg/L/d for gases, > 0.2 mg/L ≤ 1 .0 mg/L/d for vapours or > 0.02 mg/L ≤ 0.2 mg/L/d for dust/mists/fumes [3]	NDF	NOAEC for rats 30 mg/m^3 (20 ppm) (UNEP 2002) no LOAEC given.
Skin Sensitiser	No	ECHA (2013)
Hazard Band 1		
Acute Toxicity-Harmful • oral $LD_{50} > 300$ mg/kg ≤ 2000 mg/kg • dermal LD_{50} >1 000 mg/kg ≤ 2000 mg/kg; • inhalation LC_{50} (6 h/d) > 10 mg/L ≤ 20 mg/L for vapours) [3]	No	Aerosol: 46.5 mg/L (5 min) and 8.3 mg/L (30 min) Gas: 40,989 ppm (5 min) and 4,701 ppm (30 min) (ECHA 2013)
Irritant (reversible effect)	No	ECHA (2013)
Hazard Band 0 **All indicators outside criteria listed in Hazards 1-4**	No	
Physical Hazards		
Flammable potential	No	Reacts violently in contact with metals (UNEP 2002)
Explosive potential	No	Reacts violently in

		contact with metals (UNEP 2002)
Hazard Evaluation (highest band) not including physical hazards	3	
Uncertainty analysis /data confidence (out of 12 parameters)	9/12	**75%**

* Based on IMAP Framework [NICNAS (2013) Inventory Multi-tiered Assessment and Prioritisation (IMAP) Framework. National Industrial Chemicals Notification and Assessment Scheme. Department of Health and Aging, Canberra].

"[1]*Based on list of endocrine disrupting chemicals from the European Commission's Endocrine Disrupters website.*

[2]*milligrams per kilogram body mass (mg/kg) or milligrams per kilogram body mass per day (mg/kg/d).*

[3] *Based on GHS cut-offs for hazard classification. For chronic/repeat dose toxicity, GHS cut-offs are provided as guidance values (i.e. the dose/concentration at or below which significant health effects are observed)". (p 18, NICNAS 2013).*

Human Health Guidelines		
Media	**Concentration (mg/m^3; mg/L; mg/kg)**	**Reference**
Occupational Exposure Limits		
Air (OEL)		
8-h TWA	7.5 mg/m^3	HSIS (2013)
STEL	7.5 mg/m^3	ACGIH (2001) as cited in UNEP (2002)
Peak Limitation	NDF	
Environmental Exposure		
Air, ambient	NDF	
Air, indoor	NDF	
Water, potable	NDF	ADWG (2011)
Water, recreational	NDF	NEPM (1999)
Soil, residential	NDF	NEPM (1999)
Soil, commercial/industrial	NDF	NEPM (1999)

Footnotes:
OEL = Occupational Exposure Limit
TWA= 8-h Time-Weighted Average
STEL = (15 min) Short-term Exposure Limit
NDF – no data found within the limits of the search strategy

Qualifying Summary Comments

Hydrogen chloride gas and hydrochloric acid have the same CAS Registry number. Since the gas becomes the acid in aqueous systems and volatilization of the gas can occur from aqueous systems, it is often difficult to determine which is being considered in a specific item in the literature. Hydrogen chloride in either of its forms exhibits high levels of concern in relation to its irritant, corrosive and necrotic properties on the lung, eyes, skin and mucous membranes. These are acute or short-term effects of exposures to toxic concentrations.

Hydrogen chloride is not classifiable as to its carcinogenicity to humans, mutagenic activity, and reproductive and developmental effects, although the information about these is limited. Based on its acute toxicity via inhalation and its corrosive properties, hydrochloric acid falls in the Hazard Band category 3. In occupational settings, all direct contact with high concentration of hydrochloric acid should be avoided. If released to water, hydrogen chloride dissociates readily to form hydrochloric acid, decreasing the pH of the water. Hydrochloric acid is a strong acid; it reacts violently with oxidants forming toxic gas (chlorine) as well as bases and is corrosive. Hydrochloric acid attacks many metals in the presence of water forming flammable/explosive gas (hydrogen).

It is of concern for occupational settings and in cases where large scale spills may occur of the concentrated form. In the environment it may acidify waters if sufficient discharge occurs. All of these settings require appropriate management measures.

References

ADWG (Australian Drinking Water Guidelines) 2011, National Health and Medical Research Council (NHMRC) Australian Drinking Water Guidelines 6, Available at: http://www.awa.asn.au/uploadedFiles/NHMRC_aust_drinking_water_guidelines.pdf. [Accessed 16 December 2013]

EC (European Commission) 2000, Towards the establishment of a priority list of substances for further evaluation of their role in endocrine disruption Final Report (Incorporating corrigenda to final report dated 21 June 2000) – Annex 10: List of 564 substances with their selection criteria Available at: http://ec.europa.eu/environment/archives/docum/pdf/bkh_annex_10.pdf. [Accessed 16 December 2013]

ECHA (European Chemical Agency) 2013, Registered Substances List Dossier for hydrochloric acid (CAS no 7647-01-0). Available at: http://echa.europa.eu/web/guest/information-on-chemicals/registered-substances . [Accessed 16 December 2013]

HSDB (Hazardous Substance Data Bank) 2011, Hydrogen Chloride CASRN: 7647-01-0, Toxicology Data Network (TOXNET), Available: at http://toxnet.nlm.nih.gov/ . [Accessed 16 December 2013]

HSIS (Hazardous Substance Information System) 2013, Search Hazardous Substances for Hydrogen Chloride, Available at http://hsis.safeworkaustralia.gov.au/HazardousSubstance . [Accessed 16 December 2013].

IARC (International Agency for Research on Cancer) 2013, Agents Classified by the *IARC Monographs*, Volumes 1–109, Available at: http://monographs.iarc.fr/ENG/Classification/ClassificationsAlphaOrder.pdf . [Accessed 16 December 2013]

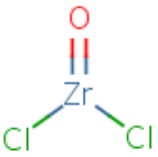
IPCS (International Program on Chemical Safety) 2000, Hydrogen Chloride information card, INCHEM, Available at: http://www.inchem.org/documents/icsc/icsc/eics0163.htm . [Accessed 16 December 2013].

NEPM: (National Environment Protection Measure) 1999, Available at: http://www.comlaw.gov.au/Details/F2013C00288/Download. [Accessed 16 December 2013]

UNEP (United Nations Environment Programme) 2002, Hydrogen Chloride CAS N°: 7647-01-0 SIDS (Screening Information Data Sets) Initial Assessment Report, UNEP Publications, Available at: http://www.inchem.org/documents/sids/sids/7647010.pdf, [Accessed 16 December 2013].

Created by:	JB	07/07/2011
	JC	16/12/2013 (Rev 2)
Reviewed and edited by	LT	09/07/2011 (Rev0) 22/08/2012 (Rev1)
Reviewed and edited by	PDM	13/01/2014 (Rev2)

Project number: 127666004
Project name: Hydraulic Stimulation Chemicals Assessment, Southwest Queensland
Client name: Santos Ltd

Name	Zirconium dichloride oxide
Synonyms	Dichlor(oxo)zirconium, Zirconyl Chloride, zirconium oxychloride, zirconyl chloride, zirconium oxide chloride
CAS number	7699-43-6
Molecular formula	Cl_2OZr
Molecular Structure	

Overview	References
Zirconium dichloride oxide is a crystalline solid at 20 degrees C and 1013 hPa. It is very soluble in water (>10 000mg/L) and instantaneous hydrolysis of zirconium dichloride oxide occurs under neutral condition. It is not possible to determine the melting point of zirconium dichloride oxide solid as the substance decomposes to zirconium dioxide with the loss of water and hydrogen chloride. Decomposition is indicated by a significant weight loss starting at ca 60 °C.	ECHA, 2013
Zirconium dichloride oxide is used in textile (to prepare high quality pigment toner), cosmetic, and grease additive; water repellent; oil field acidizing aid. It is also used to make other zirconium compounds and in preparation of body deodorants and antiperspirant preparation.	HSDB, 2008

Human Health Toxicity Summary	Reference
Carcinogenicity Not classified by IARC. Data lacking for classification by ECHA. Not classifiable as a human carcinogen.	IARC 2013 ECHA, 2013 HSDB, 2008
Mutagenicity/Genotoxicity Not classified as a mutagen.	ECHA, 2013
Reproductive Toxicity Not classified as a reproductive toxicant.	ECHA, 2013
Developmental Toxicity/Teratogenicity No data found.	
Endocrine Disruption Not listed as an endocrine disruptor.	EC 2000
Neurotoxicity	

No data found.	
Acute Toxicity (oral, dermal, inhalation) Not classified as acutely toxic via oral exposure Two LD50 studies are presented on ECHA 2013: Rat, oral (gavage) LD50: ~ 3500 mg/kg (data reliability – reliable with restrictions). The time of death varied from a few hours to a few days following the exposure to the test substance. Animals exposed to the test substance showed a progressive depression and decrease in activity until death occurred. Rat, oral (gavage) LD50: 4330 mg/kg (data reliability – not reliable). Some animals died during the 24 hours following administration. For the survivors, the behavior is characterized by poor appetite, progressive weight loss, prostrate animal, dull coat. At autopsy are often found gastrointestinal necrosis and sometimes lung necrosis. Acute poisoning from ingestion of Zr oxychloride resulted in the following symptoms: burning pain in the mouth and throat, vomiting, watery or bloody diarrhea, tenesmus, retching, haemolysis, haematuria, anuria, liver damage with jaundice, convulsions, hypotension, and collapse. Through its hydrolysis to hydrochloric acid, zirconium oxychloride can irritate the respiratory tract and other superficial surfaces of the body on exposure.	ECHA, 2013 HSDB, 2006
Chronic/repeat dose toxicity (oral, dermal, inhalation) Inhalation of 11.3 mg/m^3 zirconium dichloride oxide for 60 days produced no significant changes in animals in mortality rate, growth, biochemistry, hematology values or histopathology. On two animals (cats) among 124 were found testicular atrophy. (data reliability - reliable with restrictions)	ECHA, 2013
Sensitisation of the skin or respiratory system No data found(NDF)	
Corrosion (irreversible and reversible)/irritation of the skin or eye Releases hydrogen chloride in contact with water leading to a pH <2. It is therefore proposed to follow the classification of hydrogen chloride dissolved in water (hydrochloric acid) for corrosion. Therefore classified as skin corrosive category 1 B – H314 – GHS05. Causes severe skin burn and eye damage Eye damage category 1 according to the criteria of the CLP Regulation. Xi; R41 Risk of serious damage to eyes C; R34 Causes burns.	ECHA, 2013
Flammable Potential Not classified as flammable	ECHA, 2013
Explosive Potential Not classified as explosive	ECHA, 2013

Toxicity Values	Value	Reference
Human Toxicity Data		
Acute Toxicity		
LD_{50}	NDF	
LC_{50}	NDF	
High Chronic/Repeat Dose Toxicity		
Animal Toxicity Data		
Acute Toxicity		
LD_{50}		
Rat, oral (gavage)	4330 mg/kg bw	ECHA 2013
Rat, oral (gavage)	~ 3500 mg/kg bw	ECHA 2013
Rat, dermal	NDF	
Rabbit, dermal	NDF	
LOAEL	NDF	
LOAEC	NDF	
LC_{50}		
Rat		
High Chronic/Repeat Dose Toxicity		
LOAEL	NDF	
LOAEC	NDF	
NOAEL, inhalation, 60 day (6 hours/day, 5 days/week) (cat, dog, guinea pig, rabbit, rat)	11.3 mg/m^3	ECHA 2013

Footnotes:
LD_{50} – lethal dose for 50% of experimental population
LC_{50} – lethal air concentration for 50% of experimental population
LOAEL – Lowest Observed Adverse Effect Level
LOAEC – Lowest Observed Adverse Effect Concentration

Human Health Toxicity Ranking*		
	Hazard data	**Comment**
Hazard Band 4		
Carcinogenicity	NDF	
Mutagenicity/Genotoxicity	No	
Reproductive Toxicity	No	
Developmental Toxicity/ Teratogenicity	NDF	
Endocrine Disruption[1]	No	
Neurotoxicity[2]	NDF	
Hazard Band 3		
Acute Toxicity (oral, dermal or inhalation) Very Toxic/Toxic • oral LD_{50} ≤ 300 mg/kg[3] • dermal LD_{50} ≤ 1000 mg/kg • inhalation LC_{50} ≤ 10 mg/L[4] (or mg/m^3) (vapour)	No	
High Chronic/repeat dose toxicity • oral LOAEL ≤ 10 mg/kg/d[3]; • dermal LOAEL ≤ 2 0 mg/kg/d; • inhalation LOAEC (6 h/d) ≤ 50 ppm/d for gases, ≤ 0.2 mg/L/d for vapours or ≤ 0.02 mg/L/d for dust/mists/fumes[4]	No	
Corrosive (irreversible damage)	Yes	Skin corrosive classification: H314
Respiratory sensitiser	NDF	
Hazard Band 2		
Harmful chronic/repeat dose toxicity • oral LOAEL > 10 mg/kg and ≤ 100 mg/kg/d • dermal LOAEL > 20 mg/kg/d and ≤ 200 mg/kg/d • inhalation (6-h/d) LOAEC > 50 mg/L ≤ 250 mg/L/d for gases, > 0.2 mg/L ≤ 1 .0 mg/L/d for vapours or > 0.02 mg/L ≤ 0.2 mg/L/d for dust/mists/fumes[4]	No	
Skin Sensitiser	NDF	
Hazard Band 1		
Acute Toxicity-Harmful • oral LD_{50} > 300 mg/kg ≤ 2000 mg/kg • dermal LD_{50} >1 000 mg/kg ≤ 2000 mg/kg; • inhalation LC_{50} (6 h/d) > 10 mg/L ≤ 20 mg/L for vapours)[4]	No	
Irritant (reversible damage)		
Hazard Band 0 **All indicators outside criteria listed in Hazards 1-4**		
Physical Hazards		
Flammable potential	No	
Explosive potential	No	
Hazard Evaluation (highest band) not including physical hazards	3	
Uncertainty analysis /data confidence		

* Based on IMAP Framework [NICNAS (2013) Inventory Multi-tiered Assessment and Prioritisation (IMAP) Framework. National Industrial Chemicals Notification and Assessment Scheme. Department of Health and Aging, Canberra].

"[1]Based on list of endocrine disrupting chemicals from the European Commission's Endocrine Disrupters website.

[2] Based on list of neurotoxic chemicals from US Agency for Toxic Substances and Disease Registry (ATSDR).

[3] milligrams per kilogram body mass(mg/kg) or milligrams per kilogram body mas per day (mg/kg/d)

[4] Based on GHS cut-offs for hazard classification. For chronic/repeat dose toxicity, GHS cut-offs are provided as guidance values (i.e. the dose/concentration at or below which significant health effects are observed"). (p 18, NICNAS 2013).

Human Health Guidelines		
Media	**Concentration (mg/m^3; mg/L; mg/kg)**	**Reference**
Occupational Exposure Limits		
Air (OEL)		
8-h TWA	NDF	
STEL	NDF	
Peak Limitation	NDF	
Environmental Exposure		
Air, ambient	NDF	
Air, indoor	NDF	
Water, potable	NDF	
Water, recreational	NDF	
Soil, residential	NDF	
Soil, commercial/industrial	NDF	

Footnotes:

OEL = Occupational Exposure Limit

TWA= 8 h Time-Weighted Average

STEL = (15 min) Short-term Exposure Limit

Qualifying Summary Comments

Zirconium dichloride oxide has a low order of acute toxicity. It is conservatively classified as a skin and eye corrosion hazard on the expectation of release of hydrogen chloride in contact with moisture. The repeat dose toxicity, carcinogenicity, reproductive toxicity and mutagenicity of zirconium dichloride oxide has not been well characterised. Given the possible corrosivity in contact with moisture, zirconium dichloride oxide was categorised in Hazard Band 3.

References and Notes

European Chemicals Agency (ECHA), 2013. Registered Substances List Dossier for zirconium dichloride oxide. Available at http://echa.europa.eu/web/guest/information-on-chemicals/registered-substances [Accessed 1 November 2013].

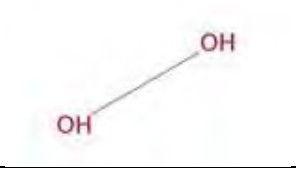
European Commission (EC) (2000). Towards the establishment of a priority list of substances for further evaluation of their role in endocrine disruption, preparation of a candidate list of substances as a basis for priority setting, Final Report (Incorporating corrigenda to final report dated 21 June 2000).

Hazardous Substance Data Base (HSDB), 2006. Zirconium Oxychloride. U.S. National Library of Medicine, National Institute of Health, Department of Health and Human Services, U.S. Government. Last date of revision: 14/06/2006.

NDF - No data found within the limits of the search strategy.

Created by:	OH/MGT	Date 1/11/2013
Reviewed and edited by:	JF	Date and Revision 8/11/13

Project number: 127666004
Project name: Hydraulic Stimulation Chemicals Assessment, Southwest Queensland
Client name: Santos Ltd

Name	Hydroxide peroxide (impurity)
Synonyms	
CAS number	7722-84-1
Molecular formula	H_2O_2
Molecular Structure	

Overview	Reference
Hydrogen peroxide is a colourless and odourless liquid which is exclusively produced and marketed as an aqueous solution of concentrations between 30 to 90 % w/w. It is produced in moderately high volume and is widely used (estimated 670 000 t/annum used in Europe in 1995) The uses of hydrogen peroxide depend on its concentration. Less concentrated solutions of hydrogen peroxide are used in bleaching hair solutions, contact lenses solutions, chlorine free bleaches, fabric stain removers. More concentrated solutions are used as blenching and oxidising agents or as rocket fuel. Hydrogen peroxide is also used as an oxidant in the treatment of drinking water.	ADWG (2011); ECHA (2013); IPCS (2006); SIDS (1999).

Human Health Toxicity Summary	Reference
Carcinogenicity Hydrogen peroxide is not classifiable as to its carcinogenicity (Group 3) to humans.	IARC (2013)
Mutagenicity/Genotoxicity ECHA has not reported this substance to be mutagenic or genotoxic. The genetic toxicity classification of hydrogen peroxide is based on a study of mammalian cell mutagenicity with metabolic activation (S9) which produced negative results. In addition, an *in vivo* study where a hydrogen peroxide solution administered to mice via the intra-peritoneal route prior to micronucleus testing showed that hydrogen peroxide did not have a genotoxic potential under the experimental conditions of this test. However, other mammalian cell studies showed positive results but without metabolic activation. It is inferred that the genetic toxicity classification was based on the aforementioned in vitro and in vivo studies.	ECHA (2013)
Reproductive Toxicity A 90-day drinking water study with mice did not report effects associated with reproductive toxicity.	SIDS (1999)
Developmental Toxicity/Teratogenicity NDF.	ECHA (2013)
Endocrine Disruption Not listed as an endocrine disruptor according to the list of endocrine disrupting chemicals from the European Commission .	EC (2002)
Acute Toxicity (oral, dermal, inhalation)	ECHA

ECHA has reported that this substance is harmful if swallowed (Acute Tox. 4 H302) or inhaled (Acute Tox. 4 H332) (as per the GHS classification) .ECHA has not reported this substance to be as acutely toxic via dermal route. Dermal acute toxicity data exceeds the threshold established in Hazard Band 1. ECHA has also reported that this substance may cause respiratory irritation (STOT Single Exp. 3 H335). This is based on inhalation exposure studies in rats with 50% solution hydrogen peroxide.	(2013)
Chronic/repeat dose toxicity (oral, dermal, inhalation) Not classified as chronic toxic.	ECHA (2013)
Sensitisation of the skin or respiratory system Not classified as a sensitiser to the skin or respiratory system.	ECHA (2013)
Corrosion (irreversible and reversible)/irritation of the skin or eye ECHA has reported that this substance causes severe burns and eye damage (Skin Corr. 1A H314 as per the GHS classification) However, the irritation and corrosive potentials of this substance vary with its concentration. Three different concentrations of solution of hydrogen peroxide (10%, 35% and 49.2%) were tested in New Zealand White rabbits. These studies concluded 10% solution of hydrogen peroxide was not irritating to rabbit skin, 35% aqueous solution of hydrogen peroxide was judged to be moderately irritating to the rabbit's skin but non-corrosive within 48h of dosing and 49.2 % solution of hydrogen peroxide is highly irritating to the rabbit's skin. This suggests that the classification reflects higher concentration solutions.	ECHA (2013)

Physical Hazards	Reference
Flammable Potential Not classified as flammable.	ECHA (2013).
Explosive Potential Not classified as explosive. As a potent oxidising agent it may cause fire and explosion as a result of contact with other substances (incompatibilities).	ECHA (2013).

Toxicity Values	Value	Reference
Human Toxicity Data		
Acute Toxicity		
	NDF	
High Chronic/Repeat dose Toxicity		
	NDF	
Animal Toxicity Data		
Acute Toxicity		
LD_{50}		
Rat, oral	805 mg/kg (70% w/w solution)	ECHA (2013)
Rat, dermal	NDF	
Rabbit, dermal	> 2000 mg/kg	ECHA (2013)
LOAEL	NDF	
LC_{50}		
Rat	> 170 mg/m^3 (50% w/w	ECHA (2013)

	solution)	
High Chronic/Repeat dose Toxicity		
LOAEL (mouse, oral)	300 ppm	ECHA (2013)
LOAEC (rat)	14.6 mg/m^3 6h/day	ECHA (2013)
NOAEC (rat)	2.9 mg/m^3 6h/day	ECHA (2013)

Footnotes:
LD_{50} – lethal dose for 50% of experimental population
LC_{50} – lethal air concentration for 50% of experimental population
LOAEL – Lowest Observed Adverse Effect Level
LOAEC – Lowest Observed Adverse Effect Concentration
NOAEL – No Observed Adverse Effect Level

Human Health Toxicity Ranking*		
	Hazard data	**Comment**
Hazard Band 4		
Carcinogenicity	NDF	IARC Group 3
Mutagenicity/Genotoxicity	No	ECHA (2013)
Reproductive Toxicity	No	ECHA (2013)
Developmental Toxicity/ Teratogenicity	No	ECHA (2013)
Endocrine Disruption[1]	No	EC (2000)
Hazard Band 3		
Acute Toxicity (oral, dermal or inhalation) Very Toxic/Toxic • oral LD_{50} ≤ 300 mg/kg[2] • dermal LD_{50} ≤ 1000 mg/kg • inhalation LC_{50} ≤ 10 mg/L[3] (or mg/m3) (vapour)	No	ECHA (2013)
Possible carcinogenicity, mutagenicity, reproductive or High Chronic/repeat dose toxicity • oral LOAEL ≤ 10 mg/kg/d[3]; • dermal LOAEL ≤ 2 0 mg/kg/d; • inhalation LOAEC (6 h/d) ≤ 50 ppm/d for gases, ≤ 0.2 mg/L/d for vapours or ≤ 0.02 mg/L/d for dust/mists/fumes[3]	No	ECHA (2013)
Corrosive (irreversible damage)	Yes	ECHA (2013)
Respiratory sensitiser	No	ECHA (2013)
Hazard Band 2		
Harmful chronic/repeat dose toxicity • oral LOAEL > 10 mg/kg and ≤ 100 mg/kg/d • dermal LOAEL > 20 mg/kg/d and ≤ 200 mg/kg/d • inhalation (6-h/d) LOAEC > 50 mg/L ≤ 250 mg/L/d for gases, > 0.2 mg/L ≤ 1 .0 mg/L/d for vapours or > 0.02 mg/L ≤ 0.2 mg/L/d for dust/mists/fumes [3]	No	ECHA (2013)
Skin Sensitiser		ECHA (2013)
Hazard Band 1		
Acute Toxicity-Harmful • oral LD_{50} > 300 mg/kg ≤ 2000 mg/kg • dermal LD_{50} >1 000 mg/kg ≤ 2000 mg/kg; • inhalation LC_{50} (6 h/d) > 10 mg/L ≤ 20 mg/L for vapours)[3]	Yes	ECHA (2013)
Irritant (reversible damage)	No	ECHA (2013)
Hazard Band 0 **All indicators outside criteria listed in Hazards 1-4**		
Physical Hazards		
Flammable potential	No	ECHA (2013)
Explosive potential	Yes	Based on oxidising potential and incompatibilities
Hazard Evaluation (highest band) not including physical hazards	**Band 3**	
Uncertainty analysis /data confidence	12/13	**92.3%**

* Based on IMAP Framework [NICNAS (2013) Inventory Multi-tiered Assessment and Prioritisation (IMAP) Framework. National Industrial Chemicals Notification and Assessment Scheme. Department of Health and Aging, Canberra].

"[1]Based on list of endocrine disrupting chemicals from the European Commission's Endocrine Disrupters website.

[2]milligrams per kilogram body mass(mg/kg) or milligrams per kilogram body mas per day (mg/kg/d)

[3] Based on GHS cut-offs for hazard classification. For chronic/repeat dose toxicity, GHS cut-offs are provided as guidance values (i.e. the dose/concentration at or below which significant health effects are observed"). (p 18, NICNAS 2013).

Human Health Guidelines		
Media	**Concentration (mg/m^3; mg/L; mg/kg)**	**Reference**
Occupational Exposure Limits		
Air (OEL)		
8-h TWA	1.4 mg/m^3	HSIS, 2013
STEL	NDF	
Peak Limitation	NDF	
Environmental Exposure		
Air, ambient	NDF	NEPM, 2003
Air, indoor	NDF	WHO, 2010
Water, potable	Used as an oxidant in the treatment of drinking water (often in conjunction with ozone)	ADWG, 2011
Water, recreational	NDF	NEPM, 1999 - amended
Soil, residential	NDF	NEPM, 1999 - amended
Soil, commercial/industrial	NDF	NEPM, 1999 - amended

Footnotes:

OEL = Occupational Exposure Limit

TWA= 8 h Time-Weighted Average

STEL = (15 min) Short-term Exposure Limit

NDF - No data found within the limits of the search strategy.

Qualifying Summary Comments

Hydrogen peroxide is a colourless and odourless liquid but exhibits strong oxidising and thus corrosive properties. These properties result in a potential to cause severe eye irritation and respiratory irritation. The corrosive nature results in severe health effects if swallowed or inhaled. Hydrogen peroxide is not classified as a carcinogen, mutagen or reproductive toxicant but on the basis of severe burns and eye damage it is categorised as Hazard Band 3. The main concern for this chemical thus resides in its corrosive properties, however, hydrogen peroxide breaks down quickly and subsequently the public health issues will be limited to occupational exposures to high concentration solutions of hydrogen peroxide or where large scale spills may result in exposure to members of the public.

References

ADWG (2011) Australian Drinking Water Guidelines. National Health and Medical Research Council. Available from http://www.nhmrc.gov.au/_files_nhmrc/publications/attachments/eh52_aust_drinking_water_guidelines.pdf

ECHA (2013) European Chemicals Agency. Registered Chemical Substances Search. Available at http://echa.europa.eu/web/guest/information-on-chemicals/registered-substances. [Accessed 16 October and 1 November 2013]

EC (2000) European Commission. Towards the establishment of a priority list of substances for further evaluation of their role in endocrine disruption, preparation of a candidate list of substances as a basis for priority setting, Final Report (Incorporating corrigenda to final report dated 21 June 2000).

HSIS (2013) Hazardous Substances Information System Exposure Standards. Available at http://hsis.safeworkaustralia.gov.au/ExposureStandards/Details?exposureStandardID=325 . [Accessed 16 October 2013].

IARC (2013) International Agency for Research on Cancer Agents classified by IARC Monographs, Volumes 1-108. Available at http://monographs.iarc.fr/ENG/Classification/ClassificationsGroupOrder.pdf.

IPCS (1999 International Program on Chemical Safety Hydrogen peroxide (Group 3) 5. Summary of Data reported and Evaluation. Available at http://www.inchem.org/documents/iarc/vol71/023-hydrogenper.html [Accessed 1 November 2013].

IPCS (2006) International Program on Chemical Safety Hydrogen peroxide summary. Available at http://www.inchem.org/documents/pims/chemical/pim946.htm . [Accessed 16 October 2013].

NEPM (2003) National Environment Protection (Ambient Air Quality) Measure
NEPM (1999 - amended) National Environment Protection (Assessment of Site Contamination) Measure 1999.

SIDS (1999) SIDS (Screen Information Dataset) Initial Assessment Profile of hydrogen peroxide. Organization for Economic Cooperation and Development (OECD) High Production Volume (HPV) Existing Chemicals Database. Available at http://webnet.oecd.org/Hpv/UI/handler.axd?id=54ceac36-34f1-4ce4-a1b4-0accb92f9d01 [Accessed 1 November 2013].

WHO (2011) World Health Organisation Guidelines for Indoor Air Quality: Selected Pollutants.

NDF – No data found within the limits of the search strategy

Created by:	JC	Date: 16/10/2013
Reviewed and edited by:	LT	Date 23/10/2013 Rev0

Project number: 127666004
Project name: Hydraulic Stimulation Chemicals Assessment, Southwest Queensland
Client name: Santos Ltd

Name	Nitrogen, liquid form
Synonyms	Numerous synonyms including azote, nitrogen, nitrogen gas, nitrogen-14, nitrogeno, diatomic, diazyne
CAS number	7727-37-9
Molecular formula	N_2
Molecular Structure	

Overview	References
Nitrogen is an inert, odourless, colourless gas, under standard temperature and pressure. At extremely low temperatures, nitrogen gas condenses to form liquid nitrogen. Liquid nitrogen is stored under pressure in cylinders to prevent rapid evaporation back to nitrogen gas. Nitrogen has a melting point of -210°C and a boiling point of –195.8°C. Nitrogen is thermodynamically stable and only reacts under ambient conditions in the presence of a catalyst (e.g. nitrogen fixing bacteria, lightning, etc.). Nitrogen is considered non-flammable, non-explosive and non-oxidising.	ECHA 2008
Nitrogen forms 78.1% v/v of the earth's atmosphere. The majority of Earth's organisms are exposed to this concentration of atmospheric nitrogen for their entire life cycle. Therefore, under standard temperature and pressure nitrogen does not exhibit any adverse toxicological, metabolic or environmental effects. However, when the concentration of atmospheric nitrogen increases (e.g. in confined spaces) it can become asphyxiating (through displacement of ambient oxygen.	ECHA 2008
Nitrogen is widely used and is employed for such uses as an insecticide, medical aid and food additive. As a broad-spectrum insecticide it is used to eradicate wood destroying insects, stored product pests, textile pests and other arthropods. Nitrogen acts as a biocide through inhalation by depleting oxygen which the target insects require for respiration and does not directly affect the insect's physiology.	ECHA 2008

Human Health Toxicity Summary	Reference
Carcinogenicity IARC has not evaluated nitrogen for its carcinogenicity.	IARC
Mutagenicity/Genotoxicity NDF.	
Reproductive Toxicity NDF.	
Developmental Toxicity/Teratogenicity NDF.	
Endocrine Disruption The European Commission in examining endocrine disruptors has not evaluated nitrogen.	EC 2000
Neurotoxicity NDF.	

Acute Toxicity (oral, dermal, inhalation) Increased concentrations of nitrogen in the atmosphere can lead to asphyxiation. This is particularly relevant when used in a confined space. Due to the very cold temperature of liquid nitrogen, it is irritating to the eyes and skin. Contact may cause frostbite and severe burns. Exposure may also produce discomfort in breathing and can provoke an asthma attack in susceptible individuals.	ECHA 2008 NTC 2011, SA 1997
Chronic/repeat dose toxicity (oral, dermal, inhalation) NDF.	
Sensitisation of the skin or respiratory system NDF.	
Corrosion (irreversible)/irritation (reversible) effects on the skin or eye Contact with liquid nitrogen may cause frostbite and severe burns.	NTC 2011, SA 1997

Physical Hazards	Reference
Flammable Potential Nitrogen gas is considered non-flammable. Release of nitrogen gas at very low temperatures can lead to the condensation of liquid oxygen, which can increase the combustibility of many materials (e.g. solvents, hydrocarbons).	ECHA 2008 SA 1997
Explosive Potential Nitrogen gas is considered non-explosive.	ECHA 2008

Toxicity Values	Value	Reference
Animal Toxicity Data		
Acute Toxicity		
LD_{50}		
Rat, oral	NDF.	
LC_{50}		
Rat	NDF.	
High Chronic/Repeat Dose Toxicity		
LOAEL	NDF.	

Footnotes:
LD_{50} – lethal dose for 50% of experimental population
LC_{50} – lethal air concentration for 50% of experimental population
LOAEL – Lowest Observed Adverse Effect Level
LOAEC – Lowest Observed Adverse Effect Concentration
NDF – No data found within the limits of the search strategy

Human Health Toxicity Ranking*		
	Hazard data	**Comment**
Hazard Band 4		
Carcinogenicity (IARC Group 1 or 2A)	NDF	Not currently evaluated by IARC.
Mutagenicity/Genotoxicity (GHS Category 1A and 1B)	NDF	
Reproductive Toxicity/Developmental toxicity (GHS Category 1, 1A and 1B)	NDF	
Endocrine Disruption[1]	NDF	Not currently evaluated by EC.
Hazard Band 3		
Carcinogenicity (IARC Group 2B)	NDF	
Mutagenicity/Genotoxicity (GHS Category 2)	NDF	
Reproductive Toxicity/Developmental toxicity (GHS Category 2)	NDF	
Acute Toxicity (oral, dermal or inhalation) Very Toxic/Toxic • oral LD_{50} ≤ 300 mg/kg[3] • dermal LD_{50} ≤ 1000 mg/kg • inhalation LC_{50} ≤ 10 mg/L[4] (or mg/m^3) (vapour)	NDF	
Possible carcinogenicity, mutagenicity, reproductive or High Chronic/repeat dose toxicity • oral LOAEL ≤ 10 mg/kg/d[3]; • dermal LOAEL ≤ 2 0 mg/kg/d; • inhalation LOAEC (6 h/d) ≤ 50 ppm/d for gases, ≤ 0.2 mg/L/d for vapours or ≤ 0.02 mg/L/d for dust/mists/fumes[4]	NDF	
Corrosive (irreversible effect)	Yes	Potential to cause frostbite due to extremely low temperatures when in liquid form
Respiratory sensitiser	NDF	
Hazard Band 2		
Harmful chronic/repeat dose toxicity • oral LOAEL > 10 mg/kg and ≤ 100 mg/kg/d • dermal LOAEL > 20 mg/kg/d and ≤ 200 mg/kg/d • inhalation (6-h/d) LOAEC > 50 mg/L ≤ 250 mg/L/d for gases, > 0.2 mg/L ≤ 1 .0 mg/L/d for vapours or > 0.02 mg/L ≤ 0.2 mg/L/d for dust/mists/fumes[4]	NDF	
Skin Sensitiser	NDF	
Hazard Band 1		
Acute Toxicity-Harmful • oral LD_{50} > 300 mg/kg ≤ 2000 mg/kg • dermal LD_{50} >1 000 mg/kg ≤ 2000 mg/kg; • inhalation LC_{50} (6 h/d) > 10 mg/L ≤ 20 mg/L for vapours)[4]	NDF	
Irritant (reversible effect)	NDF	
Hazard Band 0 **All indicators outside criteria listed in Hazards 1-4**	No	
Physical Hazards		
Flammable potential	No	
Explosive potential	No	
Hazard Evaluation (highest band) not including physical hazards	Hazard Band 3	Corrosive in liquid form
Uncertainty analysis /data confidence (out of 12	1/12	**8%**

parameters)		

* Based on IMAP Framework [NICNAS (2013) Inventory Multi-tiered Assessment and Prioritisation (IMAP) Framework. National Industrial Chemicals Notification and Assessment Scheme. Department of Health and Aging, Canberra].

"[1]Based on list of endocrine disrupting chemicals from the European Commission's Endocrine Disrupters website.

[2] Neurotoxicity based on REACH assessments.

[3] milligrams per kilogram body mass (mg/kg) or milligrams per kilogram body mass per day (mg/kg/d)

[4] Based on GHS cut-offs for hazard classification. For chronic/repeat dose toxicity, GHS cut-offs are provided as guidance values (i.e. the dose/concentration at or below which significant health effects are observed"). (p 18, NICNAS 2013).

Human Health Guidelines		
Media	**Concentration (mg/m^3; mg/L; mg/kg)**	**Reference**
Occupational Exposure Limits		
Air (OEL)		
8-h TWA	NDF	
STEL	NDF	
Peak Limitation	NDF	
Environmental Exposure		
Air, ambient	NDF	
Air, indoor	NDF	
Water, potable	NDF	
Water, recreational	NDF	
Soil, residential	NDF	
Soil, commercial/industrial	NDF	

Footnotes:

OEL = Occupational Exposure Limit

TWA= 8 h Time-Weighted Average

STEL = (15 min) Short-term Exposure Limit

Concluding Summary Comments

Nitrogen is an inert gas at standard temperature and pressure, which forms 78.1 % v/v of the Earth's atmosphere. Nitrogen is used as an insecticide and food additive. At extremely low temperatures (–195.8°C) nitrogen gas, will condense to form liquid nitrogen. The risks associated with liquid nitrogen arise from the physical conditions (i.e. extremely low temperature and high pressure) under which it exists. These include the potential for frostbite and burns. In addition, the release of liquid nitrogen to atmosphere can lead to the condensation of oxygen, which presents another physical fire and explosion risk as it creates a localised enrichment of oxygen which may ignite. Nitrogen gas can also act as an asphyxiant by displacing oxygen in confined spaces.While liquid nitrogen has been grouped in Hazard Band 3, the risks are limited to the occupational setting and also to cases of large scale emergency environmental spills or releases. While it is expected that liquid nitrogen would be the dominant form used in stimulation activities it would rapidly convert to gaseous form and be lost to atmosphere with no residual effects apart from the acute effects described above.

References

ECHA (2008). *Biocide Assessment Report: Nitrogen Product-type 18 (Insecticides) 2.1.2.1.* European Chemicals Agency , an Agency of the European Union. Available at: http://dissemination.echa.europa.eu/Biocides/ActiveSubstances/0046-18/0046-18_Assessment_Report.pdf, Accessed 8 January 2014.

EC (2000). *Towards the establishment of a priority list of substances for further evaluation of their role in endocrine disruption, preparation of a candidate list of substances as a basis for priority setting, Final Report* (Incorporating corrigenda to final report dated 21 June 2000) European Commission. Available at http://ec.europa.eu/environment/chemicals/endocrine/strategy/substances_en.htm#priority_list, Accessed 8 January 2014

IARC, (2013). Agents Classified by the *IARC Monographs*, Volumes 1–108. International Agency for Research on Cancer , WHO. Available at http://monographs.iarc.fr/ENG/Classification/index.php., Accessed January 2014.

NTC, (2011). *Australian Dangerous Goods Code for the Transport of Dangerous Goods by Road and Rail*, Version 7. National Transport Commission. Available at http://www.ntc.gov.au/filemedia/Publications/ADG7October2011.pdf, Accessed 8 January 2014.

SA (1997). *AS 1894 (1997): The storage and handling of non-flammable cryogenic & refrigerated liquids*. Standards Australia, Available at: http://www.standards.org.au/Pages/default.aspx, Accessed 8 January 2014

Created by:	MGT	Date: 08/01/2014
Reviewed by:	LT	Date: 14/01/2014

Project number: 127666004
Project name: Hydraulic Stimulation Chemicals Assessment, Southwest Queensland
Client name: Santos Ltd

Name	Sodium Thiosulphate
Synonyms	Disodium thiosulphate, sodium thiosulphate, Ametox, sodium hyposulfite, S-Hydril, Sodothiol, sodium thiosulphate pentahydrate, thiosulfuric acid, disodium salt
CAS number	7772-98-7
Molecular formula	$H_2O_3S_2.2Na$
Molecular Structure	

Overview	References
Sodium thiosulphate can be present in an anhydrous or pentahydrate form. It is water soluble solid.	SWA, 2013
Sodium thiosulphate is used as a stabilizer of potassium iodide salt, as a sequestrant in alcoholic beverages, and as an additive in food packaging materials. It is also used to remove chlorine from solution; as "antichlor" in bleaching of paper pulp; fixer in photography; mordant in dyeing & printing textiles; reducer in chrome dyeing, manufacturing of leather; extracting of silver from ores; bleaching bone, straw, ivory; reagent in analytical chemistry; antidote (cyanide poisoning).	ECHA, 2013 HSDB, 2013
Sodium thiosulphate is a normal constituent of human body fluids and is excreted in the urine of mammals. In quantitative studies it has been demonstrated that 2 to 17 milligrams (mg) of thiosulphate sulfur occur in 24-hour urine specimens of healthy young adults. Variations in excretion of thiosulphate are related to the extent of protein metabolism, activity of the intestinal flora, and the sulfur-amino acid content of the diet. The sulfur-containing amino acids of dietary protein are the source of the endogenous thiosulphate pool.	CCOHS, 2013
Orally administered thiosulphate that is absorbed from the gastrointestinal tract is excreted in the urine unchanged or after oxidation to sulfate. Uo to 70% of an oral dose of sodium thiosulphate is considered to be absorbed from the gastrointestinal tract of humans and the remainder to be excreted in the faeces.	
Sodium thiosulphate is not classified as a hazardous substance according to the criteria of the Global Harmonised Scheme (GHS) for classifying hazardous substances and is not listed as a hazardous substance on the Australian Hazardous Substance Information Service.	
High concentrations of dust may result in irritation to eyes and respiratory tract.	

Human Health Toxicity Summary	Reference
Carcinogenicity Not classed as carcinogenic by ACGIH, IARC, OSHA or NTP.	CCOHS, 2013
Mutagenicity/Genotoxicity Not known to cause heritable genetic damage.	Schlumberger, 2013

There was no evidence of chromosomal damage in a bone-marrow assay in rats and mice following single oral doses of 50 to 5000 mg/kg of sodium thiosulphate. In one experiment no statistically significant increases in mutant frequency were observed following treatment with ammonium thiosulphate at any concentration tested.	OECD, 2004 ECHA, 2013
Reproductive Toxicity Not known to adversely affect reproductive functions and organs.	Schlumberger, 2013
Developmental Toxicity/Teratogenicity Not known to cause birth defects or have a deleterious effect on a developing fetus. Up to 550 mg/kg bw/d of sodium thiosulphate to pregnant mice for 10 consecutive days had no clearly discernible effect on nidation or on maternal or foetal survival.	Schlumberger, 2013 ECHA, 2013
Endocrine Disruption Not listed as an endocrine disruptor.	EC, 2000
Acute Toxicity (oral, dermal, inhalation) Considered an inert ingredient by the US EPA. Investigations in which it has been administered to normal and diseased persons, clearly show that very large therapeutic doses cause no adverse effects.	EPA, 2001 FDA, 2013
Chronic/repeat dose toxicity (oral, dermal, inhalation) Threshold limit values not established. Acceptable daily intake 0-0.7 mg/kg bw.	IPCS, 2013 IPCS, 2013
Sensitisation of the skin or respiratory system Not known to cause an allergic reaction. Ammonium thiosulphate is not classified as skin sensitizer.	Schlumberger, 2013 ECHA, 2013
Corrosion (irreversible and reversible)/irritation of the skin or eye The results of a draize test was found to be non-irritating to eyes and skin.	ECHA, 2013

Physiochemical Properties	References
Flammable Potential Not combustible. Product does not burn.	IPCS, 2013 ECHA, 2013
Explosive Potential Not explosive.	ESIS, 2013

Toxicity Values	Value	Reference
Human Toxicity Data		
Acute Toxicity		
	No	FDA, 2013, EPA, 2001
High Chronic/Repeat Dose Toxicity		
LOAEC	No data found (NDF)	
LOAEL	Acceptable daily intake 0-0.7 mg/kg bw.	IPCS, 2013
Animal Toxicity Data		
Acute Toxicity		
LD_{50}		
Rat, oral	>2000 mg/kg (female rat) for calcium thiosulphate >5000 mg/kg (male rat) for potassium thiosulphate >5,000 mg/kg	ECHA, 2013 CCOHS, 2013
Mouse, oral	50-5,000 mg/kg (single dose) gavage, negative result in cytogenetic assay	OECD, 2006
Rabbit, dermal	Acute dermal LD_{50} of potassium thiosulphate was estimated to be >2000 mg/kg Acute dermal LD_{50} of Thio-Sul (Ammonium thiosulphate solution) is estimated to be >2000 mg/kg of body weight	ECHA, 2013 Potassium thiosulphate is not classified as acute toxic by the dermal route.
LC_{50}		
Rat (inhalation)	Four-hour acute inhalation LC_{50} of potassium thiosulphate was estimated to be > 2.60 mg/L Four-hour acute inhalation LC_{50} of sodium sulfite was estimated to be > 5.5 mg/L One-hour acute inhalation LC_{50} of sodium sulfite was estimated to be > 22 mg/L	ECHA, 2013 No concentration values greater than this given value have been examined. For sodium sulfite the test item is not classified as acute toxic via the inhalation route
Mice (inhalation)	NDF	
High Chronic/Repeat Dose Toxicity		
LOAEL	NDF	
LOAEC	NDF	
NOAEL (Rat)	Oral: Disodium disulfite NOAEL for local effects 108 mg/kg bw/d Na2S2O5. NOAEL for systemic effects can be expected above 955 mg/kg bw/d of Na2S2O5	ECHA, 2013

Footnotes:
LD_{50} – lethal dose for 50% of experimental population
LC_{50} – lethal air concentration for 50% of experimental population
LOAEL – Lowest Observed Adverse Effect Level
LOAEC – Lowest Observed Adverse Effect Concentration
NOAEL – No Observed Adverse Effect Level

Human Health Toxicity Ranking*		
	Hazard data	**Comment**
Hazard Band 4		
Carcinogenicity	No	
Mutagenicity/Genotoxicity	No	
Reproductive Toxicity	No	
Developmental Toxicity/ Teratogenicity	No	
Endocrine Disruption[1]	No	
Hazard Band 3		
Acute Toxicity (oral, dermal or inhalation) Very Toxic/Toxic • oral LD_{50} ≤ 300 mg/kg[3] • dermal LD_{50} ≤ 1000 mg/kg • inhalation LC_{50} ≤ 10 mg/L4 (or mg/m^3) (vapour)	No	For sodium sulfite the test item is not classified as acute toxic via the inhalation route (ECHA, 2013)
High Chronic/repeat dose toxicity • oral LOAEL ≤ 10 mg/kg/d[3]; • dermal LOAEL ≤ 2 0 mg/kg/d; • inhalation LOAEC (6 h/d) ≤ 50 ppm/d for gases, ≤ 0.2 mg/L/d for vapours or ≤ 0.02 mg/L/d for dust/mists/fumes[4]	No	
Corrosive (irreversible damage)	No	
Respiratory sensitiser	No	
Hazard Band 2		
Harmful chronic/repeat dose toxicity • oral LOAEL > 10 mg/kg and ≤ 100 mg/kg/d • dermal LOAEL > 20 mg/kg/d and ≤ 200 mg/kg/d • inhalation (6-h/d) LOAEC > 50 mg/L ≤ 250 mg/L/d for gases, > 0.2 mg/L ≤ 1 .0 mg/L/d for vapours or > 0.02 mg/L ≤ 0.2 mg/L/d for dust/mists/fumes[4]	No	
Skin Sensitiser	No	
Hazard Band 1		
Acute Toxicity-Harmful • oral LD_{50} > 300 mg/kg ≤ 2000 mg/kg • dermal LD_{50} >1 000 mg/kg ≤ 2000 mg/kg; • inhalation LC_{50} (6 h/d) > 10 mg/L ≤ 20 mg/L for vapours)[4]	No	
Irritant (reversible damage)	No	ECHA,2013
Hazard Band 0 All indicators outside criteria listed in Hazards 1-4	Yes	
Physical Hazards		
Flammable potential	No	IPCS, 2013, ECHA, 2013
Explosive potential	No	ESIS, 2013
Hazard Evaluation (highest band) not including physical hazards	Hazard Band 0	
Uncertainty analysis /data confidence	14/14	**100%**

* Based on IMAP Framework [NICNAS (2013) Inventory Multi-tiered Assessment and Prioritisation (IMAP) Framework. National Industrial Chemicals Notification and Assessment Scheme. Department of Health and Aging, Canberra].

"[1]Based on list of endocrine disrupting chemicals from the European Commission's Endocrine Disrupters website.

[2] *Based on list of neurotoxic chemicals from US Agency for Toxic Substances and Disease Registry (ATSDR).*
[3] *milligrams per kilogram body mas s(mg/kg) or milligrams per kilogram body mas per day (mg/kg/d)*

[4] *Based on GHS cut-offs for hazard classification. For chronic/repeat dose toxicity, GHS cut-offs are provided as guidance values (i.e. the dose/concentration at or below which significant health effects are observed"). (p 18, NICNAS 2013).*

Human Health Guidelines		
Media	**Concentration (mg/m^3; mg/L; mg/kg)**	**Reference**
Occupational Exposure Limits		
Air (OEL)		
8-h TWA	10 mg/m^3 (total inhalable dust) (UK) 5 mg/m^3 (respirable dust) (UK) 2 mg/m^3 Maximum workplace concentration (Germany) 10 mg/m^3 (ACGIH) inhalable particulate 3 mg/m3 (ACGIH) respirable particulate 15 mg/m3 (OSHA) total dust 5 mg/m3 (OSHA) respirable fraction	ESIS, 2013 CCOHS, 2013
STEL	None	Schlumberger, 2013
Peak Limitation	NDF	
Environmental Exposure		
Air, ambient	NDF	
Air, indoor	NDF	
Water, potable	NDF Class of danger: 0 – generally not water polluting	ESIS, 2013
Water, recreational	NDF	
Soil, residential	NDF	
Soil, commercial/industrial	NDF	

Footnotes:

OEL = Occupational Exposure Limit

TWA= 8 h Time-Weighted Average

STEL = (15 min) Short-term Exposure Limit

NDF - No data found within the limits of the search strategy.

Qualifying Summary Comments

Sodium thiosulphate is a normal constituent of human body fluids, is generally recognised as safe (GRAS) and is a non-hazardous substance. It is used as a direct and indirect food additive. At very high dust concentrations it may cause transient irritation to the respiratory tract. Sodium thiosulphate falls into the Hazard Band 0 category.

There is no evidence to suggest any adverse effects following repeated exposure at low environmental levels. On contact with acid it can liberate sulphur dioxide. Sulphur dioxide can cause irritation of the respiratory tract and is a trigger for asthma in sensitive individuals. Sodium thiosulphate is not expected to be persistent or bioaccumulative in the environment.

References

Canadian Centre for Occupational Health and Safety (CCOHS) MSDS database (2013). Sodium Thiosulphate (anhydrous and pentahydrate) MSDS. Available at http://ccinfoweb.ccohs.ca/msds/pdf/cn1300/6540290.pdf [Accessed 13 August 2013]

European Chemical Substances Information System (ESIS) (2013). Sodium Thiosulphate IUCLID Dataset. Available at http://esis.jrc.ec.europa.eu/doc/IUCLID/data_sheets/7772987.pdf [Accessed 13 August 2013]

European Chemicals Agency (ECHA) (2013) Sodium Thiosulphate. Available at http://echa.europa.eu/information-on-chemicals/registered-substances [Accessed 12 August 2013]

European Commission (EC) (2000) Towards the establishment of a priority list of substances for further evaluation of their role in endocrine disruption, preparation of a candidate list of substances as a basis for priority setting, Final Report (Incorporating corrigenda to final report dated 21 June 2000).

FDA, US Food and Drug Administration (2013) Select Committee on GRAS Substances (SCOGS) Opinion: Sodium thiosulfate, SCOGS-Report Number: 52. Available at
http://www.fda.gov/Food/IngredientsPackagingLabeling/GRAS/SCOGS/ucm261420.htm [Accessed 30 August 2013]

Hazardous Substances Data Bank (HSDB) (2013). Sodium Thiosulphate . Available at http://toxnet.nlm.nih.gov/cgi-bin/sis/search/f?./temp/~A3lzxx:1 [Accessed 12 August 2013]

International Program on Chemical Safety (IPCS) INCHEM (2013). Sodium Thiosulphate. Available at http://inchemsearch.ccohs.ca/inchem/jsp/search/search.jsp?inchemcasreg=1&Coll=inchemall&serverSpec=charlie.ccohs.ca%3A9900&QueryText1=7772-98-7&QueryText2=&Search.x=39&Search.y=11 [Accessed 13 August 2013]

OECD (2004) OECD SIDS Initial Assessment Report for SIAM 19 on Sodium Dithionite. Available at http://www.inchem.org/documents/sids/sids/7775146.pdf [Accessed 13 August 2013]

Safework Australia (SWA) (2013) Hazardous Substances Information System (HSIS). Available at http://hsis.safeworkaustralia.gov.au/HazardousSubstance [Accessed 12 August 2013].

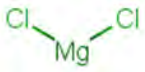
Schlumberger (2013) Safety Datasheet (Australia), High Temperature Gel Stabiliser J353L (component: sodium thiosulphate), dated January 2013.

United States Environmental Protection Agency (EPA). Sodium thiosulfate Exemption from the Requirement of a Tolerance 12/01, Dated 21 December 2001. Available at
http://pmep.cce.cornell.edu/profiles/inert/sodium_thiosulfate/sodium_thio_tol_1201.html [Accessed 30 August 2013]

Project number: 127666004
Project name: Hydraulic Stimulation Chemicals Assessment, Southwest Queensland
Client name: Santos Ltd

Created by:	CM	Date 30 August 2013
Reviewed and edited by:	JF	30 August 2013

Project number: 127666004
Project name: Hydraulic Stimulation Chemicals Assessment, Southwest Queensland
Client name: Santos Ltd

Name	Magnesium Chloride
Synonyms	
CAS number	7786-30-3
Molecular formula	Cl2Mg
Molecular Structure	

Overview	References
Magnesium Chloride is an inorganic, mono constituent substance, colourless to white crystals and thin white to gray coloured granules/flakes at solid at 20°C and 1013 hPa. The melting/freezing point of magnesium chloride is reported by ECHA to be 712°C at 101 kPa. Magnesium chloride substances can accelerate the burning process of a fire. Some substances may decompose explosively when heated, involved in a fire or contaminated. Magnesium chloride is a deliquescent chemical. It also has the ability to react explosively with hydrocarbons (fuel), and ignite combustibles (wood, paper, oil, clothing). Magnesium chloride is a component of fire extinguishers, ceramics, textile and paper manufacturing. It is also used in medication and disinfectants. Magnesium chloride in solution dissociates to magnesium and chloride ions. Magnesium is an essential mineral in all life. It is non hazardous to human health.	ECHA,2013 HSDB,1993

Human Health Toxicity Summary	Reference
Carcinogenicity Not classified by ECHA (conclusive data but not sufficient for classification). A lifetime oral mice carcinogenicity study (similar to OECD Guideline 453 (Combined Chronic Toxicity / Carcinogenicity Studies)) was conducted. The dose concentration was 0.5% and 2% magnesium chloride hexahydrate in the test mice diets. Frequency of treatment was daily for a 96 week period. NOAEL for male mice was 2,810 mg/kg bw/day (2% in feed) and female mice 3,930 mg/kg bw/day (2% in feed). IARC has not evaluated the evidence for the carcinogenicity of magnesium chloride.	ECHA,2013 IARC,2013
Mutagenicity/Genotoxicity Not classified by ECHA (conclusive data but not sufficient for classification). Test equivalent or similar to OECD Guideline 476 (In vitro Mammalian Cell Gene Mutation Test) was carried out on target gene, thymidine kinase, species/strain – mouse lymphoma L5178Y cells to see if there was potential to induce mutations. Test concentrations range between 22,000 – 36,000 µg/ml of magnesium chloride hexahydrate. Multiple controls used. The results conclude that the test substance shows no treatment related increase in mutation frequency. A study according to OECD Guideline 473 (In vitro Mammalian Chromosome Aberration Test) was carried out on species/strain: lymphocytes: human peripheral blood lymphocytes. Tests were undertaken with and without metabolic activation at varying concentrations of magnesium chloride hexahydrate. Multiple controls used. Conditions of the study conclude that the test substance is a	ECHA,2013

non-mutagenic agent.	
Reproductive Toxicity Not classified by ECHA (conclusive data but not sufficient for classification). Test according to OECD Guideline 422 (Combined Repeated Dose Toxicity Study with the Reproduction / Developmental Toxicity Screening Test) was carried out on Wistar rats by oral administration. Dose concentrations of magnesium chloride hexahydrate was 250, 500, 1000 mg/kg bw/day orally ingested. Test male rats were exposed for 28-29 days and female rats exposed for maximum 54 days. Controls were used. For both generations, parent and off-springs, NOAEL was >1000mg/kg bw/day.	ECHA,2013
Developmental Toxicity/Teratogenicity Not classified by ECHA (conclusive data but not sufficient for classification). A test equivalent to OECD Guideline 414 (Prenatal Developmental Toxicity Study) was carried out on Wistar rats. The dose concentration of magnesium chloride hexahydrate was 200, 400, 800 mg/kg bw/day orally ingested. Exposure was from day 6 – 15 of pregnancy. No clinical observations for teratogenicity and maternal toxicity effects. The NOAEL for both parent and fetuses was >800 mg/kg bw/day.	ECHA,2013
Endocrine Disruption Not listed as an endocrine disruptor by European Commission.	EC,2000
Neurotoxicity Not classified by ECHA. No data found.	ECHA,2013
Acute Toxicity (oral, dermal, inhalation) Not classified by ECHA (conclusive data but not sufficient for classification) – oral and dermal, (data lacking) – inhalation. A test according to OECD Guideline 423 (Acute Oral toxicity – Acute Toxic Class Method) was carried out on female Wistar rats. The dose concentration of magnesium chloride hexahydrate was 2000mg/kg b/w. No controls were used. No observations of mortality or clinical effects. Test concludes that the LD50 after a single oral administration to female rats, observed over a period of 14 days, is 5000 mg/kg body weight. A test according to OECD Guideline 402 (Acute Dermal Toxicity), was performed on Wistar rats. The dose concentration of magnesium chloride hexahydrate was 2000mg/kg b/w and covered approximately 10% total body surface. Slight dermal irritation observed from 1 of ten test rats and clinical signs of stress; however no control rats to compare with. The dermal LD50 was determined to be > 2000 mg/kg body weight. HSNO Classification 6.1E, acutely toxic (oral) – GHS classification, category 5 (Acute toxicity: oral). The classification comes from reference *Kali und Salz AG Lehrte (21) Journal of Pharmacology and Experimental Theraputics.* The test species were rats, the LD50 was 2800 mg/kg.	ECHA,2013 NZEPA - HSNO CCID,2013
Chronic/repeat dose toxicity (oral, dermal, inhalation) Not classified by ECHA (conclusive data but not sufficient for classification) – oral, (data lacking) – inhalation and dermal. A test according to OECD Guideline 422 (Combined Repeated Dose Toxicity Study with the Reproduction / Developmental Toxicity Screening Test) was carried out on Wistar rats. Dose concentrations of magnesium chloride hexahydrate was 250, 500, 1000 mg/kg bw/day orally ingested. Test male rats were exposed for 28-29 days and female rats exposed for maximum 54 days. Controls were used. NOAEL on general toxicity endpoints is >1000 mg/kg bw/day for male and female test rats.	ECHA,2013

Sensitisation of the skin or respiratory system Not classified by ECHA (conclusive data but not sufficient for classification) – skin, (data lacking) – respiratory. A test according to OECD Guideline 406 (Skin Sensitisation) was carried out on female Hartley guinea pigs. Dose concentrations were 5% and 50% suspension w/w of of magnesium chloride hexahydrate. Exposure was intradermal, epicutaneous and occlusive. Under the study conditions, there was no evidence of sensitisation in the test animals. A bibliographic study of multiple clinical case studies was performed by Scientific committee on Food (SCF) to assess the endpoint of repeat dose toxicity for humans when orally ingesting magnesium salts as a food additive. Mild diarrhoea was the most sensitive non-desirable effect of orally administrated easily dissociable magnesium salts occurring at 360/365 mg of magnesium per day (LOAEL). The SCF has set a human NOAEL of 250 mg of magnesium per day. HSNO Classification 6.4A, irritating to the eye – GHS classification, category 2A (Serious damage/eye irritation). A reference supporting this classification is *Kali und SAlz AG Lehrte (27) international Bio Research Forschungs GmbH.* The test spices were rabbits, the result was that the test substance was not irritating.	ECHA,2013 NZEPA - HSNO CCID,2013
Corrosion (irreversible)/irritation (reversible) effects on the skin or eye Not classified by ECHA (conclusive data but not sufficient for classification) A test according to EU method B46 (irritation) was carried out on reconstituted three-dimensional human skin model EPISKIN-SM (Skinethic). The dose concentration of magnesium chloride hexahydrate was approximately 10mg to dermal surface. Controls used. No irritant effects were observed after 15 minutes of treatment and 42 hours post incubation. A test according to OECD Guideline 405 (Acute Eye Irritation / Corrosion) was carried out on New Zealand White rabbits. A dose concentration of 0.1g was applied to the test site for a 72hr exposure period followed by an 8 day observation period. The control was the untreated eye of each rabbit. No observations at 24, 48 and 72 hours for the cornea and iris. Observations of irritation to the chemosis and conjunctivae occurred in some of the test animals, however all effects reversible within 48hrs to 6 days. With the EU criteria, the test substance is not irritating to the eye.	ECHA,2013

Physical Hazards	Reference
Flammable Potential Not classified by ECHA (Data lacking).	ECHA,2013
Explosive Potential Not classified by ECHA (Data lacking).	ECHA,2013

Toxicity Values	Value	Reference
Human Toxicity Data		
High Chronic/Repeat Dose Toxicity		
LOAEC	NDF	
LOAEL	NDF	
Animal Toxicity Data		
Acute Toxicity		
LD_{50}		
Rat, oral	5000 mg/kg	LD50 = 5000mg/kg body weight, test species, rat. ECHA, 2013
Rat, oral	2800 mg/kg	LD50 = 2800 mg/kg body weight, test species, rats. NZEPA - HSNO CCID,2013
Rabbit, oral	NDF	
Rat, dermal	>2000 mg/kg b/w	LD50 > 2000 mg/kg body weight, test species, rats. ECHA, 2013.
Rabbit, dermal	NDF	
Mouse, dermal	NDF	
LC_{50}		
Rat	NDF	
High Chronic/Repeat Dose Toxicity		
LOAEL	NDF	
LOAEC	NDF	

Footnotes:
LD_{50} – lethal dose for 50% of experimental population
LC_{50} – lethal air concentration for 50% of experimental population
LOAEL – Lowest Observed Adverse Effect Level
LOAEC – Lowest Observed Adverse Effect Concentration
Conclusive data: means that the study itself was conclusive in its reported finding, but was not sufficient for classifying the material according to ECHA guidelines.

Human Health Toxicity Ranking*		
	Hazard data	**Comment**
Hazard Band 4		
Carcinogenicity (IARC Group 1 or 2A)	No	Not classified by ECHA, 2013 Has not be evaluated by IARC,2013
Mutagenicity/Genotoxicity (GHS Category 1A and 1B)	No	Not classified by ECHA, 2013
Reproductive Toxicity/Developmental toxicity (GHS Category 1, 1A and 1B)	No	Not classified by ECHA, 2013
Endocrine Disruption[1]	No	Not classified by ECHA, 2013
Hazard Band 3		
Carcinogenicity (IARC Group 2B)	No	Not classified by ECHA, 2013 Has not be evaluated by IARC,2013
Mutagenicity/Genotoxicity (GHS Category 2)	No	Not classified by ECHA, 2013
Reproductive Toxicity/Developmental toxicity (GHS Category 2)	No	Not classified by ECHA, 2013
Acute Toxicity (oral, dermal or inhalation) Very Toxic/Toxic • oral LD_{50} ≤ 300 mg/kg[3] • dermal LD_{50} ≤ 1000 mg/kg inhalation LC_{50} ≤ 10 mg/L[4] (or mg/m^3) (vapour)	No	Not classified by ECHA, 2013
Possible carcinogenicity, mutagenicity, reproductive or High Chronic/repeat dose toxicity • oral LOAEL ≤ 10 mg/kg/d[3]; • dermal LOAEL ≤ 2 0 mg/kg/d; • inhalation LOAEC (6 h/d) ≤ 50 ppm/d for gases, ≤ 0.2 mg/L/d for vapours or ≤ 0.02 mg/L/d for dust/mists/fumes[4]	No	Not classified by ECHA, 2013
Corrosive (irreversible effect)	No	Not classified by ECHA, 2013
Respiratory sensitiser	No	Not classified by ECHA, 2013
Hazard Band 2		
Harmful chronic/repeat dose toxicity • oral LOAEL > 10 mg/kg and ≤ 100 mg/kg/d • dermal LOAEL > 20 mg/kg/d and ≤ 200 mg/kg/d • inhalation (6-h/d) LOAEC > 50 mg/L ≤ 250 mg/L/d for gases, > 0.2 mg/L ≤ 1 .0 mg/L/d for vapours or > 0.02 mg/L ≤ 0.2 mg/L/d for dust/mists/fumes[4]	No	Not classified by ECHA, 2013
Skin Sensitiser		
Hazard Band 1		
Acute Toxicity-Harmful • oral LD_{50} > 300 mg/kg ≤ 2000 mg/kg • dermal LD_{50} >1 000 mg/kg ≤ 2000 mg/kg; • inhalation LC_{50} (6 h/d) > 10 mg/L ≤ 20 mg/L for vapours)[4]	No	LD50 = 5000mg/kg body weight, test species, rat. ECHA, 2013 LD50 = 2800 mg/kg body weight, test species, rats.

		NZEPA - HSNO CCID,2013 LD50 > 2000 mg/kg body weight, test species, rats. ECHA, 2013.
Irritant (reversible effect)	No	Not classified by ECHA, 2013
Hazard Band 0 **All indicators outside criteria listed in Hazards 1-4**		
Physical Hazards		
Flammable potential	No	
Explosive potential	No	
Hazard Evaluation (highest band) not including physical hazards	Hazard Band 0	
Uncertainty analysis /data confidence (out of 12 parameters)	12/12 = 100%	

* Based on IMAP Framework [NICNAS (2013) Inventory Multi-tiered Assessment and Prioritisation (IMAP) Framework. National Industrial Chemicals Notification and Assessment Scheme. Department of Health and Aging, Canberra].

"[1]Based on list of endocrine disrupting chemicals from the European Commission's Endocrine Disrupters website.

[2] Neurotoxicity based on REACH assessments.

[3] milligrams per kilogram body mass(mg/kg) or milligrams per kilogram body mas per day (mg/kg/d)

[4] Based on GHS cut-offs for hazard classification. For chronic/repeat dose toxicity, GHS cut-offs are provided as guidance values (i.e. the dose/concentration at or below which significant health effects are observed"). (p 18, NICNAS 2013).

Human Health Guidelines		
Media	**Concentration (mg/m^3; mg/L; mg/kg)**	**Reference**
Occupational Exposure Limits		
Air (OEL)	No data found	
8-h TWA	No data found	
STEL	No data found	
Peak Limitation	No data found	
Environmental Exposure		
Air, ambient	No data found	
Air, indoor	No data found	
Water, potable	>1200 mg/L	>1200 TDS = unacceptable (unpalatable) criteria based on WHO 2004, reference ADWGL, 2011
Water, recreational	No data found	
Soil, residential	No data found	
Soil, commercial/industrial	No data found	

Footnotes:

OEL = Occupational Exposure Limit

TWA= 8 h Time-Weighted Average

STEL = (15 min) Short-term Exposure Limit

Qualifying Summary Comments

Magnesium is an essential mineral for humans. It is non hazardous to human health. On this basis it is categorised in the lowest hazard band. (Hazard Band 0).

References and Notes

European Chemicals Agency (ECHA), 2013. *Registered Substances List Dossier for magnesium chloride.* Available at: http://apps.echa.europa.eu/registered/data/dossiers/DISS-9eba3f59-f247-5596-e044-00144f67d031/AGGR-0eeb287c-21c3-4ad6-8787-9e9fc114ebf0_DISS-9eba3f59-f247-5596-e044-00144f67d031.html#AGGR-0eeb287c-21c3-4ad6-8787-9e9fc114ebf0 [Accessed 26 November 2013]

European Commission (EC) (2000). Towards the establishment of a priority list of substances for further evaluation of their role in endocrine disruption, preparation of a candidate list of substances as a basis for priority setting, Final Report (Incorporating corrigenda to final report dated 21 June 2000).

Hazardous Substance Data Bank (HSDB), *Toxnet, toxicology data network – magnesium chloride* 13 February 2003. Available at: http://toxnet.nlm.nih.gov/cgi-bin/sis/search/f?./temp/~0kpVZo:1 [Accessed 26 November 2013]

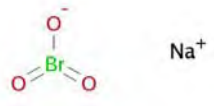
International Agency for Research on Cancer (IARC), 16 June 2013. Agents Classified by the *IARC Monographs*, Volumes 1–108. Available at http://monographs.iarc.fr/ENG/Classification/index.php. [Accessed 26 November 2013].

New Zealand Environment Protection Authority (NZEPA) - New Zealand Hazardous Substances and New Organisms (HSNO) Chemical Classification Information Database (CCID), magnesium chloride, Available at: http://www.epa.govt.nz/search-databases/Pages/ccid-details.aspx?SubstanceID=1983 [Accessed 26 November 2013].

NDF - No data found within the limits of the search strategy.

Created by:	CS	Date: 28/11/2013
Reviewed by:	JF	Date: 11/12/2013

Project number: 127666004
Project name: Hydraulic Stimulation Chemicals Assessment, Southwest Queensland
Client name: Santos Ltd

Name	Sodium bromate
Synonyms	Sodium bromate(V), Bromic acid, sodium salt, Sodium trioxidobromate, Sodium trioxobromate
CAS number	7789-38-0
Molecular formula	BrHO3.Na
Molecular Structure	

Overview	References
Sodium bromate is an odourless white crystalline substance that is readily soluble in water. It is produced by the introduction of bromine into a solution of sodium carbonate. Sodium bromate readily dissociates in water. Sodium bromate is used as an analytical reagent, in the oxidation of sulfur and vat dyes, and for cleaning boilers. When it is mixed with sodium bromide, it is used for dissolving gold from its ores. The cosmetic industry uses sodium bromate as a neutralizer or oxidizer in hair wave preparations. Following ingestion sodium bromate is rapidly absorbed from the gastrointestinal tract and appears in plasma and urine unchanged and in other tissues as bromide. Most bromate is excreted in the urine, either as bromate or bromide. Given the sodium and potassium salts readily dissociate data for sodium and potassium salts were considered in this profile. Acute toxicity following ingestion of sodium bromate and its surrogate potassium bromate include nausea and vomiting accompanied by abdominal pain and diarrhoea, anaemia, destruction of the red blood cells, decreased blood pressure, convulsions, coma, respiratory depression, and possibly death. Repeat dose toxicity studies with rats, mice and hamsters using the surrogate potassium bromate have identified the kidney as the target organ of bromate. Specific effects include necrosis and degenerative changes in renal tubules and urothelial hyperplasia leading to renal tubular tumours upon oral administration. The relevance of the tumours to humans in unclear (Possible human carcinogen).	US EPA (2001) NCBI (2013) FDA(2013) ECHA (2013)

Human Health Toxicity Summary	Reference
Carcinogenicity -May cause cancer based on demonstrated animal carcinogenicity (The CLP Regulation (which aligns itself with the Globally Harmonised System (GHS) of Classification and Labelling of Chemicals) classifies sodium bromate as a 1B). -IARC (IARC classification of bromate is 2B) has concluded that although there is inadequate evidence of carcinogenicity in humans, there is sufficient evidence for the carcinogenicity of bromate from high- dose studies in experimental animals. This is based on studies where	ECHA (2013) IARC (2013)

potassium bromate was administered orally to rats, mice and hamsters. In rats, it produced renal tubular tumours (adenomas and carcinomas) and thyroid follicular tumours. In mice, it produced a low incidence of renal tubular tumours in males and in hamsters the incidence of renal tubular tumours was marginally increased.	
Mutagenicity/Genotoxicity -Suspected of causing genetic defects (GHS Mutagencity Category 2) based on investigations performed with potassium bromate. In an experiment where V79 Chinese hamster ovary cells were used, bromate increased the frequency of cells with micronuclei, the number of chromosomal aberrations and the number of DNA strand breaks. Potassium bromate also induced gene mutations at the HPRT locus and was mutagenic in Salmonella typhimurium strain TA100 in the presence of S9 activation and produced chromosomal aberrations in cultured Chinese hamster fibroblast cells. Positive results were observed in several in vivo studies.	ECHA (2013)
Reproductive Toxicity -No information on sodium bromate but a one generation reproductive toxicity study with rats was performed on the analogues potassium bromate and a decrease (18%) in epididymal sperm density was observed. Based on this a NOAEL of 7.7 mg /kg/d was obtained (measured as $BrO3^-$).	ECHA (2013)
Developmental Toxicity/Teratogenicity -Not known to cause birth defects or have a deleterious effect on a developing foetus.	SDS (2013)
Endocrine Disruption -Not classified as an endocrine disruptor.	ECED (2013)
Neurotoxicity **-No data found using all proposed data sources.** -	-
Acute Toxicity (oral, dermal, inhalation) -Harmful if swallowed (GHS Acute Toxicity Classification of 4). For rats an oral LD_{50} of 301 mg/kg has been reported for sodium bromate. Sodium bromate was administered orally to women with the lowest toxic dose TD_{LO} of 150mg/kg reported. Behavioural effects included somnolence (general depressed activity), sense organs effects includes changes in ear acuity, and kidney, ureter and bladder effects were observed with a decrease in urine volume. - May cause respiratory irritation (STOT Single Exp. 3) of the respiratory tract via inhalation. -Insufficient data for dermal.	ECHA (2013) ChemIDplus 2013
Chronic/repeat dose toxicity (oral, dermal, inhalation) **-**A 13 weeks toxicity study with rats was performed by dosing the animals with potassium bromate in the drinking water. The LOAEL was below 63 mg/kg/d (as BrO_3^-). -Another 15 months toxicity study with male rats was performed by dosing the animals with potassium bromate in the drinking water. The LOAEL was 30 mg/kg/d (as BrO_3^-). -Insufficient data for dermal -Insufficient data for inhalation	ECHA (2013)
Sensitisation of the skin or respiratory system -Not known to cause allergic reaction. **-**May cause respiratory irritation, including pain and coughing.	SDS(2013) ECHA (2013)
Corrosion (irreversible and reversible)/irritation of the skin or eye -Causes skin irritation (GHS Skin Irritation Category 2) including redness and dermatitis. -Causes serious eye irritation (GHS Eye Irritation Category 2).	ECHA (2013) SDS (2013)

Physical hazards	Reference
Flammable Potential -Not classified as a flammable. -Sodium bromate is a known oxidizing substance (GHS Oxidising. Solid Category 1) which enhances combustion of other substances.	ECHA (2013) IPCS (2013)
Explosive Potential -Not classified as an explosive -There is a risk of explosion on contact with combustible substances or reducing agents.	ECHA (2013) IPCS (2013)

Toxicity Values	Value	Reference
Human Toxicity Data		
Acute Toxicity		
	TDL_0 (oral, women) 150 mg/kg	ChemIDplus 2013
High Chronic/Repeat Dose Toxicity		
Animal Toxicity Data		
Acute Toxicity		
LD_{50}		
Rat, oral	301 mg/kg	ECHA 2013
Mouse, oral	140 mg/kg	ChemIDplus 2013
LDL_0		
Rabbit (oral)	250 mg/kg	ChemIDplus 2013
LC_{50}		
	No data found.	All proposed data sources.
High Chronic/Repeat Dose Toxicity		
LOAEL (rats)	< 63 mg/kg/d (based on potassium bromate).	ECHA 2013
LOAEL (rats)	30 mg/kg/d (based on potassium bromate).	ECHA 2013

Footnotes:
LD_{50} – lethal dose for 50% of experimental population
LC_{50} – lethal air concentration for 50% of experimental population
LOAEL – Lowest Observed Adverse Effect Level
LOAEC – Lowest Observed Adverse Effect Concentration
TDL_0 – Lowest toxic dose
LDL_0 – Lowest lethal dose

Human Health Toxicity Ranking*		
	Hazard data	**Comment**
Hazard Band 4		
Carcinogenicity	YES	May cause cancer (CLP classification of 1B)
Mutagenicity/Genotoxicity	NO	Insufficient evidence
Reproductive Toxicity	YES	Based on a rats study.
Developmental Toxicity/ Teratogenicity	NO	-
Endocrine Disruption[1]	NO	-
Hazard Band 3		
Acute Toxicity (oral, dermal, inhalation) Very Toxic/Toxic • Oral $LD_{50} \leq 300$ mg/kg[3] • dermal $LD_{50} \leq 1000$ mg/kg • inhalation $LC_{50} \leq 10$ mg/L[4] (or mg/m^3) (vapour)	NO	-
Carcinogenicity, Mutagencity, Reproductive (Category 2) High Chronic/repeat dose toxicity • oral LOAEL ≤ 10 mg/kg/d[3]; • dermal LOAEL ≤ 20 mg/kg/d; • inhalation LOAEC (6 h/d) ≤ 50ppm/d for gases,≤ 0.2 mg/L/d for vapours or ≤ 0.02 mg/L/d for dust/mists/fumes[4]	YES	Mutagen Category 2 IARC Group 2B
Corrosive (irreversible damage)	NO	
Respiratory sensitiser	NO	
Hazard Band 2		
Harmful chronic/repeat dose toxicity • oral LOAEL > 10 mg/kg and ≤ 100 mg/kg/d • dermal LOAEL > 20 mg/kg/d and ≤ 200 mg/kg/d • inhalation (6-h/d) LOAEC > 50 mg/L ≤ 250 mg/L/d for gases, > 0.2 mg/L ≤1.0 mg/L/d for vapours or > 0.02 mg/L ≤0.2 mg/L/d for dust/mists/fumes[4]	YES	Renal tumours in animal studies.
Skin Sensitiser	NO	-
Hazard Band 1		
Acute Toxicity-Harmful • oral$LD_{50} > 300$ mg/kg ≤ 2000 mg/kg • dermal $LD_{50} > 1000$ mg/kg ≤ 2000 mg/kg; • inhalationLC_{50} (6 h/d) > 10 mg/L ≤ 20mg/L for vapours)[4]	YES	For rats an LD_{50} (oral) of 301 mg/kg reported (ECHA 2013)
Irritant (reversible damage)	YES	
Hazard Band 0 **All indicators outside criteria listed in Hazards 1-4**		
Physical Hazards		
Flammable potential	NO	-
Explosive potential	NO	-
Hazard Evaluation (highest band) not including physical hazards	**Band 4**	
Uncertainty analysis /data confidence	13/13	**100%**

* Based on IMAP Framework [NICNAS (2013) Inventory Multi-tiered Assessment and Prioritisation (IMAP) Framework. National Industrial Chemicals Notification and Assessment Scheme. Department of Health and Aging, Canberra].

"[1]Based on list of endocrine disrupting chemicals from the European Commission's Endocrine Disrupters website.

[2]Based on list of neurotoxic chemicals from US Agency for Toxic Substances and Disease Registry (ATSDR).

[3] milligrams per kilogram body mass (mg/kg) or milligrams per kilogram body mas per day (mg/kg/d)

[4]Based on GHS cut-offs for hazard classification. For chronic/repeat dose toxicity, GHS cut-offs are provided as guidance values (i.e. the dose/concentration at or below which significant health effects are observed") (p18, NICNAS 2013).

Human Health Guidelines		
Media	**Concentration (mg/m^3; mg/L; mg/kg)**	**Reference**
Occupational Exposure Limits		
Air (OEL)	No data found.	All proposed data sources.
8-h TWA	No data found.	All proposed data sources.
STEL	No data found.	All proposed data sources.
Peak Limitation	No data found.	All proposed data sources.
Environmental Exposure		
Air, ambient	No data found.	All proposed data sources.
Air, indoor	No data found.	All proposed data sources.
Water, potable	No data found.	All proposed data sources.
Water, recreational	No data found.	All proposed data sources.
Soil, residential	No data found.	All proposed data sources.
Soil, commercial/industrial	No data found.	All proposed data sources.

Footnotes:

OEL = Occupational Exposure Limit

TWA= 8 h Time-Weighted Average

STEL = (15 min) Short-term Exposure Limit

Qualifying Summary Comments

Sodium bromate is an odourless white crystalline substance that is readily soluble in water. Following ingestion sodium bromate is rapidly absorbed from the gastrointestinal tract and appears in plasma and urine unchanged and in other tissues as bromide. Given that sodium and potassium salts readily dissociate data for sodium and potassium salts were considered in the human health assessment. Health effects following ingestion of sodium bromate and its surrogate potassium bromate include nausea and vomiting accompanied by abdominal pain and diarrhoea, anaemia, destruction of the red blood cells, decreased blood pressure, convulsions, coma, respiratory depression, and possibly death. Sodium bromate may cause cancer based on demonstrated animal carcinogenicity and is suspected of causing genetic and reproductive defects. Furthermore, sodium bromate causes skin irritation and serious eye irritation. Based on the classifications and data considered sodium bromate is classified as hazard band 4.

References and Notes

ChemIDplus Lite NLM (2013). United States National Library of Medicine. Available at http://chem.sis.nlm.nih.gov/chemidplus/jsp/common/Toxicity.jsp?calledFrom=lite [Accessed 22 August 2013]

ECED (2013). European Commission Endocrine Disrupters website. Available at

http://ec.europa.eu/environment/endocrine/strategy/substances_en.htm#priority_list/ [Accessed 22 August 2013]

European Chemicals Agency (ECHA) Classification and Labelling Inventory Database. Available at http://echa.europa.eu/web/guest/information-on-chemicals/cl-inventory-database. [Accessed 21 August 2013]

FDA (2013) (U.S. Food and Drug Administration) 2013. Guide to Inspections of Cosmetic Product Manufacturers. Available at http://www.fda.gov/ICECI/Inspections/InspectionGuides/ucm074952.htm [Accessed 22 August]

HSDB (2013) Hazardous Substances Data Bank. Toxicology Data Network (TOXNET). Available at http://toxnet.nlm.nih.gov/cgi-bin/sis/search/f?./temp/~xoeBga:1 [Accessed 21 August 2013]

IARC (2013) Agents classified by IARC Monographs Volume 73 Some Chemicals that Cause Tumours of the Kidney or Urinary Bladder in Rodents and Some Other Substances. Available at http://monographs.iarc.fr/ENG/Monographs/vol73/mono73-22.pdf. [Accessed 21 August 2013]

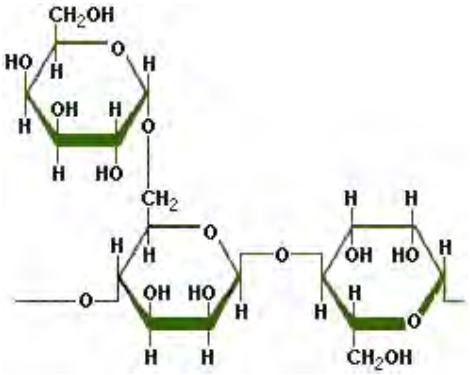
IPCS INCHEM (2013), International Program on Chemical Safety, Available at http://www.inchem.org/documents/icsc/icsc/eics0196.htm [Accessed 21 August 2013]

NCBI (2013) US National Library of Medicine, National Institute of Health. Toxicology studies of sodium bromate (CAS No. 7789-38-0) in genetically modified mice (dermal and drinking water studies) and carcinogenicity studies of sodium bromate in genetically modified mice (drinking water studies). Available at http://www.ncbi.nlm.nih.gov/pubmed/18784759 [Accessed 22 August]

US EPA (2001) U.S. Environmental Protection Agency. Toxicological Review of Bromate. In Support of Summary Information on the Integrated Risk. Available at http://www.epa.gov/iris/toxreviews/1002tr.pdf [Accessed 22 August 2013]

Created by:	JH	Date 22/08/13
Reviewed and edited by:	JF	Date 29/08/13
Reviewed and edited by:	PDM	Date 28/08/13

Project number: 127666004
Project name: Hydraulic Stimulation Chemicals Assessment, Southwest Queensland
Client name: Santos Ltd

Name	Guar Gum
Synonyms:	A-20D, J 2FP, 1212A, Burtonite V-7-E, Cyamopsis gum, Cyanopsis tetragonoloba, Dealca TP1, Dealca TP2, Decorpa, Gendriv 162, Gum cyamopsis Guaran, Guaran, Guar flour, Indalca AG, Jaguar, Jaguar 6000, Jaguar A 20B, Jaguar A 20D, Jaguar A40F, Jaguar Gum A-20-D, Jaguar No 124, Jaguar Plus, Lycoid Dr, NCI-C50395, Regonol, Rein Guarin, Supercol GF, Supercol U Powder, Syngum D 46D, Uni-Gaur
CAS number :	9000-30-0
Molecular formula	Unknown/ Unspecified
Molecular Structure	

Overview	References
Guar gum is a yellowish-white free-flowing powder. It is completely soluble in water and practically insoluble in oils, greases, hydrocarbons, ketones and esters. Water solutions are tasteless, odourless and a pale, translucent grey colour and neutral. The powder has 5 to 8 times the thickening power of starch. Water solution may be converted to a gel by adding a small amount of borox and are stable to heat. Guar gum is extensively used in the community, e.g. typically used as a protective colloid, stabilizer, thickening and film forming agent for cheese, salad dressing, milk products including ice cream and soups; in paper sizing; as a binding and disintegration agent in tablet formulations; in pharmaceutical jelly formulations; in suspension, emulsions, lotions, creams and toothpastes; in bulk laxatives and appetite depressants; in mining industry as a flocculent, for hydraulic fracturing aid in oil well recovery and as a filtering ages; gelling and waterproofing agent in explosive and in water treatment as a coagulant.	HSDB, 2002

Human Health Toxicity Summary	Reference
Carcinogenicity NDF	
Mutagenicity/Genotoxicity Guar gum induced no consistent responses in dominant lethal gene tests to suggest that it was mutagenic to the rat.	HSDB, 2002
Reproductive Toxicity NDF	
Developmental Toxicity/Teratogenicity The developmental effects of guar gum were evaluated in groups of 20 rabbits by daily dermal administration of the test substance for 6 hours/day at dose levels of 0, 2, 10 and 50 mg/kg/day on days 6 through 18 of gestation. The number of early resorptions was significantly increased and the number of viable foetuses was correspondingly decreased at 50 mg/kg/day ($p<0.05$). The NOEL was 2 mg/kg/day. The frequency of foetal malformations and variations in the treated groups was comparable to that of the control group at all dose levels.	HSNO, 2013
Endocrine Disruption NDF	
Neurotoxicity NDF	
Acute Toxicity (oral, dermal, inhalation) Guar gum has been blamed for causing esophageal obstruction. A death has been attributed to the use of one guar gum tablet product, which apparently swelled in the esophagus, indirectly resulting in complications that caused the fatality. Mildly toxic by ingestion.	HSDB, 2002
Chronic/repeat dose toxicity (oral, dermal, inhalation) NDF	
Sensitisation of the skin or respiratory system Occupational asthma has been reported in subjects working with industrial production of guar gum. A respiratory sensitizer.	HSDB, 2002; HSNO, 2013
Corrosion (irreversible and reversible)/irritation of the skin or eye Mildly irritating to the skin. The developmental effects of guar gum were evaluated in groups of 20 rabbits by daily dermal administration of the test substance for 6 hours/day at dose levels of 0, 2, 10 and 50 mg/kg/day on days 6 through 18 of gestation. A dose-related increase in dermal irritation (including erythema, edema, and desquamation) was observed in animals receiving 10 and 50 mg/kg/day.	HSDB, 2002; HSNO, 2013

Physical hazards	Reference
Flammable Potential NDF	
Explosive Potential NDF	

Toxicity Values	Value	Reference
Human Toxicity Data		
Acute Toxicity	NDF	
High Chronic/Repeat Dose Toxicity		
Animal Toxicity Data		
Acute Toxicity		
LD_{50}		
Rat, oral	6770 mg/kg	HSDB, 2002
Rabbit, oral	7000 mg/kg	HSDB, 2002
Mouse, oral	8100 mg/kg	HSDB, 2002
Hamster, oral	6000 mg/kg	HSDB, 2002
LOAEL	NDF	
LOAEC	NDF	
LC_{50}		
Rat	NDF	
High Chronic/Repeat Dose Toxicity		
LOAEL	NDF	
LOAEC	NDF	
NOEL, rabbit, dermal	2 mg/kg/day	HSNO, 2013

Footnotes:
LD_{50} – lethal dose for 50% of experimental population
LC_{50} – lethal air concentration for 50% of experimental population
LOAEL – Lowest Observed Adverse Effect Level
LOAEC – Lowest Observed Adverse Effect Concentration
NOEL – No Observed Effect Limit

Human Health Toxicity Ranking*		
	Hazard data	**Comment**
Hazard Band 4		
Carcinogenicity	NDF	
Mutagenicity/Genotoxicity	No	HSDB, 2002
Reproductive Toxicity	NDF	
Developmental Toxicity/ Teratogenicity	No	HSNO, 2013
Endocrine Disruption[1]	NDF	
Neurotoxicity[2]	NDF	
Hazard Band 3		
Acute Toxicity (oral, dermal or inhalation) Very Toxic/Toxic • oral $LD_{50} \leq 300$ mg/kg[3] • dermal $LD_{50} \leq 1000$ mg/kg • inhalation $LC_{50} \leq 10$ mg/L[4] (or mg/m^3) (vapour)	No	HSDB,2002
High Chronic/repeat dose toxicity • oral LOAEL ≤ 10 mg/kg/d[3]; • dermal LOAEL ≤ 2 0 mg/kg/d; • inhalation LOAEC (6 h/d) ≤ 50 ppm/d for gases, ≤ 0.2 mg/L/d for vapours or ≤ 0.02 mg/L/d for dust/mists/fumes[4]	NDF	
Corrosive (irreversible damage)	NDF	
Respiratory sensitiser	Yes	HSDB,2002; HSNO, 2013
Hazard Band 2		
Harmful chronic/repeat dose toxicity • oral LOAEL > 10 mg/kg and ≤ 100 mg/kg/d • dermal LOAEL > 20 mg/kg/d and ≤ 200 mg/kg/d • inhalation (6-h/d) LOAEC > 50 mg/L ≤ 250 mg/L/d for gases, > 0.2 mg/L ≤ 1 .0 mg/L/d for vapours or > 0.02 mg/L ≤ 0.2 mg/L/d for dust/mists/fumes[4]		
Skin Sensitiser	Yes	HSNO, 2013
Hazard Band 1		
Acute Toxicity-Harmful • oral $LD_{50} > 300$ mg/kg ≤ 2000 mg/kg • dermal LD_{50} >1 000 mg/kg ≤ 2000 mg/kg; • inhalation LC_{50} (6 h/d) > 10 mg/L ≤ 20 mg/L for vapours)[4]	No	Rat, oral, LD_{50} 6770 mg/kg (HSDB,2002)
Irritant (reversible damage)	Yes	HSNO, 2013
Hazard Band 0 **All indicators outside criteria listed in Hazards 1-4**	No	
Physical Hazards		
Flammable potential	NDF	
Explosive potential	NDF	
Hazard Evaluation (highest band) not including physical hazards	3	Based on respiratory and skin sensitising potential
Uncertainty analysis /data confidence		

* Based on IMAP Framework [NICNAS (2013) Inventory Multi-tiered Assessment and Prioritisation (IMAP) Framework. National Industrial Chemicals Notification and Assessment Scheme. Department of Health and Aging, Canberra].

"[1]*Based on list of endocrine disrupting chemicals from the European Commission's Endocrine Disrupters website.*

[2] *Based on list of neurotoxic chemicals from US Agency for Toxic Substances and Disease Registry (ATSDR).*

[3] *milligrams per kilogram body mass(mg/kg) or milligrams per kilogram body mas per day (mg/kg/d)*

[4] *Based on GHS cut-offs for hazard classification. For chronic/repeat dose toxicity, GHS cut-offs are provided as guidance values (i.e. the dose/concentration at or below which significant health effects are observed"). (p 18, NICNAS 2013).*

Human Health Guidelines		
Media	**Concentration (mg/m^3; mg/L; mg/kg)**	**Reference**
Occupational Exposure Limits		
Air (OEL)		
8-h TWA	NDF	
STEL	NDF	
Peak Limitation	NDF	
Environmental Exposure		
Air, ambient	NDF	
Air, indoor	NDF	
Water, potable	NDF	
Water, recreational	NDF	
Soil, residential	NDF	
Soil, commercial/industrial	NDF	

Footnotes:

OEL = Occupational Exposure Limit

TWA= 8 h Time-Weighted Average

STEL = (15 min) Short-term Exposure Limit

NDF - No data found within the limits of the search strategy.

Project number: 127666004
Project name: Hydraulic Stimulation Chemicals Assessment, Southwest Queensland
Client name: Santos Ltd

Qualifying Summary Comments

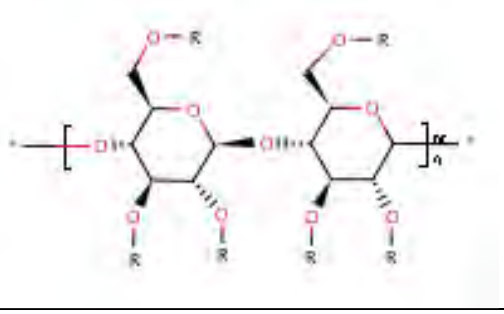
Guar Gum is extensively used in the community and is of limited acute toxicity as reflected in its use as a food additive. The Hazard Band 3 rating is a consequence of its sensitising and irritant properties which are a concern for occupationally-exposed individuals. Such exposure is unlikely following environmental distribution through hydraulic fracturing operations unless there are processes where it results in drying and accumulation of guar gum to the extent that sufficient exposure results.

References

1. HSDB (2002). *Guar Gum*. Hazardous Substances Data Bank, Toxicology Data Network (TOXNET) United States Nation Library of Medicine, 8600 Rockville Pike, Bethesda, MD 2094. [Accessed 10/07/2013].
2. Hazardous Substances and New Organisms (HSNO) 2013, Chemical Classification and Information Database (CCID). *Guar Gum*. New Zealand Environmental Protection Authority, New Zealand Government. [Accessed 10/07/2013].

Created by:	MT	Date 10 July 2013
Reviewed and edited by	LT	Date 23 July 2013 Rev0
Updated	JC	21 August 2013

Project number: 127666004
Project name: Hydraulic Stimulation Chemicals Assessment, Southwest Queensland
Client name: Santos Ltd

Name	Hydroxypropyl methylcellulose (SURROGATE FOR Hydroxypropyl cellulose 9004-64-2)
Synonyms	2-Hydroxypropyl cellulose methyl ether , 2-Hydroxypropyl methyl cellulose, Cellulose hydroxypropyl methyl ether, Cellulose, 2-hydroxypropyl methyl ether, Hydroxypropyl methyl cellulose, Hydroxypropyl methylcellulose, Hypromellose, Hypromellosum Isopto alkaline, Methocel, Methyl cellulose, propylene glycol ether, Methyl hydroxypropyl cellulose, Methylhydroxypropylcellulosum
CAS number	9004-65-3, surrogate for 9004-64-2
Molecular formula	C3-H8-O2.x-C-H4-O.x-Unspecified
Molecular Structure	

Overview	Reference
Hydroxypropyl cellulose is a derivative of cellulose with both water solubility and organic solubility. It is an organic polymer. It used as an ophthalmic lubricant (component of contact lens wetting solutions), pharmaceutics aid (suspending agent, tablet excipient, viscosity-increasing agent) and food additive (thickening agent, stabilizer and emulsifier).	US NLM (2013); U.S. FDA (2013)
The Joint Food and Agriculture Organization and the World Health Organization (FAO/WHO) Expert Committee for Food Additives (JECFA) has evaluated the food uses of modified celluloses, including hydroxypropyl cellulose, and has concluded that, as a group, modified celluloses are of very low toxicity at the levels of intake necessary to achieve the desired effect and do not pose a hazard to health.	JECFA, 1969
The U.S. Food and Drug Administration's (FDA) Committee on GRAS Substances (SCOGS) considers hydroxypropylmethyl cellulose as Generally Recognized as Safe (GRAS). It is a food additive used as a thickening agent, stabilizer and emulsifier. Hydroxypropylmethyl cellulose is synthesised from methyl cellulose by the action of alkali and propylene oxide. There are no data available to suggest that hydroxypropylmethyl cellulose possesses adverse health effects. However, teratology studies similar to those conducted with methyl cellulose are not available for its hydroxypropyl derivative. Therefore, it is suggested that, in due course, appropriate studies should be conducted with hydroxypropylmethyl cellulose. The Select Committee has weighed the foregoing and concludes that: "*There is no evidence in the available information on hydroxypropylmethyl cellulose that demonstrates, or suggested reasonable grounds to suspect, a hazard to the public when it is used at levels that are now current and in the manner now practiced*".	US FDA (2013)

Human Health Toxicity Summary	Reference
Carcinogenicity Not classified by IARC (not currently evaluated by IARC).	IARC 2013
Mutagenicity/Genotoxicity NDF.	
Reproductive Toxicity NDF.	
Developmental Toxicity/Teratogenicity NDF.	
Endocrine Disruption Not listed as an endocrine disruptor by European Commission.	EC 2000
Acute Toxicity (oral, dermal, inhalation) An industrial Bio-test Lab, conducted in 1962 and referenced by JECFA (1969) suggests the LD50 for rat, via oral exposure is10 200 mg/kg.	Industrial Bio-Test Lab, 1962, cited by JECFA (1969)
Chronic/repeat dose toxicity (oral, dermal, inhalation) Groups of five male and five female rats received in their diet 0.2 %, 1.0 % and 5.0 % of hydroxypropyl cellulose for 90 days (concentrations were not provided). Controls received unmodified cellulose at the same levels. There were no differences observed between tests and controls as regards mortality, growth, food utilization, urinalysis, haemotological indices, organ weight, gross pathology and histopathology. At higher dietary levels there were increased food consumption and decreased food utilisation consequential to the inertness of the material.	Industrial Bio-Test Lab, 1963, cited by JECFA (1969)
Sensitisation of the skin or respiratory system NDF.	
Corrosion (irreversible)/irritation (reversible) of the skin or eye NDF.	

Physical Hazards	Reference
Flammable Potential NDF.	
Explosive Potential NDF.	

Toxicity Values	Value	Reference
High Chronic/Repeat dose Toxicity		
Animal Toxicity Data		
Acute Toxicity		
LD_{50}		
Rat, oral	10 200 mg/kg	Industrial Bio-test Lab, 1962 referenced by JECFA, 1969
Rat, dermal	NDF	
Rabbit, dermal	NDF	
LOAEL	NDF	
LOAEC		
LC_{50}		
Rat	NDF	
High Chronic/Repeat dose Toxicity		
NOAEL	Estimated to be 2 500 mg/kg	JECFA, 1969
LOAEC	NDF	

Footnotes:
LD_{50} – lethal dose for 50% of experimental population
LC_{50} – lethal air concentration for 50% of experimental population
LOAEL – Lowest Observed Adverse Effect Level
LOAEC – Lowest Observed Adverse Effect Concentration
NOAEL – No Observed Adverse Effect Level

Human Health Toxicity Ranking*		
	Hazard data	**Comment**
Hazard Band 4		
Carcinogenicity	NDF	
Mutagenicity/Genotoxicity	NDF	
Reproductive Toxicity	NDF	
Developmental Toxicity/ Teratogenicity	NDF	
Endocrine Disruption[1]	No	Not listed as an endocrine disruptor by European Commission, EC 2000
Hazard Band 3		
Acute Toxicity (oral, dermal or inhalation) Very Toxic/Toxic • oral $LD_{50} \leq 300$ mg/kg[2] • dermal $LD_{50} \leq 1000$ mg/kg • inhalation $LC_{50} \leq 10$ mg/L^3 (or mg/m^3) (vapour)	No	See studies listed for Hazard Band 1
Possible carcinogenicity, mutagenicity, reproductive or High Chronic/repeat dose toxicity • oral LOAEL ≤ 10 mg/kg/d[3]; • dermal LOAEL ≤ 2 0 mg/kg/d; • inhalation LOAEC (6 h/d) ≤ 50 ppm/d for gases, ≤ 0.2 mg/L/d for vapours or ≤ 0.02 mg/L/d for dust/mists/fumes[3]	No	
Corrosive (irreversible damage)	NDF	
Respiratory sensitiser	NDF	
Hazard Band 2		
Harmful chronic/repeat dose toxicity • oral LOAEL > 10 mg/kg and ≤ 100 mg/kg/d • dermal LOAEL > 20 mg/kg/d and ≤ 200 mg/kg/d • inhalation (6-h/d) LOAEC > 50 mg/L ≤ 250 mg/L/d for gases, > 0.2 mg/L ≤ 1 .0 mg/L/d for vapours or > 0.02 mg/L ≤ 0.2 mg/L/d for dust/mists/fumes[3]	No	See studies listed for Hazard Band 1
Skin Sensitiser	NDF	
Hazard Band 1		
Acute Toxicity-Harmful • oral $LD_{50} > 300$ mg/kg ≤ 2000 mg/kg • dermal LD_{50} >1 000 mg/kg ≤ 2000 mg/kg; • inhalation LC_{50} (6 h/d) > 10 mg/L ≤ 20 mg/L for vapours)[3]	No	Oral LD_{50} for rat, oral, reported as 10 200 mg/kg
Irritant (reversible damage)	NDF	
Hazard Band 0 **All indicators outside criteria listed in Hazards 1-4**	Yes	
Physical Hazards		
Flammable potential	NDF	
Explosive potential	NDF	
Hazard Evaluation (highest band) not including physical hazards	**0**	
Uncertainty analysis /data confidence	23%	

* Based on IMAP Framework [NICNAS (2013) Inventory Multi-tiered Assessment and Prioritisation (IMAP) Framework. National Industrial Chemicals Notification and Assessment Scheme. Department of Health and Aging, Canberra].

"[1]Based on list of endocrine disrupting chemicals from the European Commission's Endocrine Disrupters website.

[2]milligrams per kilogram body mass(mg/kg) or milligrams per kilogram body mas per day (mg/kg/d)

[3] Based on GHS cut-offs for hazard classification. For chronic/repeat dose toxicity, GHS cut-offs are provided as guidance values (i.e. the dose/concentration at or below which significant health effects are observed"). (p 18, NICNAS 2013).

Human Health Guidelines		
Media	**Concentration (mg/m^3; mg/L; mg/kg)**	**Reference**
Occupational Exposure Limits		
Air (OEL)		
8-h TWA	NDF	
STEL	NDF	
Peak Limitation	NDF	
Environmental Exposure		
Air, ambient	NDF	
Air, indoor	NDF	
Water, potable	NDF	
Water, recreational	NDF	
Soil, residential	NDF	
Soil, commercial/industrial	NDF	

Footnotes:

OEL = Occupational Exposure Limit

TWA= 8 h Time-Weighted Average

STEL = (15 min) Short-term Exposure Limit

NDF - No data found within the limits of the search strategy.

Qualifying Summary Comments

Hydroxypropyl cellulose is an organic polymer which is derivative of cellulose. Based on limited available toxicology data it is considered in Hazard Band 0. However, the JECFA has evaluated the food uses of modified celluloses, including hydroxypropyl cellulose, and has concluded that, as a group, modified celluloses are of very low toxicity at the levels of intake necessary to achieve the desired effect and do not pose a hazard to human health. The SCOGS also reports there are no data available to suggest that hydroxypropylmethyl cellulose possesses adverse health effects. As these cellulose compounds are solids in powder form there is the potential for dust related inhalation hazards. In addition as an organic dust there is the potential for ignition and dust explosions. Taken collectively this hazard profile implies a negligible hazard across most toxicological parameters, however, in the case of dust generation and explosive risk, management of these occupational hazards is required.

References

EC (2000). Towards the establishment of a priority list of substances for further evaluation of their role in endocrine disruption, preparation of a candidate list of substances as a basis for priority setting, European Commission. Final Report (Incorporating corrigenda to final report dated 21 June 2000).

JECFA (1969) (JECFA), 1969. Hydroxypropyl Cellulose Evaluations of the Joint FAO/WHO Expert Committee on Food Additives Toxicology Monograph 687, FAS 26-JECFA 35/85, 1989. Available at *http://apps.who.int/food-additives-contaminants-jecfa-database/chemical.aspx?chemID=609.* [accessed 18 November 2013].

US NLM (2013) Chem ID Plus Lite Database. Hydroxypropyl methylcellulose. United States National Library of Medicine (NLM) . Available at http://chem.sis.nlm.nih.gov/chemidplus/chemidlite.jsp [Accessed 29 September 2013].

US FDA (2013). Select Committee on GRAS Substances (SCOGS) Opinion: Hydroxypropylmethyl cellulose. U.S. Food and Drug Administration, 10903 New Hampshire Avenue, Silver Spring, MD 20993. U.S. Departments of Health and Human Services. Available at http://www.fda.gov/Food/IngredientsPackagingLabeling/GRAS/SCOGS/ucm260434.htm. [accessed on 18/11/2013].

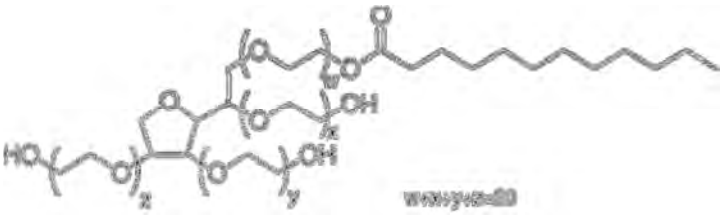
IARC (2013). Agents Classified by the *IARC Monographs*, Volumes 1–108. International Agency for Research on Cancer . Available at http://monographs.iarc.fr/ENG/Classification/index.php. [Accessed 30/10/2013]

Notes

NDF – No data found within the limits of the search strategy

Created by:	MGT	Date: 18/11/2013
Reviewed and edited by:	LT	Date: 11/12/2013

Project number: 127666004
Project name: Hydraulic Stimulation Chemicals Assessment, Southwest Queensland
Client name: Santos Ltd

Name	Sorbitan, monododecanoate, poly(oxy-1,2-ethanediyl) derivatives
Synonyms	Polysorbate 20; PEG(20)sorbitan monolaurate; PEG-10 SORBITAN LAURATE; PEG-40 SORBITAN LAURATE; PEG-44 SORBITAN LAURATE; PEG-75 SORBITAN LAURATE; PEG-80 SORBITAN LAURATE; Polyoxyethylene sorbitan monolaurate; POLYSORBATE 20; POLYSORBATE 21, Commercial brand names: Alkest TW 20 and Tween 20.
CAS number	9005-64-5
Molecular formula	$C_{58}H_{114}O_{26}$
Molecular Structure	

Overview	References
Sorbitan, mono-dodecanoate, poly(oxy-1,2-ethanediyl) derivatives, commonly referred to as Polysorbate 20, belongs to a group of polysorbates which are hydrophilic, non-ionic compounds.	
Polysorbates are widely used in industry, research, pharmacy, and food production. Polysorbate 20 is approved by the US FDA for use as emulsifiers, defoaming agents, synthetic flavorings, stabilizers and thickeners in food, cosmetics, medical products, lubricants and other applications applied up to several times a day to all areas of the skin, hair, nails, and mucous membranes with daily and/or occasional use extending over many years.	HSDB, 2010 US EPA, 2005
It has not been found on a regulatory classification list (Safework Australia).	HSIS, 2013
Sorbitan fatty acid esters and polysorbates show low acute toxicity by the oral and dermal routes and, in general, theirchronic and subchronic toxicity is also low. They show little potential for reproductive or developmental effects, and are generally not considered mutagenic or carcinogenic via oral exposure.	NS, 2008

Human Health Toxicity Summary	Reference
Carcinogenicity	
Not classified on European Chemical Agency (ECHA) database (data lacking).	ECHA,2013
IARC has not evaluated the evidence for the carcinogenicity of Sorbitan, monododecanoate, poly(oxy-1,2-ethanediyl) derivatives.Oral multi-species studies showed no evidence for carcinogenicity. Upon topical application to mice skin, the polysorbates produced benign dermal tumours. Several studies on mouse carcinoma cells have shown that the polysorbates at higher concentrations may inhibit tumour growth in vitro but not in vivo.	IARC,2013 HSDB,2010/ USEPA,2005

Mutagenicity/Genotoxicity Not classified on ECHA database (conclusive but not sufficient for classification). A study according to OECD Guideline 471 (Bacterial Reverse Mutation Assay) was carried out in vitro on test strains S. typhimurium TA 1535, TA 1537, TA 98 and TA 100 and E. coli WP2 uvr A, target genes 'his and trp operon'. The dose concentrations of test substance, PC-2012-412, were between 10 and 5000 µg/plate in the presence and absence of 5-10% S9-mix (metabolic activation system). Multiple tests were ran at varying concentrations and percentages of S9-mix. Cytotoxicity was observed in some test strains at 3330 µg/plate and greater in the presence and absence of the S9-mix. Genotoxicity was not observed in any of the strains tested with or without metabolic activation. A study according to OECD Guideline 473 (In vitro Mammalian Chromosome Aberration Test) was carried out in vitro on peripheral human lymphocytes (isolated from the blood of a healthy adult, non-smoking, male volunteers (26-31 years old)). The dose concentration of test substance, PC-2012-412, were between 10 and 800 µg/mL culture medium in the presence and absence of S9-mix. Multiple tests were run at varying concentrations, and over different exposure/fixation periods. Cytotoxicity was observed in a continuous experiment (48hr exposure and fixation period) at dose of 300 µg/mL. Genotoxicity observations were negative.	ECHA,2013
Reproductive Toxicity Not classified on ECHA database (data lacking). Reproductive toxicity induced in rats and mice by intraperitoneal injections during pregnancy was not observed in rats given the polysorbate 20 either orally or dermally.	BIBRA,1989
Developmental Toxicity/Teratogenicity Not classified on ECHA database (conclusive but not sufficient for classification). A study similar to OECD Guideline 414 (Prenatal Developmental Toxicity Study) was carried out on female Sprauge-Dawley rats. Oral dose concentrations of test substance, Polyoxyethylene sorbitan monolaurate, polysorbate 20, 500 and 5000 mg/kg bw were administered daily for a 20 day period (from gestation day 6-15). Maternal toxic effects observed decrease in weight gain, LOAEL was 5000 mg/kg bw/day and NOAEL >5000 mg/kg bw/day. No teratogenic effects observed, NOAEL >5000 mg/kg bw/day.	ECHA,2013 US EPA, 2005
Endocrine Disruption Not listed as an endocrine disruptor by European Commission.	EC,2000
Neurotoxicity No data found.	
Acute Toxicity (oral, dermal, inhalation) Not classified on ECHA database (oral and inhalation - conclusive but not sufficient for classification), (dermal – data lacking). The LD50 values for 33 acute oral toxicity studies in rats ranged between 5000 and 38,900 mgkg. A study similar to OECD Guideline 402 (Acute Dermal Toxicity) was carried out on albino guinea pigs exposed to test substance Polysorbate 20 (3000mg/kg) via dermal contact for 24	USEPA, 2005

hours. No controls used. No observations of toxicity and no gross pathology abnormalities at necropsy. LD50 >3000 mg/kg bw. A study according to OECD Guideline 403 (Acute Inhalation Toxicity) carried out on rats via 4 hour inhalation exposure to the nose, test substance, PC-2012-412, concentration 5.1 mg/L. No control animals used. No mortalities occurred, no clinical observations of systemic toxicity over 14 day period and no gross pathology abnormalities at macroscopic examination. LC50 >5.1mg/L air. An intravenous acute toxicity study was undertaken on Wistar rats, predating toxicity classifications. A 50% (w/v) solution of the test substance in propylene glycol was administered via tail vein infusion. Dose concentrations of 795, 1000, 1260, 1410 and 1580 mg/kg bw. No control animals. Toxicity observations of depression, laboured respiration ataxia and convulsions. Gross pathology observations on mortalities of congested lungs, clotted blood in hearts. For test rats who survived, no remarkable gross pathology observations. LD50 1380 mg/kg bw.	ECHA,2013
Chronic/repeat dose toxicity (oral, dermal, inhalation) Not classified on ECHA database (conclusive but not sufficient for classification). A study predating toxicity classification was undertaken on rats. Test substance, polyoxyethylene sorbitan monolaurate 21 at 2000 mg/kg bw/day in the diet of male rats for a 2 year period. Controls used. No observations of mortality, systemic toxicology or gross pathology. NOAEL >2000mg/kg bw/day. On repeated intravenous administration, effects on the liver, spleen and kidneys were seen in premature babies (animals) exposed to polysorbate 80:polysorbate 20 mixture and some fatalities occurred. In rats and hamsters, repeated oral exposure to polysorbate 20 produced damage at a range of sites including the gastro-intestinal tract, liver and kidneys. No data found for dermal or inhalation chronic toxicity.	ECHA,2013/ US EPA, 2005 BIBRA,1989
Sensitisation of the skin or respiratory system Not classified on ECHA database (skin - conclusive but not sufficient for classification and respiratory system – data lacking). A study according to OECD Guideline 406 (Skin Sensitisation) was carried out in vivo on female guinea pigs. Controls used. Clinical observations 72 hours after exposure indicate that test substance, PC-2012-412 administered interdermal and on skin surface is not sensitising. No data found for respiratory system.	ECHA,2013
Corrosion (irreversible)/irritation (reversible) effects on the skin or eye Not classified on ECHA database (conclusive but not sufficient for classification). A study according to OECD Guideline 404 (Acute Dermal Irritation / Corrosion) was carried out in vivo on New Zealand White rabbits. Dose concentration of test substance, PC-2012-412, 0.5mL, applied over 4 hr, 14 day observation period. Slight erythema (score of 0.89/4) but not oedema was observed, these slight effects fully reversed within 7 days. A study according to OECD Guideline 405 (Acute Eye Irritation / Corrosion) was carried out in	ECHA,2013

vivo on New Zealand White rabbits. Untreated eyes were the controls. Test material (0.1mL) single application, washed or unwashed after 2 seconds. Observations over 7 days indicate negative results for conjunctivae, iris and cornea, therefore results are non-irritating. Primary rabbit skin irritation studies using the Draize method were performed, with 6 studies showing no signs of irritation, 3 studies showing minimal irritation, and one study showing mild irritation. All of these studies used 100% concentrations of polysorbate, 20, 40, 60, or 80. The polysorbates were non-irritating to mildly irritating in both in-vivo and in-vitro ocular irritation assays (CIR 2000). Twenty-three Draize rabbit eye irritation studies of the polysorbates showed either no irritation or minimal irritation using concentrations ranging between 30% w/v in distilled water and 100% polysorbate 20,2 1,40, 60,61,65, 80, 8 1, or 85	US EPA, 2005

Physical Hazards	Reference
Flammable Potential Flashpoint >149°C. Flashpoint >148.9 °C	NS, 2008 FDA, 2010
Explosive Potential No data found.	

Toxicity Values	Value	Reference
Human Toxicity Data		
High Chronic/Repeat Dose Toxicity		
LOAEC	No data found (NDF)	
LOAEL	NDF	
Animal Toxicity Data		
Acute Toxicity		
LD_{50}		
Rodents, oral	5000mg/kg	EPA,2005
Mouse, oral	NDF	
Rabbit, oral	NDF	
Guinea pig, dermal	>3000 mg/kg bw	ECHA, 2013
Rabbit, dermal	NDF	
Rats, intravenous	1380 mg/kg bw	ECHA, 2013
LC_{50}		
Rat, inhalation	>5.1mg/L	ECHA, 2013
High Chronic/Repeat Dose Toxicity		
LOAEL	NDF	
LOAEC	NDF	
NOAEL, rats, oral	>2000 mg/kg bw/day	ECHA, 2013

Footnotes:
LD_{50} – lethal dose for 50% of experimental population
LC_{50} – lethal air concentration for 50% of experimental population
LOAEL – Lowest Observed Adverse Effect Level
LOAEC – Lowest Observed Adverse Effect Concentration
Conclusive data: means that the study itself was conclusive in its reported finding, but was not sufficient for classifying the material according to ECHA guidelines.

Human Health Toxicity Ranking*		
	Hazard data	**Comment**
Hazard Band 4		
Carcinogenicity (IARC Group 1 or 2A)	No	ECHA, 2013, US EPA, 2005
Mutagenicity/Genotoxicity (GHS Category 1A and 1B)	No	ECHA,2013
Reproductive Toxicity/Developmental toxicity (GHS Category 1, 1A and 1B)	No	BIBRA,1989
Endocrine Disruption[1]	No	EU, 2000
Hazard Band 3		
Carcinogenicity (IARC Group 2B)	No	ECHA, 2013, US EPA, 2005
Mutagenicity/Genotoxicity (GHS Category 2)	No	ECHA,2013
Reproductive Toxicity/Developmental toxicity (GHS Category 2)	No	BIBRA,1989
Acute Toxicity (oral, dermal or inhalation) Very Toxic/Toxic • oral $LD_{50} \leq 300$ mg/kg[3] • dermal $LD_{50} \leq 1000$ mg/kg inhalation $LC_{50} \leq 10$ mg/L[4] (or mg/m^3) (vapour)	No	Oral, rats LD50 5000mg/kg USEPA,2005 Dermal, guinea pig LD50 >3000mg/kg bw Intravenous, rat LD50 1380mg/kg bw Inhalation, rat LD50 >5.1mg/L ECHA, 2013
Possible carcinogenicity, mutagenicity, reproductive or High Chronic/repeat dose toxicity • oral LOAEL ≤ 10 mg/kg/d[3]; • dermal LOAEL ≤ 2 0 mg/kg/d; • inhalation LOAEC (6 h/d) ≤ 50 ppm/d for gases, ≤ 0.2 mg/L/d for vapours or ≤ 0.02 mg/L/d for dust/mists/fumes[4]	No	Oral study – Maternal toxicity LOAEL 5000 mg/kg bw/day NOAEL >5000 mg/kg bw/day teratogenicity toxicity NOAEL >5000 mg/kg bw/day. ECHA, 2013
Corrosive (irreversible effect)	No	ECHA, 2013 USEPA, 2013
Respiratory sensitiser	NDF	
Hazard Band 2		
Harmful chronic/repeat dose toxicity • oral LOAEL > 10 mg/kg and ≤ 100 mg/kg/d • dermal LOAEL > 20 mg/kg/d and ≤ 200 mg/kg/d • inhalation (6-h/d) LOAEC > 50 mg/L ≤ 250 mg/L/d for gases, > 0.2 mg/L ≤ 1 .0 mg/L/d for vapours or > 0.02 mg/L ≤ 0.2 mg/L/d for dust/mists/fumes[4]	No	Oral, rats NOAEL >2000mg/kg bw/day
Skin Sensitiser	No	ECHA, 2013
Hazard Band 1		
Acute Toxicity-Harmful • oral $LD_{50} > 300$ mg/kg ≤ 2000 mg/kg • dermal LD_{50} >1 000 mg/kg ≤ 2000 mg/kg; • inhalation LC_{50} (6 h/d) > 10 mg/L ≤ 20 mg/L for vapours)[4]	No	Oral, rats LD50 5000mg/kg USEPA,2005 Dermal, guinea pig LD50 >3000mg/kg bw Intravenous, rat LD50 1380mg/kg bw Inhalation, rat LD50 >5.1mg/L

		ECHA, 2013
Irritant (reversible effect)	Yes	ECHA,2013
Hazard Band 0 **All indicators outside criteria listed in Hazards 1-4**		
Physical Hazards		
Flammable potential	Yes	NS, 2008 FDA, 2010
Explosive potential	NDF	
Hazard Evaluation (highest band) not including physical hazards	1	
Uncertainty analysis /data confidence (out of 12 parameters)	11/12	**92%**

* Based on IMAP Framework [NICNAS (2013) Inventory Multi-tiered Assessment and Prioritisation (IMAP) Framework. National Industrial Chemicals Notification and Assessment Scheme. Department of Health and Aging, Canberra].

"[1] *Based on list of endocrine disrupting chemicals from the European Commission's Endocrine Disrupters website.*

[2] *Neurotoxicity based on REACH assessments.*

[3] *milligrams per kilogram body mass(mg/kg) or milligrams per kilogram body mas per day (mg/kg/d)*

[4] *Based on GHS cut-offs for hazard classification. For chronic/repeat dose toxicity, GHS cut-offs are provided as guidance values (i.e. the dose/concentration at or below which significant health effects are observed"). (p 18, NICNAS 2013).*

Human Health Guidelines		
Media	**Concentration (mg/m^3; mg/L; mg/kg)**	**Reference**
Occupational Exposure Limits		
Air (OEL)	NDF	
8-h TWA	NDF	
STEL	NDF	
Peak Limitation		
Environmental Exposure		
Air, ambient	NDF	
Air, indoor	NDF	
Water, potable	NDF	
Water, recreational		
Soil, residential	NDF	
Soil, commercial/industrial	NDF	

Footnotes:
OEL = Occupational Exposure Limit
TWA= 8 h Time-Weighted Average
STEL = (15 min) Short-term Exposure Limit

Qualifying Summary Comments

Polysorbate 20 is a non hazardous substance with a variety of uses including food, medicine and cosmetics. Polysorbate 20's can result in transient mild irritant effects. as observed in animal studies with some limited human evidence of the potential for sensitisation. The most likely exposure to these chemicals is via the dermal route, however a low concern for human health effects is anticipated based on their low potential for irritation and dermal absorption on intact skin. Polysorbate is categorised as hazard band 1, due to reversible irritation.

The direct use of this substance by workers (or those acutely exposed through emergency spills) presents as the main hazard that could be realised and would be the subject of management controls. It is not anticipated that incorporation at low concentrations into hydraulic fracturing mixtures and environmental dissemination would observe the above adverse outcomes following exposure to hydraulic fracturing fluids. Further evaluation of resultant mixtures is required to support this interpretation.

References and Notes

European Chemicals Agency (ECHA) (2013) Sorbitan monolaurate, ethoxylated. Available at: <http://apps.echa.europa.eu/registered/data/dossiers/DISS-dffb4072-e33d-47ae-e044-00144f67d031/AGGR-cbca8e7d-d960-410d-9a51-57023442a95f_DISS-dffb4072-e33d-47ae-e044-00144f67d031.html#GEN_RESULTS_HD> [Accessed 5 December 2013].

European Commission (EC) (2000) Towards the establishment of a priority list of substances for further evaluation of their role in endocrine disruption, preparation of a candidate list of substances as a basis for priority setting, Final Report (Incorporating corrigenda to final report dated 21 June 2000).

Hazardous Substance Data Bank (HSDB), Toxnet, toxicology data network – Polysorbate 20 (2010). Available at <http://toxnet.nlm.nih.gov/cgi-bin/sis/search/f?./temp/~QpjLUp:> [Accessed 5 December 2013].

IARC (2012) Agents classified by IARC Monographs Volumes 1- 105. Available at http://monographs.iarc.fr/ENG/Classification/ClassificationsGroupOrder.pdf. [Accessed 5 December 2013].

Natural Sourcing (NS), Specialists in Cosmeceutical Ingedients, MSDS Polysorbate 20, Avaliable at: <http://www.naturalsourcing.com/msds/MSDS_Polysorbate_20.pdf>[Accessed 5 December 2013].

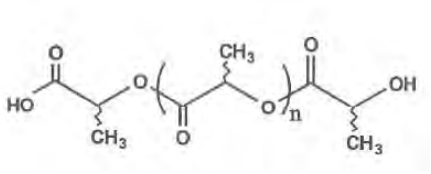
Safework Australia (SWA) (2013) Hazardous Substances Information System (HSIS). Available at: <http://hsis.safeworkaustralia.gov.au/HazardousSubstance> [Accessed 5 December 2013].

United States Environmental Protection Agency (EPA) (2005) Office of Prevention, Pesticides and Toxic Substances: Action Memorandum: Inert Reassessment – Members of the Sorbitan Fatty Acid Esters and the Polysorbates. Available at: <http://www.epa.gov/opprd001/inerts/sorbitan5-20-05.pdf>[Accessed 5 December 2013].

NDF - No data found within the limits of the search strategy.

Created by:	CS	Date: 5/12/2013
Reviewed by:	JF	Date 13/12/2013

Project number: 127666004
Project name: Hydraulic Stimulation Chemicals Assessment, Southwest Queensland
Client name: Santos Ltd

Name	Polylactide resin
Synonyms	Not Applicable
CAS number	9051-89-2
Molecular formula	(C6H8O4.C6H8O4.C6H8O4)x
Molecular Structure	

Overview	References
Polylactide (PLA), a polymer derived from lactic acid (2-hydroxy propionic acid). PLA is a solid resin (powder or pellets) and is insoluble in water. PLA can hydrolyse in water to form lactic acid. Migrants from PLA may include lactic acid, lactoyl-lactic acid, other small oligomers of PLA and lactide. However, lactic acid is the primary substance of interest as the other species are expected to ultimately hydrolyse to lactic acid in the media commonly found in food systems or in the human digestive track. As a result the human health toxicology data has been predominantly based on lactic acid, with a few inferences made from calcium lactate where lactic acid data was not available.	
PLA offers several technical properties that make it useful in a variety of food and pharmaceutical applications. Particularly, the moisture and oxygen barrier properties of this polymer make it useful in food and pharmaceutical flexible packaging and in certain rigid pack applications.	FDA (2013)
Some of the common food packaging applications of PLA include short shelf life products such as containers, drinking cups, sundae and salad cups, overwrap and lamination films and blister packages. Newer applications include thermoformed PLA containers being used in retail markets for fresh fruit and vegetables.	FDA (2009)
Furthermore, PLA has been widely studied for use in medical applications because of its bioresorbable and biocompatible properties in the human body.	Conn *et al.* (1995)
PLA has been assessed by the US Food and Drug Administration. It is non-hazardous. The Safety assessment of PLA is based on lactic acid which is a raw material in PLA manufacture and a hydrolysis product. Other studies have done safety assessments on the use of PLA for food packaging and concluded that PLA is safe or use for fabricating articles that will hold and/or package food. This is primarily due to the studies finding that the amount of lactic acid and its derivatives that migrate to food simulant solutions from PLA is much lower than the current average dietary lactic acid intake values allowed by several government agencies.	Auras *et al.* (2004)
Lactic acid is produced in varying amounts by most living tissues as a normal metabolic intermediate. The lactate turnover rate in man has been estimated to be of the order of 2g per kg per day. It is generally recognised as safe. When present in the neat form it is a hazardous substance as it can cause severe eye irritation and moderate skin irritation.	

Human Health Toxicity Summary	Reference
Carcinogenicity Not classified as to its carcinogenicity to humans. *Notes:* The long-term toxicity carcinogenicity of calcium lactate, a food additive, was examined in a rat study. Calcium lactate was given in the drinking-water at levels of 0, 2 5 or 5% to groups of 50 male and 50 female rats for two years. No clear toxic lesion was specifically caused by long-term administration of calcium lactate. No significant dose-related increase was found in the incidences of tumours in any organ or tissue The results indicated that calcium lactate had neither toxic nor carcinogenic activity in the rats. Based on this data and lactic acid being a major metabolic species, and a ubiquitous food ingredient, carcinogenicity was considered an irrelevant end point.	ECHA (2013)
Mutagenicity/Genotoxicity Not classified as a mutagenic/genotoxic chemical.	ECHA (2013)
Reproductive Toxicity Not classified as having reproductive toxicity effects.	ECHA (2013)
Developmental Toxicity/Teratogenicity Not classified as having developmental toxic/teratogenic effects	ECHA (2013)
Endocrine Disruption PLA or lactic acid have not been included in the European Commission's Endocrine Disrupters Priority List.	ECED (2013)
Neurotoxicity No information found.	All proposed data sources
Acute Toxicity (oral, dermal, inhalation) Not classified as having acute toxic effects when administered orally, applied to the skin or when inhaled. *Notes:* Lactic acid was administered to rats by oral gavage. The LD_{50} is higher than the upper limit for classification (2000 mg/kg bw). The LD_{50} of 3543 mg/kg was reported for the female rats and an LD_{50} of 4936 mg/kg for the male rats. Acute dermal toxicity was evaluated by applying 2000 mg/kg to the skin (clipped free of hair and abraded) of 5 male and 5 female rabbits for 24 hours of exposure. No abnormal clinical signs were observed during the 14 day study. It was concluded that the application was irritating but otherwise practically non-toxic. Male and female rats were exposed to a concentration of approximately 7.94 mg/L for four hours to determine any acute inhalation toxicity. Rapid breathing and eye tearing were observed during exposure however, most of the animals appeared normal at 24 hours and for the remainder of the 14 day observation period (with the exception of one female rat that died on day nine). The LC_{50} is greater than 7.94 mg/L.	ECHA (2013)
Chronic/repeat dose toxicity (oral, dermal, inhalation) Not classified as having chronic oral, dermal or inhalation effects. *Notes:* Calcium lactate was administered orally to rats for 13 weeks. All observed effects could be attributed to calcium overload/imbalance. No lactate toxicity was observed.	ECHA (2013)

Lactic acid was applied dermally to rates at a concentration of 886 mg/kg. All animals survived to study termination. No significant gross observations, with the exception of minimal skin irritation throughout the study.	
Sensitisation of the skin or respiratory system Not classified as a skin or respiratory sensitiser.	
Corrosion (irreversible and reversible)/irritation of the skin or eye Causes skin irritation (GHS Skin Irritation Category 2). Causes serious eye irritation (GHS Eye Irritation Category 1). *Notes:* Primary dermal irritation potential was evaluating by the application of the chemical to intact and abraded test sites on the skin of 6 albino rabbits covered with impervious bandages for 24 hours. Severe conditions were observed including severe erythema, severe edema and missing skin. Lactic acid was examined undiluted for eye irritating/corrosive potential in an ex-vivo bioassay, namely the Enucleated Eye Test with chicken eyes (CEET). The results showed that it induced severe corneal effects.	ECHA (2013)

Physical Hazards	Reference
Flammable Potential Not classified as a flammable liquid. Lacking data for classification in the solids, gases and aerosols forms.	ECHA (2013)
Explosive Potential Not classified as an explosive chemical.	ECHA (2013)

Toxicity Values	Value	Reference
Human Toxicity Data		
Acute Toxicity		
High Chronic/Repeat Dose Toxicity		
NOEC	Lactic acid is produced in varying amounts by most living tissues as a normal metabolic intermediate. The lactate turnover rate in man has been estimated to be of the order of 2g per kg per day.	FDA (2013)
LOAEL		
Animal Toxicity Data		
Acute Toxicity		
LD_{50}		
Rat, oral	3543 mg/kg (female), 4936 mg/kg (male)	ECHA 2013
Mouse, oral		
Rabbit, oral		
Rat, dermal		
Rabbit, dermal	>2000 mg/kg	ECHA 2013
Mouse, dermal		
LOAEL		

LOAEC		
LC_{50}		
Rat	>7.94 mg/L	ECHA 2013
High Chronic/Repeat Dose Toxicity		
LOAEL		
LOAEC		

Footnotes:
LD_{50} – lethal dose for 50% of experimental population
LC_{50} – lethal air concentration for 50% of experimental population
LOAEL – Lowest Observed Adverse Effect Level
LOAEC – Lowest Observed Adverse Effect Concentration

Human Health Toxicity Ranking*		
	Hazard data	**Comment**
Hazard Band 4		
Carcinogenicity	NO	
Mutagenicity/Genotoxicity	NO	
Reproductive Toxicity	NO	
Developmental Toxicity/ Teratogenicity	NO	
Endocrine Disruption[1]	NO	
Hazard Band 3		
Acute Toxicity (oral, dermal or inhalation) Very Toxic/Toxic • oral LD_{50} ≤ 300 mg/kg[3] • dermal LD_{50} ≤ 1000 mg/kg • inhalation LC_{50} ≤ 10 mg/L[4] (or mg/m^3) (vapour)	NO	
Possible carcinogenicity, mutagenicity, reproductive or High Chronic/repeat dose toxicity • oral LOAEL ≤ 10 mg/kg/d[3]; • dermal LOAEL ≤ 2 0 mg/kg/d; • inhalation LOAEC (6 h/d) ≤ 50 ppm/d for gases, ≤ 0.2 mg/L/d for vapours or ≤ 0.02 mg/L/d for dust/mists/fumes[4]	NO	
Corrosive (irreversible damage)	NO	Lactic acid can cause serious eye damage given its relatively high solubility and low molecular weight. PLA is not expected to cause serious eye damage as it is less soluble and its physical form as a resin prevents intimate contact with the mucous membrane.
Respiratory sensitiser	NO	
Hazard Band 2		
Harmful chronic/repeat dose toxicity • oral LOAEL > 10 mg/kg and ≤ 100 mg/kg/d • dermal LOAEL > 20 mg/kg/d and ≤ 200 mg/kg/d • inhalation (6-h/d) LOAEC > 50 mg/L ≤ 250 mg/L/d for gases, > 0.2 mg/L ≤ 1 .0 mg/L/d for vapours or > 0.02 mg/L ≤ 0.2 mg/L/d for dust/mists/fumes[4]	NO	
Skin Sensitiser	NO	
Hazard Band 1		
Acute Toxicity-Harmful • oral LD_{50} > 300 mg/kg ≤ 2000 mg/kg • dermal LD_{50} >1 000 mg/kg ≤ 2000 mg/kg; • inhalation LC_{50} (6 h/d) > 10 mg/L ≤ 20 mg/L for vapours)[4]	NO	
Irritant (reversible damage)	YES	Causes skin irritation (based on lactic acid).

Hazard Band 0 **All indicators outside criteria listed in Hazards 1-4**		
Physical Hazards		
Flammable potential	NO	Not classified as a flammable liquid. Data lacking for solid, gas and aerosol forms.
Explosive potential	NO	
Hazard Evaluation (highest band) not including physical hazards	Band 1	
Uncertainty analysis /data confidence	13/13	**100%**

* Based on IMAP Framework [NICNAS (2013) Inventory Multi-tiered Assessment and Prioritisation (IMAP) Framework. National Industrial Chemicals Notification and Assessment Scheme. Department of Health and Aging, Canberra].

"[1]Based on list of endocrine disrupting chemicals from the European Commission's Endocrine Disrupters website.

[2] Based on list of neurotoxic chemicals from US Agency for Toxic Substances and Disease Registry (ATSDR).

[3] milligrams per kilogram body mass(mg/kg) or milligrams per kilogram body mas per day (mg/kg/d)

[4] Based on GHS cut-offs for hazard classification. For chronic/repeat dose toxicity, GHS cut-offs are provided as guidance values (i.e. the dose/concentration at or below which significant health effects are observed"). (p 18, NICNAS 2013).

Human Health Guidelines		
Media	**Concentration (mg/m^3; mg/L; mg/kg)**	**Reference**
Occupational Exposure Limits		
Air (OEL)	No data found.	All proposed data sources.
8-h TWA	No data found.	All proposed data sources.
STEL	No data found.	All proposed data sources.
Peak Limitation	No data found.	All proposed data sources.
Environmental Exposure		
Air, ambient	No data found.	All proposed data sources.
Air, indoor	No data found.	All proposed data sources.
Water, potable	No data found.	All proposed data sources.
Water, recreational	No data found.	All proposed data sources.
Soil, residential	No data found.	All proposed data sources.
Soil, commercial/industrial	No data found.	All proposed data sources.

Footnotes:

OEL = Occupational Exposure Limit

TWA= 8 h Time-Weighted Average

STEL = (15 min) Short-term Exposure Limit

NDF - No data found within the limits of the search strategy.

Qualifying Summary Comments

PLA has been assessed by the US Food and Drug Administration and has been classified as non-hazardous where the safety assessment of PLA was based on lactic acid. It is approved for use in food packaging and for use in some therapeutic product applications. Lactic acid has been used as a surrogate for the hazard profile because it is the raw material in PLA manufacture and a hydrolysis product. Furthermore, the other migrants from PLA are expected to ultimately hydrolyse to lactic acid in the media commonly found in food systems or in the human digestive track. Based on similar approach (i.e. using lactic acid data), other safety assessments on the use of PLA for food packaging and concluded that PLA is safe or use for fabricating articles that will hold and/or package food. Although lactic acid is considered as generally recognised as safe it can cause severe eye irritation and moderate skin irritation when in its neat form. Given that polylactide is relatively less soluble and is present in a resin form with a higher molecular weight it is unlikely to cause the same degree of irritation to the eye or skin. On this basis polylactide was categorised as Hazard Band 1.

References and Notes

Auras R., Harte B. and Selke D (2004). An Overview of Polylactides as Packaging Materials. Macromolecular Bioscience. Vol. 4, pp. 835-864.

Conn R.E, Kolstad J.J., BorzelleCa J.F., Dixler D.S., Filer L.J., LaDu, Jr, B.N. and Pariza M.W. (1995). Safety Assessment of Polylactide (PLA) for Use as a Food-contact Polymer, Fd. Chem. Tox. Vol.33, No.4, pp.273-283

ECED (2013) European Commission's Endocrine Disrupters Priority List http://ec.europa.eu/environment/endocrine/strategy/substances_en.htm#priority_list/ [Accessed 3 September 2013]

ECHA (2013) European Chemicals Agency) Classification and Labelling Inventory Database. Available at http://apps.echa.europa.eu/registered/data/dossiers/DISS-9d98ad08-1f3b-2a26-e044-00144f67d249/AGGR-58133d46-163f-4924-a788-00a7ae469396_DISS-9d98ad08-1f3b-2a26-e044-00144f67d249.html#L-d56b04f9-c773-4e6e-b619-c3c9bae8a8d6 [Accessed 4 September 2013]

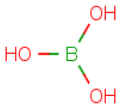
FDA (2009). U.S. Food and Drug Administration, Attachment 9: Environmental Assessment. Available at http://www.fda.gov/downloads/Food/FoodIngredientsPackaging/EnvironmentalDecisions/UCM214608.pdf [Accessed 4 September 2013]

FDA (2013). U.S. Food and Drug Administration. Database of Select Committee on GRAS Substances (SCOGS) Reviews, L(+)-lactic acid. Accessed from http://www.accessdata.fda.gov/scripts/fcn/fcnDetailNavigation.cfm?rpt=scogslisting&id=180. [Accessed 4 September 2013]

Project number: 127666004
Project name: Hydraulic Stimulation Chemicals Assessment, Southwest Queensland
Client name: Santos Ltd

Created by:	JH	Date 2/9/13
Reviewed and edited by:	JF	Date 5/9/13

Project number: 127666004
Project name: Hydraulic Stimulation Chemicals Assessment, Southwest Queensland
Client name: Santos Ltd

Name	Boric Acid
Synonyms	Hydrogen borate; boracic acid; acidum boricum; trihydroxidoboron
CAS number	10043-35-3
Molecular formula	H_3BO_3
Molecular Structure	

Overview	References
Boric acid is an inorganic, white, odourless, crystalline solid with a water solubility of approximately 49.2 g/L at 20°C.	ECHA (2013)
The substance decomposes on heating above 100°C, producing water and the irritant boric anhydride. The solution in water is a weak acid.	ICPS (1994)
Low concentrations of simple inorganic borates (e.g. boric acid, disodium tetraborate pentahydrate, boric oxide and disodium octaborate tetrahydrate) will predominately exist as un-dissociated boric acid in aqueous solutions at physiological and acidic pH. At about pH10 the metaborate anion ($B(OH)_4^-$) becomes the main species in solution. This leads to the conclusion that the main species in the plasma of mammals and in the environment is un-dissociated boric acid.	ECHA (2014)/ WHO (1998)
Boric acid is classified as a hazardous substance by Safe Work Australia, within its Hazardous Substances Information System, with associated safety phrases of "*Risk Phase R60 (may impair fertility)*" and "*R61 (may cause harm to the unborn child)*".	SafeWork (2009)
Boric acid is also a classified substance according to the Global Harmonised System (GHS) classification.	ECHA (2014)
The US EPA (2004) states that the main uses of boric acid (and sodium salts of boron (primarily borax, or disodium tetraborate decahydrate)) are: • industrial purposes including manufacture of glass, fiberglass insulation, porcelain enamel, ceramic glazes, and metal alloys • as fire retardants in cellulose insulation • laundry additives • fertilisers (boron is an essential element for plants) • herbicides (at high concentrations, boron is toxic to certain plant species) • insecticides.	US EPA (2004)

Human Health Toxicity Summary	Reference
Carcinogenicity ECHA (2014) states that '*an OECD 451 study in mice consisting of 50 per sex per group treated in diet for 103 weeks with 0 ppm, 2,500 ppm or 5,000 ppm boric acid showed no evidence of carcinogenicity (NTP classification meaning no chemically related increase in benign or malignant neoplasms)*'. IARC have not reviewed the carcinogenicity of boric acid. The US EPA has classified boric acid as Group E – evidence of non-carcinogenicity for humans.	ECHA (2014) IARC (2011), US EPA (2006)
Mutagenicity/Genotoxicity ECHA report a study in male and female mice following oral administration at doses of 0 mg/kg/d, 225 mg/kg/d, 450 mg/kg/d, 900 mg/kg/d, 1 800 mg/kg/d and 3 500 mg/kg/d of boric acid in distilled water over a 2 day period. Boric acid at the concentrations used in the study was not reported as being genotoxic.	ECHA (2014)
Reproductive Toxicity ECHA (2014) reports that boric acid may damage fertility or the unborn child with a subsequent classification of Category 1B. Short- and long-term oral exposures to boric acid or borax in laboratory animals have demonstrated that the male reproductive tract is a consistent target of toxicity. Testicular lesions have been observed in rats, mice, and dogs given boric acid or borax in food or drinking-water. A three-generation study in rats was undertaken at doses of 0 ppm, 670 ppm, 2 000 ppm or 6 700 ppm boric acid in the diet. Rats exposed to the highest dose were sterile and evidence of decreased ovulation was observed in about half of the ovaries examined from the females exposed to the highest dose. There were no adverse effects on reproduction reported at the lower doses with a LOAEL for reproductive toxicity of 336 mg/kg.	ECHA (2014)
Developmental Toxicity/Teratogenicity The teratogenicity of the test substance was assessed according to OECD guideline 414. There was no evidence of developmental toxicity in offspring of rats fed boric acid in diet throughout gestation up to a dose of 0.075 % (55 mg/kg boric acid). At 0.1 % boric acid (76 mg/kg boric acid) effects such as reduced fetal bodyweight and short and wavy ribs were observed with more marked effects at the highest dose of 0.2 % (143 mg/kg boric acid).	ECHA (2014)
Endocrine Disruption Not listed as an endocrine disruptor by European Commission.	BKH (2000)
Neurotoxicity NDF.	
Acute Toxicity (oral, dermal, inhalation) **Oral** An acute oral LD_{50} value of >2 600 mg/kg was determined from a study on rats in which the animals were administered doses of anhydrous boric acid at concentrations of 1 540 mg/kg or 2 600 mg/kg. No symptoms were observed for animals dosed at 1,540 mg/kg. Six groups of 5 male and 5 female rats were orally administered boric acid as 50% w/v suspension in 0.5% aqueous methyl cellulose at 2 000 mg/kg, 2 500 mg/kg, 3 160 mg/kg, 3 980 mg/kg, 5 010 mg/kg and 6 310 mg/kg. The rats were then observed at 1 h, 2 h, 4 h, and 24 h intervals and then once a day for a total of 14 days. The LD_{50} for male rats was determined as 3,450 (2,950 – 4,040) mg boric acid/kg, and as 4,080 (3,640 – 4,560) mg boric acid/kg for female rats. A study of 45 rats determined an oral LD_{50} of 2 660 mg/kg. Test conditions such as the number of animals per dose, the doses and the use of control groups was not provided.	ECHA (2014)

Symptoms included signs of central nervous system depression, ataxia and convulsions. **Inhalation:** Five male and five female rats were exposed to an aerosol of boric acid for a duration of 4 h and 9 m at a maximum dose of ~ 2 mg/L. The animals were then observed for a total of 14 days following exposure. An LC_{50} of > 2.03 mg/L air was determined from the results of the study. Five female and five male rats were exposed to boric acid dust at an analytical concentration of 2,120 ± 140 mg/m^3 over a 4 h period. The animals were then observed for a total of 14 days. An LC_{50} of > 2.12 mg/L was determined from the study. **Dermal:** Boric acid at a concentration of 2 000 mg/kg (moistened with 1.5 mL saline) was applied to the skin of five male and five female rabbits and removed following a 24 h period. The rabbits were observed for a 14 day period following administration. An LD_{50} of >2 000 mg/kg was determined from the study with clinical changes observed being erythema, oedema, atonia, desquamation, necrosis and some incidences of skin irritation following 24 h of treatment.	ECHA (2014) ECHA (2014)
Chronic/repeat dose toxicity (oral, dermal, inhalation) A 2 year dietary feeding study in rats at a dose rate of 0 ppm, 670 ppm, 2 000 ppm and 6 690 ppm boric acid, equivalent to 0 mg boric acid/kg/d, 33 mg boric acid/kg/d, 100 mg boric acid/kg/d and 334 mg boric acid/kg/d was undertaken. Testicular atrophy and seminiferous tubule degeneration was observed at 6, 12 and 24 months at the highest dose level only. No treatment related effects were observed in the mid and low dose groups. A NOAEL of 100 mg boric acid/kg/d (nominal) and LOAEL of 334 mg boric acid/kg/d (nominal) were reported.	ECHA (2014)
Sensitisation of the skin or respiratory system A 95 % w/w (400 mg) boric acid moistened with distilled water was applied to the skin of twenty guinea pigs with '*very faint erythema observed in one animal at induction stage and 2 animals at challenge stage and also in one naïve control. No other adverse effects were observed therefore the test substance was considered a non-sensitiser'.* In a supporting study within ECHA (2014) three patients (human) were patch tested with 3% w/v boric acid. No sensitisation was reported.	ECHA (2014)
Corrosion (irreversible)/irritation (reversible) effects on the skin or eye **Skin** Boric acid was applied to the skin of ten rabbits at a concentration of 0.5 g (moistened with physiological saline) for a 24 h period with subsequent observations over a 72 h period. No irritancy was observed. Boric acid was applied to six rabbits with intact and 6 rabbits with abraded skin at a concentration of 5 mL as a 10 % solution on a cellulose pad. The study concluded that at 10% boric acid was not considered irritating to skin. The same study was also undertaken on guinea pigs with the same conclusion reached. Anhydrous boric acid 100 mesh (concentration not specified) was applied to the skin of 6 rabbits for a 4 h period with subsequent observations for a 48 h period. The study concluded that the test substance was not considered corrosive to the skin. **Eye** Boric acid (100 mg) was applied to one eye each of 6 rabbits for a period of 24 h with boric acid used at up to 5 % in eye washes. The animals were observed for a 21 day period following application. It was reported that boric acid applied to the eye at this concentration was slightly irritating based on changes in colouration and texture of the eye and blistered appearance of the conjunctiva. These effects were reversed after seven days. Additional studies in rabbits have reported similar results demonstrating reversible eye irritation	ECHA (2014)

with increasing severity in cases where the anhydrous form was retained within the eye.	

Physical Hazards	Reference
Flammable Potential The results of one study classified boric acid as non-flammable based on the boric acid crystals not igniting during the test.	ECHA (2014)
Explosive Potential NDF.	

Toxicity Values	Value	Reference
Human Toxicity Data		
High Chronic/Repeat Dose Toxicity		
LOAEC	NDF	
LOAEL	NDF	
Animal Toxicity Data		
Acute Toxicity		
LD_{50}		
Rat, oral	>2 600 mg/g 3 450 mg/kg (male) 4 080 mg/kg (female) 2 660 mg/kg	ECHA (2014)
Mouse, oral	3 450 mg/kg	ECHA (2014)
Rat, dermal	NDF	
Rabbit, dermal 24 h	>2 000 mg/kg	
Mouse, dermal	NDF	
LC_{50}		
Rat (inhalation) 2 h aerosol	>2.03 mg/L (4 h) >2.12 mg/L (4 h, dust)	ECHA (2014)
Mouse (inhalation) 2 h aerosol	NDF	
Guinea Pig (inhalation) 2 h aerosol	NDF	
High Chronic/Repeat Dose Toxicity		
LOAEL	Oral 336 mg/kg/d (reproductive toxicity) 334 mg/kg/d (	ECHA (2014)
LOAEC	NDF	
NOAEL	Oral 100 mg/kg/d (	ECHA (2014)

Footnotes:
LD_{50} – lethal dose for 50% of experimental population
LC_{50} – lethal air concentration for 50% of experimental population
LOAEL – Lowest Observed Adverse Effect Level
LOAEC – Lowest Observed Adverse Effect Concentration
NOAEL – No Observed Adverse Effect Level
NDF – no data found within the limits of the search strategy

Human Health Toxicity Ranking*		
	Hazard data	**Comment**
Hazard Band 4		
Carcinogenicity (IARC Group 1 or 2A)	No	ECHA (2014), Not evaluated by IARC (IARC, 2011) US EPA (2006)
Mutagenicity/Genotoxicity (GHS Category 1A and 1B)	No	ECHA (2014)
Reproductive Toxicity/Developmental toxicity (GHS Category 1, 1A and 1B)	Yes	Classified as Category 1B, may damage fertility or the unborn child (ECHA, 2014)
Endocrine Disruption[1]	No	Not listed as an endocrine disruptor by European Commission (BKH, 2000)
Hazard Band 3		
Carcinogenicity (IARC Group 2B)	No	See above
Mutagenicity/Genotoxicity (GHS Category 2)	No	ECHA (2014)
Reproductive Toxicity/Developmental toxicity (GHS Category 2)	No	ECHA (2014)
Acute Toxicity (oral, dermal or inhalation) Very Toxic/Toxic • oral LD_{50} ≤ 300 mg/kg[3] • dermal LD_{50} ≤ 1000 mg/kg inhalation LC_{50} ≤ 10 mg/L[4] (or mg/m^3) (vapour)	No	Lowest LD_{50} found during search was 2 660 mg/kg. Lowest dermal LD_{50} found was >2 000 mg/kg (ECHA, 2014)
Possible carcinogenicity, mutagenicity, reproductive or High Chronic/repeat dose toxicity • oral LOAEL ≤ 10 mg/kg/d[3]; • dermal LOAEL ≤ 20 mg/kg/d; • inhalation LOAEC (6 h/d) ≤ 50 ppm/d for gases, ≤ 0.2 mg/L/d for vapours or ≤ 0.02 mg/L/d for dust/mists/fumes[4]	No	Lowest oral LOAEL for reproductive toxicity (boric acid) found during search was 334 mg/kg/d (ECHA, 2014)
Corrosive (irreversible effect)	No	ECHA (2014)
Respiratory sensitiser	NDF	
Hazard Band 2		
Harmful chronic/repeat dose toxicity • oral LOAEL > 10 mg/kg and ≤ 100 mg/kg/d • dermal LOAEL > 20 mg/kg/d and ≤ 200 mg/kg/d • inhalation (6 h/d) LOAEC > 50 mg/L ≤ 250 mg/L/d for gases, > 0.2 mg/L ≤ 1 .0 mg/L/d for vapours or > 0.02 mg/L ≤ 0.2 mg/L/d for dust/mists/fumes[4]	No	Lowest oral LOAEL for reproductive toxicity (boric acid) found during search was 334 mg/kg/d (ECHA, 2014)
Skin Sensitiser	No	ECHA (2014)
Hazard Band 1		
Acute Toxicity-Harmful • oral LD_{50} > 300 mg/kg ≤ 2,000 mg/kg • dermal LD_{50} >1,000 mg/kg ≤ 2,000 mg/kg; • inhalation LC_{50} (6 h/d) > 10 mg/L ≤ 20 mg/L for vapours)[4]	No	Lowest oral LD_{50} found during search was 2 600 mg/kg (ECHA, 2014) Lowest dermal LD_{50} found was >2 000 mg/kg (ECHA, 2014)

Irritant (reversible effect)	Yes	One study concluded that at 100 mg boric acid was considered irritating to the eyes of rabbits (ECHA, 2014)
Hazard Band 0 **All indicators outside criteria listed in Hazards 1-4**	No	
Physical Hazards		
Flammable potential	No	ECHA (2014)
Explosive potential	NDF	
Hazard Evaluation (highest band) not including physical hazards	4	
Uncertainty analysis /data confidence (out of 12 parameters)	10/12	**83%**

** Based on IMAP Framework [NICNAS (2013) Inventory Multi-tiered Assessment and Prioritisation (IMAP) Framework. National Industrial Chemicals Notification and Assessment Scheme. Department of Health and Aging, Canberra].*

"[1]Based on list of endocrine disrupting chemicals from the European Commission's Endocrine Disrupters website.
[2] Neurotoxicity based on REACH assessments.
[3] milligrams per kilogram body mass (mg/kg) or milligrams per kilogram body mass per day (mg/kg/d)
[4] Based on GHS cut-offs for hazard classification. For chronic/repeat dose toxicity, GHS cut-offs are provided as guidance values (i.e. the dose/concentration at or below which significant health effects are observed"). (p 18, NICNAS 2013).

Human Health Guidelines		
Media	**Concentration (mg/m^3; mg/L; mg/kg)**	**Reference**
Occupational Exposure Limits		
Air (OEL)		
8-h TWA	NDF	
STEL	NDF	
Peak Limitation	NDF	
Environmental Exposure		
Air, ambient	NDF	
Air, indoor	NDF	
Water, potable	4 mg boron/L	ADWG (2011)
Water, recreational	As above	NHMRC (2008)
Soil, residential	4,500 mg boron/kg	NEPM, 2013
Soil, commercial/industrial	300,000 mg boron/kg	NEPM, 2013

Footnotes:

OEL = Occupational Exposure Limit

TWA= 8 h Time-Weighted Average

STEL = (15 min) Short-term Exposure Limit

Qualifying Summary Comments

Boric acid is an inorganic, white, odourless, crystalline solid. Its primary uses (along with sodium salts of boron (primarily borax, or disodium tetraborate decahydrate)) are in industrial processes such as the manufacture of glass, as a fire retardant, in laundry additives, in fertilisers and in herbicides. Low concentrations of simple inorganic borates (e.g. boric acid, disodium tetraborate pentahydrate, boric oxide and disodium octaborate tetrahydrate) will predominately exist as un-dissociated boric acid in aqueous solutions at physiological and acidic pH. Boric acid was assigned a Human Health Toxicity Ranking of Hazard Band 4 based on research supporting a potential to cause reproductive toxicity. (In addition, anhydrous boric acid and aqueous solutions have been reported as being irritating to the eye. While acute exposures under occupational settings require management, including cases of inadvertent large scale spills (emergency response) boron and inorganic salts of boron should not be allowed to enter surface waters or waters scheduled for human use. Should the latter arise, monitoring and management measures would be required due to the persistence of boron under aqueous conditions and the potential for human exposures.

References

ADWG 2011, National Water Quality Management Strategy, *Australian Drinking Water Guidelines 6*, Australian Government, National Health and Medical Research Council, National Resource Management Ministerial Council.

BKH 2000, BKH Consulting Engineers. *Towards the establishment of a priority list of substances for further evaluation of their role in endocrine disruption: - preparation of a candidate list of substances as a basis for priority setting*. Final report (incorporating corrigenda to final report dated 21 June 2000), Annex 10: List of 564 substances with their selection criteria. Available at http://ec.europa.eu/environment/archives/docum/pdf/bkh_main.pdf [Accessed 8/01/2014]

ECHA 2014, European Chemical Agency, 2007 – 2014.

Available at http://apps.echa.europa.eu/registered/data/dossiers/DISS-9c85f941-5dd4-6d9c-e044-00144f67d249/AGGR-d776bdf6-1cdb-412e-9be4-30d52fe0ebb7_DISS-9c85f941-5dd4-6d9c-e044-00144f67d249.html#AGGR-d776bdf6-1cdb-412e-9be4-30d52fe0ebb7 [Accessed 8/01/2014]

HSDB 2012, *Boric Acid*. Hazardous Substances Data Bank, TOXNET. National Institutes of Health, Department of Health & Human Services U.S. National Library of Medicine.
8600 Rockville Pike, Bethesda, MD 20894. Available at http://toxnet.nlm.nih.gov/cgi-bin/sis/search/f?./temp/~Eehvgx:1 [Accessed 14/01/2014].

IARC 2011, International Agency for Research on Cancer (IARC). Available at http://monographs.iarc.fr/ENG/Classification/index.php. [database accessed 08/01/2014].

IPCS (International Programme on Chemical Safety) Inchem 1994, *International Chemical Safety Card 0991*. Available at http://www.inchem.org/documents/icsc/icsc/eics0991.htm [Accessed 9/01/2014].

NEPM (National Environment Protection (Assessment of Site Contamination) Amended Measure) 2013, (No.1). *Schedule B1: Guidelines on Investigation Levels for Soil and Groundwater*. National Environment Protection Council, Commonwealth Government of Australia.

NHMRC (National Health and Medical Research Council) 2008, *Guidelines for Managing Risks in Recreational Water*. Australian Government. Available at http://www.nhmrc.gov.au/_files_nhmrc/publications/attachments/eh38.pdf [Accessed 7/01/2014]

SafeWork Australia 2009, Hazardous Substance Information System (HSIS): *Boric Acid*. Available at http://hsis.safeworkaustralia.gov.au/HazardousSubstance/Details?hazardousSubstanceID=5860 [Accessed 08/01/2014]

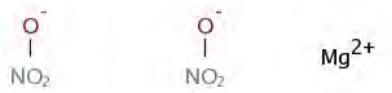
US EPA (United States Environmental Protection Agency) 2004, *Toxicological Review of Boron Compounds*, (CAS No. 7440-42-8), In Support of Summary Information on the Integrated Risk Information System (IRIS). Available at http://www.epa.gov/iris/toxreviews/0410tr.pdf [Accessed 9/01/2014]

US EPA 2006, *Chemicals Evaluated for Carcinogenic Potential*. Office of Pesticide Programs, Health Effects Division, Science Information Management Branch (as cited in HSDB, 2012).

WHO (World Health Organization) 1998, *Guidelines for drinking-water quality*, 2nd Edition, Addendum to Volume 1. Available at http://www.who.int/water_sanitation_health/dwq/2edaddvol1.pdf [Accessed: 20/11/2013]

Created by:	CM	09/01/2014
Reviewed::	LT	16/01/2014

Project number: 127666004
Project name: Hydraulic Stimulation Chemicals Assessment, Southwest Queensland
Client name: Santos Ltd

Name	Magnesium nitrate
Synonyms	Nitric acid; magnesium salt; magnesium dinitrate
CAS number	10377-60-3
Molecular formula	$Mg(NO_3)_2$
Molecular Structure	

Overview	References
Magnesium nitrate is a water soluble inorganic salt that appears as colourless or white cubic crystals. It is very hygroscopic and in air quickly forms the hexahydrate with the formula $Mg(NO_3)_2.6H_2O$. Magnesium nitrate is used in fertiliser, as a catalyst in the manufacture of petrochemicals, as a desensitiser for lithographic plates and in pyrotechnics. Magnesium nitrate hexahydrate (CAS number 13446-18-9) is a common commercial form of magnesium nitrate. Magnesium nitrate itself is not flammable or explosive but is classified as an oxidising solid which will react with reducing materials and enhance combustion of other substances. The substance decomposes on heating (at 330 ^{o}C) and in a fire may emit toxic NO_x fumes of oxides of nitrogen. Absorption of the substance may occur through the gastrointestinal system, inhalation and through dermal contact. The substance will readily dissociate into the magnesium cation and nitrate anion. Magnesium cations are integral components of normal human metabolic processes and are metabolised in the human body through well-understood pathways. Nitrate is a naturally occurring ion which is part of the nitrogen cycle. Nitrate is a natural constituent of soil and vegetation and is a normal metabolite in mammals. Methemoglobinemia is the primary adverse health effect associated with human exposure to high levels of nitrate. A nuisance-causing concentration of airborne particles can be reached quickly when dispersed; occupational exposure limits have not been established. Magnesium nitrate solution (with <5% calcium nitrate and <5% nitric acid) is classified as a skin irritant and causes serious eye damage. No LD/LC_{50} values were specifically found for magnesium nitrate. It was considered appropriate to consider information relating to the health effects of nitrates based on dissolution of the inorganic compound and the low hazard properties of magnesium in solution. LD_{50} ratings for sodium nitrate are indicated in the table below	USEPA (2005); ECHA (2013); Ropp, (2013); IPCS (1996)

Human Health Toxicity Summary	Reference
Carcinogenicity Currently not evaluated by IARC.	IARC (2013)
Mutagenicity/genotoxicity ECHA has not reported this substance to be mutagenic or genotoxic. An in vitro Salmonella typhimurium reverse mutation assay and Escherichia coli reverse mutation assay concluded that magnesium nitrate hexahydrate did not exhibit any mutagenic activity under the conditions of the test. An in vitro mammalian chromosome aberration test and mammalian cell gene mutation assay carried out for sodium nitrate (CAS number 7631-99-4) concluded that the substance did not exhibit any mutagenic activity under the conditions of the test.	ECHA (2013)
Reproductive Toxicity ECHA has not reported this substance to be toxic to the reproductive system. No adverse effects were seen on reproductive toxicity endpoints during a reproduction/developmental toxicity screening test carried out for potassium nitrate on male and female rats (gavage). The maximum dose was 1500 mg/kg/day.	ECHA (2013)
Developmental Toxicity/Teratogenicity ECHA has not reported this substance to be toxic to development. No adverse effects were seen on developmental toxicity endpoints during a reproduction/developmental toxicity screening test carried out for potassium nitrate on male and female rats (gavage). The maximum dose was 1500 mg/kg/day.	ECHA (2013)
Endocrine Disruption Not listed as an endocrine disruptor.	EC (2000)
Neurotoxicity No data available.	
Acute toxicity (Oral, Dermal or Inhalation) ECHA has not reported this substance to be acute toxic. *Oral* Classification based on an oral acute toxicity study for magnesium nitrate hexahydrate; the substance does not require classification under the GHS. A single dose of 2000 mg/kg was provided by gavage to six (two subsequent groups of three animals) female rats (Wistar). No mortality occurred and no abnormalities were found at macroscopic post mortem examination of the animals. *Dermal* Classification based on a dermal acute toxicity study for potassium nitrate, the substance does not require classification under the GHS. A maximum dose (dermal, occlusive) of 5000 mg/kg was applied to male/female rats (Sprague-Dawley). All animals survived, gained weight and appeared active and healthy. There were no signs of gross toxicity, adverse pharmacologic effects or abnormal behaviour. *Inhalation* ECHA has reported that this substance does not require classification under the GHS (conclusive data). No further details were found. A nuisance-causing concentration of airborne particles can be reached quickly when dispersed; occupational exposure limits have not been established. Exposure may cause mechanical irritation to the respiratory tract.	ECHA (2013); IPCS (2003)

Chronic/repeat dose toxicity (oral, dermal, inhalation) *Oral* No adverse effects were seen on general toxicity endpoints during a repeated dose toxicity study carried out for potassium nitrate on male and female rats (Sprague-Dawley). Rats were provided daily doses by gavage at concentrations of 0 mg/kg, 250 mg/kg, 750 mg/kg and 1,500 mg/kg for 28 days. *Dermal* NDF *Inhalation* NDF	ECHA (2013)
Sensitisation of the skin or respiratory system Not classified as a skin sensitiser by ECHA. Data lacking regarding respiratory sensitisation. An *in-vivo* mouse local lymph node assay concluded that magnesium nitrate hexahydrate was not a skin sensitisor. The substance was tested at concentrations of 0%, 10%, 25% and 50%.	ECHA (2013)
Corrosion (irreversible)/irritation (reversible) effects on the skin or eye Magnesium nitrate in its solid form (anhydrous) is not classified as corrosive or irritating to the skin or eyes by ECHA. Magnesium nitrate solution (with <5% calcium nitrate and <5% nitric acid) is classified as a skin irritant (Skin Irrit. 2 H315) and causes serious eye damage (Eye Damage 1 H318). Further information about the study used for this classification was not available. Classified under the GHS as a Category 1 eye irritant which indicated that effects are irreversible.	ECHA (2013)

Physical Hazards	Reference
Flammable Potential Non-flammable. Magnesium nitrate is classified as an oxidising solid (Oxid. Solid H272) which may intensity fire.	ECHA (2013)
Explosive Potential Not explosive.	ECHA (2013)

Toxicity Values	Value	Reference
Human Toxicity Data		
High Chronic/Repeat Dose Toxicity		
NOAEL	≥1,500 mg/kg, potassium nitrate	ECHA (2013)
LOAEC	NDF	
LOAEL	NDF	
Animal Toxicity Data		
Acute Toxicity		
LD_{50}		
Rat, oral	3,236 mg/kg, sodium nitrate	WHO JECFA (1996)
Mouse, oral	2,480 to 6250 mg/kg, sodium nitrate	WHO JECFA (1996)
Rabbit, oral	1,600 mg/kg, sodium nitrate	WHO JECFA (1996)
Rat, dermal	NDF	
Rabbit, dermal	NDF	
Mouse, dermal	NDF	
LC_{50}		
Rat	NDF	

High Chronic/Repeat Dose Toxicity		
LOAEL	NDF	
LOAEC	NDF	
NOAEC (rats and mice)	NDF	

Footnotes:
LD_{50} – lethal dose for 50% of experimental population
LC_{50} – lethal air concentration for 50% of experimental population
LOAEL – Lowest Observed Adverse Effect Level
LOAEC – Lowest Observed Adverse Effect Concentration
NDF – no data found within the limits of the search strategy
Conclusive data: means that the study itself was conclusive in its reported finding, but was not sufficient for classifying the material according to ECHA guidelines.

Human Health Toxicity Ranking*		
	Hazard data	**Comment**
Hazard Band 4		
Carcinogenicity (IARC Group 1 or 2A)	NDF	IARC (2013)
Mutagenicity/Genotoxicity (GHS Category 1A and 1B)	No	ECHA (2013)
Reproductive Toxicity/Developmental toxicity (GHS Category 1, 1A and 1B)	No	ECHA (2013)
Endocrine Disruption[1]	No	ECHA (2013)
Hazard Band 3		
Carcinogenicity (IARC Group 2B)	NDF	ECHA (2013)
Mutagenicity/Genotoxicity (GHS Category 2)	No	ECHA (2013)
Reproductive Toxicity/Developmental toxicity (GHS Category 2)	No	ECHA (2013)
Acute Toxicity (oral, dermal or inhalation) Very Toxic/Toxic • oral LD_{50} ≤ 300 mg/kg [3] • dermal LD_{50} ≤ 1000 mg/kg inhalation LC_{50} ≤ 10 mg/L [4] (or mg/m^2) (vapour)	No	ECHA (2013)
Possible carcinogenicity, mutagenicity, reproductive or High Chronic/repeat dose toxicity • oral LOAEL ≤ 10 mg/kg/d [3]; • dermal LOAEL ≤ 2 0 mg/kg/d; inhalation LOAEC (6 h/d) ≤ 50 ppm/d for gases, ≤ 0.2 mg/L/d for vapours or ≤ 0.02 mg/L/d for dust/mists/fumes [4]	No	ECHA (2013)(NDF regarding carcinogenicity)
Corrosive (irreversible effect)	Yes	ECHA (2013)
Respiratory sensitiser	NDF	
Hazard Band 2		
Harmful chronic/repeat dose toxicity • oral LOAEL > 10 mg/kg and ≤ 100 mg/kg/d • dermal LOAEL > 20 mg/kg/d and ≤ 200 mg/kg/d • inhalation (6-h/d) LOAEC > 50 mg/L ≤ 250 mg/L/d for gases, > 0.2 mg/L ≤ 1 .0 mg/L/d for vapours or > 0.02 mg/L ≤ 0.2 mg/L/d for dust/mists/fumes [4]	No	ECHA (2013)
Skin Sensitiser	No	ECHA (2013)
Hazard Band 1		
Acute Toxicity-Harmful • oral LD_{50} > 300 mg/kg ≤ 2000 mg/kg • dermal LD_{50} >1 000 mg/kg ≤ 2000 mg/kg; • inhalation LC_{50} (6 h/d) > 10 mg/L ≤ 20 mg/L for vapours)[4]	No	ECHA (2013)
Irritant (reversible effect)	Yes	ECHA (2013)
Hazard Band 0 **All indicators outside criteria listed in Hazards 1-4**		
Physical Hazards		
Flammable potential	No	ECHA (2013)
Explosive potential	No	ECHA (2013)
Hazard Evaluation (highest band) not including physical hazards	**Band 3**	
Uncertainty analysis /data confidence (out of 12 parameters)	10/12	**83%**

* Based on IMAP Framework [NICNAS (2013) Inventory Multi-tiered Assessment and Prioritisation (IMAP) Framework. National Industrial Chemicals Notification and Assessment Scheme. Department of Health and Aging, Canberra].

"[1]*Based on list of endocrine disrupting chemicals from the European Commission's Endocrine Disrupters website.*

[2] *Based on list of neurotoxic chemicals from US Agency for Toxic Substances and Disease Registry (ATSDR).*
[3] *milligrams per kilogram body mass (mg/kg) or milligrams per kilogram body mass per day (mg/kg/d)*

[4] *Based on GHS cut-offs for hazard classification. For chronic/repeat dose toxicity, GHS cut-offs are provided as guidance values (i.e. the dose/concentration at or below which significant health effects are observed)". (p 18, NICNAS 2013).*

Human Health Guidelines		
Media	**Concentration (mg/m^3; mg/L; mg/kg)**	**Reference**
Occupational Exposure Limits		
Air (OEL)		
8-h TWA	NDF	
STEL	NDF	
Peak Limitation	NDF	
Environmental Exposure		
Air, ambient	NDF	
Air, indoor	NDF	
Water, potable	Nitrate - 50	ADWG (2011)
Water, recreational	Nitrate - 10	ANZECC/ARMCANZ (2000)
Soil, residential	NDF	
Soil, commercial/industrial	NDF	

Footnotes:

OEL = Occupational Exposure Limit

TWA= 8-h Time-Weighted Average

STEL = (15 min) Short-term Exposure Limit

Qualifying Summary Comments

Magnesium nitrate is a water soluble inorganic salt that appears as colourless or white cubic crystals. In its solid form (anhydrous) it is not classified as corrosive or irritating to the skin or eyes, however, magnesium nitrate solution can cause skin irritation and serious (irreversible) eye damage. It has a low order of acute oral toxicity but in solution the generation of nitrates and their potential reduction to nitrites is the basis for the Australian potable water quality guidelines. These water quality guidelines are established on the basis of protection from the effects of nitrites which may cause methaemoglobinaemia (reduction of haemoglobin), particularly in infants. Magnesium nitrate is not classified as a mutagen or reproductive toxicant. It has not been reviewed for carcinogenicity. On the basis of serious eye damage it is categorised as Hazard Band 3. A broad range of toxicological data have been identified providing some confidence to the hazard profile for magnesium nitrate (as the nitrate). The report of the corrosivity properties are considered the main concern for this chemical. On this basis, the public health concerns are restricted to occupational exposures from direct contact with pure product and emergency spill settings as specific environmental concerns for public health. Environmental concerns may only be realised in cases where magnesium nitrate (and hence the nitrate in solution) enters a potable water source. In such cases determination of the nitrate concentrations would be required.

References

ADWG (2011) Australian Drinking Water Guidelines. National Health and Medical Research Council. Available from http://www.nhmrc.gov.au/_files_nhmrc/publications/attachments/eh52_aust_drinking_water_guidelines.pdf

ANZECC/ARMCANZ (2000) Australian and New Zealand Guidelines for Fresh and Marine Water Quality: Volume 1 - The Guidelines. Agriculture and Resources Management Council of Australia and New Zealand (ARMCANZ) and the Australian and New Zealand Environment and Conservation Council (ANZECC). Available at: http://www.environment.gov.au/system/files/resources/53cda9ea-7ec2-49d4-af29-d1dde09e96ef/files/nwqms-guidelines-4-vol1.pdf [Accessed 09 January 2014]

EC (2000) Towards the establishment of a priority list of substances for further evaluation of their role in endocrine disruption Final Report (Incorporating corrigenda to final report dated 21 June 2000) – Annex 10: List of 564 substances with their selection criteria - European Commission (EC). Available at: http://ec.europa.eu/environment/archives/docum/pdf/bkh_main.pdf [Accessed 09 January 2014]

ECHA (2013) European Chemical Agency (ECHA) Registered Substances List Dossier for magnesium nitrate (cas no 10377-60-3). Available at: http://echa.europa.eu/web/guest/information-on-chemicals/registered-substances . [Accessed 06 January 2014]

IARC (2013) International Agency for Research on Cancer (IARC). Agents Classified by the IARC Monographs, Volumes 1–109. Available at: http://monographs.iarc.fr/ENG/Classification/ClassificationsAlphaOrder.pdf . [Accessed 09 January 2014]

IPCS (1996) Poisons Information Monograph (Group Monograph) G016: Nitrates and Nitrites, INCHEM International Program on Chemical Safety (IPCS). Available at: http://www.inchem.org/documents/pims/chemical/pimg016.htm [Accessed 09 January 2014]

IPCS (2003) Magnesium nitrate information card. INCHEM International Program on Chemical Safety (IPCS). Available at: http://www.inchem.org/documents/icsc/icsc/eics1041.htm. [Accessed 9 January 2014]

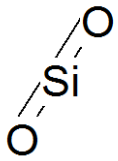
Ropp, R.C. (2013) Encyclopedia of the Alkaline Earth Compounds. Elsevier, Kidlington, Oxford, pp. 216-218.

USEPA (2005) Action Memorandum. Office of Prevention, Pesticides and Toxic Substances. Available at: http://www.epa.gov/opprd001/inerts/nitrate.pdf [Accessed 9 January 2014]

WHO JECFA (Joint Expert Committee on Food Additives). (1996), WHO Food Additives Series, No.35. Available at: http://www.inchem.org/pages/jecfa.html [Accessed 6 July 2011].

Created by:	MH	13/01/2014
Reviewed and edited by:	LT	16/01/2014

Project number: 127666004
Project name: Hydraulic Stimulation Chemicals Assessment, Southwest Queensland
Client name: Santos Ltd

Name	Cristobalite
Synonyms	Crystalline silica, cristobalite, crystalline silicon dioxide, cristobalite
CAS number	14464-46-1
Molecular formula	SiO_2
Molecular Structure	

Overview	References
Silicon is the second most abundant chemical element, after oxygen, in the earth's crust accounting for 28.15% of its mass and quartz, is by far the most common form of silica in nature, comprising 12% by volume of the Earth's crust. It is a frequently occurring solid component of most natural mineral dusts. Colourless or white crystals which are solid at room temperature and have a melting point of 1713°C – 1728°C. Cristobalite has very similar physio-chemical properties to quartz. Human exposures to crystalline silica occur most often during occupational activities that involve the movement of earth, disturbance of silica-containing products (masonry, concrete, dolomite), or the use in the manufacture of silica containing products. Environmental exposure to ambient quartz dust may occur during natural, industrial and agricultural activities. Silicosis is the critical effect for hazard identification and risk assessment in the occupational environment.	IARC (2011) INCHEM (1997) and OECD (2011)

Human Health Toxicity Summary	Reference
Carcinogenicity There is sufficient evidence in humans for the carcinogenicity of inhaled crystalline silica in the form of quartz or cristobalite from occupational sources. There is sufficient evidence in experimental animals for the carcinogenicity of quartz and cristobalite. Crystalline silica inhaled in the form of quartz or cristobalite from occupational sources is carcinogenic to humans (Group 1). US EPA A2, suspected human carcinogen. /Silica, Crystalline - alpha-Quartz (14808-60-7, 1317-95-9); and Cristobalite (14464-46-1). Respirable quartz dust particles can be inhaled and deposited in the deep parts of the lung. There	IARC (2011), ACGIH (2008)

are many epidemiological cohort studies of workers exposed to respirable quartz dust. Silicosis, lung cancer and pulmonary tuberculosis are associated with occupational exposure to quartz dust.	IARC (2011)
Mutagenicity/Genotoxicity Most cellular genotoxicity assays with crystalline silica have been performed with quartz samples. Some studies gave positive results, but most were negative. *Hprt* mutation assays in rat alveolar epithelial cells, both *in vitro* and *in vivo,* were positive in response to quartz. The actual concentrations were 3 and 50 mg/m^3 for crystalline and amorphous silica respectively. The animals were exposed for 13 weeks. Mutation frequency was greatly increased only in the crystalline silica treated rats; no treatment related increase was found in the rats treated with the amorphous form. In an 8-OHdG assay conducted to monitor DNA damage by reactive oxygen species, female rats were exposed to 0, 0.3, 1.5 and 7.5 mg/animal of quartz via intratracheal instillation. Effects were observed 90 days post-exposure. A clear dose-response relationship was identified between quartz exposure and various inflammation markers. Similarly, in another study, 8-OHdG and DNA strand breaks were observed at concentrations of or above 10 µg/m^3 in rat lung epithelial cells.	IARC 1997 OECD (2011)
Reproductive Toxicity No data available.	
Developmental Toxicity/Teratogenicity No data available.	
Endocrine Disruption No data available.	
Neurotoxicity Effects on the nervous system were not reported in either acute or repeat dose toxicity studies.	
Acute Toxicity (oral, dermal, inhalation) No data available	
Chronic/repeat dose toxicity (oral, dermal, inhalation) A study of over 9 days conducted in mice identified a LOAEC of 10 mg/m^3. The conditions of the study are not noted but are said to be similar to the previous study discussed in the paper which exposed rats to 0, 10 or 100 mg/m^3 of cristobalite via inhalation for 6 hours/day during 3 days, with animals observed 3 months after exposure. In a 4-week inhalation study, female rats were exposed to 0, 0.1, 1 or 10 mg/m^3 of quartz 6 hours/day, 5 days/week. A LOAEC of 1 mg/m^3 was identified at 24 weeks. In two separate studies, in which rats or hamsters were exposed to quartz via inhalation for at least 6 months, LOAECs of 2 and 3 mg/m^3 were identified, respectively. All the effects observed were related to inflammation and fibrosis of the lung tissue. Several chronic studies investigated exposure of the respirable forms (i.e. accumulated via inhalation in the lung tissues) of quartz and cristobalite to rats, mice and hamsters. In the study in which the lowest non neoplastic LOAEC was observed, groups of 50 rats/sex were exposed 6 hr/day, 5 days/week for 24 months to filtered air or 1 mg/m^3 of DQ-12 quartz, containing 74% of respirable quartz, through whole-body inhalation. An additional 50 rats/sex were exposed to 5 mg/m^3 of titanium dioxide as positive controls. The mean mass of particle at the end of the exposure period was 0.91 mg/lung. The LOAEC identified was 0.74 mg/m^3 (adjusted for 74% respirable quartz). In studies relating to humans, LOAECs, based on the critical endpoint of radiographic confirmed silicosis were determined at 0.053 mg/m^3 (mean exposure) - study of South African gold miners, and 0.064 mg/m^3 (mean exposure) – study of a mining community population-based random sample survey in Colorado.	OECD (2011)
Sensitisation of the skin or respiratory system No data available.	

Corrosion (irreversible)/irritation (reversible) effects on the skin or eye No data available.	

Physical Hazards	Reference
Flammable Potential Not flammable.	HSDB (2002)
Explosive Potential Not explosive.	HSDB (2002)

Toxicity Values	Value	Reference
Human Toxicity Data		
High Chronic/Repeat Dose Toxicity		
LOAEC	0.053 mg/m^3 (mean exposure)	OECD (2011)
LOAEL	No data found.	
Animal Toxicity Data		
Acute Toxicity		
LD_{50}		
Rat, oral	No data found.	
Mouse, oral	No data found.	
Rabbit, oral	No data found.	
Rat, dermal	No data found.	
Rabbit, dermal	No data found.	
Mouse, dermal	No data found.	
LC_{50}		
Rat	No data found.	
High Chronic/Repeat Dose Toxicity		
LOAEL	No data found.	
LOAEC	0.74 mg/m^3	For rats via the inhalation pathway - adjusted for 74% respirable quartz (OECD, 2011). Lowest value taken from 'Chronic' section above.

Footnotes:
LD_{50} – lethal dose for 50% of experimental population
LC_{50} – lethal air concentration for 50% of experimental population
LOAEL – Lowest Observed Adverse Effect Level
LOAEC – Lowest Observed Adverse Effect Concentration

Human Health Toxicity Ranking*		
	Hazard data	**Comment**
Hazard Band 4		
Carcinogenicity (IARC Group 1 or 2A)	Yes	Classified as Group 1 carcinogen (IARC, 2011)
Mutagenicity/Genotoxicity (GHS Category 1A and 1B)	No	
Reproductive Toxicity/Developmental toxicity (GHS Category 1, 1A and 1B)	No	
Endocrine Disruption[1]	No	
Hazard Band 3		
Carcinogenicity (IARC Group 2B)	No	IARC (2011)
Mutagenicity/Genotoxicity (GHS Category 2)	No	
Reproductive Toxicity/Developmental toxicity (GHS Category 2)	No	
Acute Toxicity (oral, dermal or inhalation) Very Toxic/Toxic • oral LD_{50} ≤ 300 mg/kg[3] • dermal LD_{50} ≤ 1000 mg/kg inhalation LC_{50} ≤ 10 mg/L[4] (or mg/m^3) (vapour)	No	
Possible carcinogenicity, mutagenicity, reproductive or High Chronic/repeat dose toxicity • oral LOAEL ≤ 10 mg/kg/d[3]; • dermal LOAEL ≤ 2 0 mg/kg/d; • inhalation LOAEC (6 h/d) ≤ 50 ppm/d for gases, ≤ 0.2 mg/L/d for vapours or ≤ 0.02 mg/L/d for dust/mists/fumes[4]	Yes	Mean exposure in a study of South African gold miners (OECD, 2011) LOAEC (Lung) at 0.053 mg/m^3
Corrosive (irreversible effect)	No	
Respiratory sensitiser	No data found.	
Hazard Band 2		
Harmful chronic/repeat dose toxicity • oral LOAEL > 10 mg/kg and ≤ 100 mg/kg/d • dermal LOAEL > 20 mg/kg/d and ≤ 200 mg/kg/d • inhalation (6-h/d) LOAEC > 50 mg/L ≤ 250 mg/L/d for gases, > 0.2 mg/L ≤ 1 .0 mg/L/d for vapours or > 0.02 mg/L ≤ 0.2 mg/L/d for dust/mists/fumes[4]	No	Categorised as Hazard Band 3 for repeat effects,
Skin Sensitiser	No data found	
Hazard Band 1		
Acute Toxicity-Harmful • oral LD_{50} > 300 mg/kg ≤ 2000 mg/kg • dermal LD_{50} >1 000 mg/kg ≤ 2000 mg/kg; • inhalation LC_{50} (6 h/d) > 10 mg/L ≤ 20 mg/L for vapours)[4]	No	
Irritant (reversible effect)	No	
Hazard Band 0 **All indicators outside criteria listed in Hazards 1-4**	No	
Physical Hazards		
Flammable potential	No	
Explosive potential	No	
Hazard Evaluation (highest band) not including physical hazards	4	Group 1 carcinogen
Uncertainty analysis /data confidence (out of 12 parameters)	10/12	**83%**

* Based on IMAP Framework [NICNAS (2013) Inventory Multi-tiered Assessment and Prioritisation (IMAP) Framework. National Industrial Chemicals Notification and Assessment Scheme. Department of Health and Aging, Canberra].

"[1]Based on list of endocrine disrupting chemicals from the European Commission's Endocrine Disrupters website.
[2] Neurotoxicity based on REACH assessments.
[3] milligrams per kilogram body mass(mg/kg) or milligrams per kilogram body mas per day (mg/kg/d)

[4] Based on GHS cut-offs for hazard classification. For chronic/repeat dose toxicity, GHS cut-offs are provided as guidance values (i.e. the dose/concentration at or below which significant health effects are observed"). (p 18, NICNAS 2013).

Human Health Guidelines		
Media	**Concentration (mg/m^3; mg/L; mg/kg)**	**Reference**
Occupational Exposure Limits		
Air (OEL)		
8-h TWA	0.1 mg/m^3	Safe Work Australia (2011)
STEL	No	Safe Work Australia (2011)
Peak Limitation	No	Safe Work Australia (2011)
Environmental Exposure		
Air, ambient	No data found	
Air, indoor	No data found	
Water, potable	No data found	
Water, recreational	No data found	
Soil, residential	No data found	
Soil, commercial/industrial	No data found	

Footnotes:

OEL = Occupational Exposure Limit

TWA= 8 h Time-Weighted Average

STEL = (15 min) Short-term Exposure Limit

Qualifying Summary Comments

Respirable crystalline silica is ubiquitous in its global distribution but presents a serious inhalation hazard for sustained exposures to elevated atmospheric concentrations of particulates. In terms of environmental distribution and persistence, silica does not degrade under standard temperature and pressure conditions and thus distribution is widespread. Cristobalite has been given a Hazard Band 4 ranking due to the carcinogenicity of this mineral via the inhalation pathway. The primary concern for human health when using this mineral in hydraulic fracturing operations would be during use of dry material containing the mineral i.e. when being used for the preparation of slurries. The use of relevant respiratory personal protective equipment is therefore recommended. It is not anticipated that subsurface introduction of a slurry will result in extensive surface deposition that exceeds background exposure potentials to crystalline silica (common in sand).

References and Notes

IARC (2011) Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. International Agency for Research on Cancer, World Health Organization, Lyon.

INCHEM (1997) Cristobalite ICSC 0809. Available at http://www.inchem.org/documents/icsc/icsc/eics0809.htm. [Accessed 21/11/2013]

OECD (2011) Organization for Economic Cooperation and Development, SIAM 32, 19-21 April 2011, Initial Targeted Assessment Profile (Human Health) Quartz and Cristobalite. Available at http://webnet.oecd.org/Hpv/UI/handler.axd?id=4bac769f-732c-4136-ba97-3b87246d3b2f [Accessed 21/11/2013]

ACGIH (2008) American Conference of Governmental Industrial Hygienists TLVs and BEIs. Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices. Cincinnati, OHIO, p. 51.

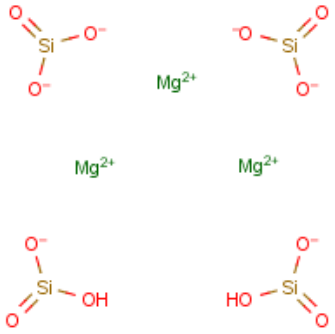
Safe Work Australia (2011) Hazardous Substance Information System (HSIS). WorkSafe Australia, Canberra.

HSDB (2002) Hazardous Substances Data Bank. Toxicology Data Network (TOXNET) Available at http://toxnet.nlm.nih.gov/cgi-bin/sis/htmlgen?HSDB. [Accessed June 2011].

NDF - No data found within the limits of the search strategy.

Created by:	CM	Date 5/12/2013
Reviewed by:	JF	Date: 17/12/2013

Project number: 127666004
Project name: Hydraulic Stimulation Chemicals Assessment, Southwest Queensland
Client name: Santos Ltd

Name	Magnesium silicate hydrate (not containing asbestos or asbestiform fibres)
Synonyms	agalite, alpine talc usp, asbestine; emtal 596; fibrene c 400; french chalk; hydrous magnesium silicate; mistron 2sc; nonasbestiform talc; nonfibrous talc; snowgoose; soapstone; steatite; steawhite; supreme;
CAS number	14807-96-6
Molecular formula	H_2-O_3-Si 3/4Mg or $Mg_3Si_4O_{10}(OH)_2$
Molecular Structure	

Overview	References
Physical Data Talc is a white to gray-white, fine crystalline powder. It is relatively inert and non-reactive with conventional acids and bases. It is thermally stable up to 930 °C, and loses its crystalline bound water (4.8%) between 930 and 970 °C, leaving an enstatite (dehydrated magnesium silicate residue). Talc is a mineral product. The main component is a crystalline hydrated silicate of magnesium, which is usually in the form of plates but may also be occasionally in the form of fibres. In many talc deposits, amphiboles and serpentines, and other "fibrous minerals", are also present. Therefore, the talc mined and used industrially generally also contains asbestos fibres (notably tremolite). **Uses** Talc is used extensively in industrial products as well as in cosmetics. Only the talc presently used in cosmetics is in the relatively pure platiform. The properties of mineral talc (platyness, softness, hydrophobicity, organophilicity and inertness) govern their specific applications in many industries and processes including production of paint, polymers, paper, ceramics, animal feed, rubber, roofing, fertilizers, cosmetics and pharmaceuticals. The principal technical applications of talc in commercial products are as an anti-sticking and anticaking agent, lubricant, carrier, thickener, strengthening and smoothing filler and absorbent. Talc is a non hazardous substance according to the GHS criteria for classifying hazardous chemicals.	(HSIS, 2013); HSDB, 1993; IARC, 2010) (ECHA, 2013)

Project number: 127666004
Project name: Hydraulic Stimulation Chemicals Assessment, Southwest Queensland
Client name: Santos Ltd

Human Health Toxicity Summary	Reference
Carcinogenicity Talc not containing asbestos or asbestiform fibres is listed as Group 3 (i.e. not classifiable as to its carcinogenicity to humans).	IARC, 2010
Mutagenicity/Genotoxicity **Talc** was not mutagenic to Salmonella typhimurium TA1530, his G46, or Saccharomyces cerevisiae D3 in vitro or in host-mediated assays in mice given 30-5000 mg/kg bw.	HSDB, 2013;
Reproductive Toxicity Not classified as a reproductive toxicant. No animal or human studies were found.	ECHA (2013)
Developmental Toxicity/Teratogenicity No developmental effects were observed in hamsters, rats, mice, or rabbits after oral administration of the following doses of **Talc**:1600 mg/kg bw to rats on days 6-15 of gestation, 1600 mg/kg bw to mice on days 6-15 of gestation, 1200 mg/kg bw to hamsters on days 6-10 of gestation, and 900 mg/kg bw to rabbits on days 6-18 of gestation.	HSDB,2013;
Endocrine Disruption Not listed as an endocrine disruptor by European Commission.	EC, 2000
Neurotoxicity NDF	
Acute Toxicity (oral, dermal, inhalation) Ingestion of large amounts may cause gastrointestinal irritation. May cause respiratory tract irritation. Symptoms may include coughing, laboured breathing, sneezing, cyanosis, and vomiting. It may produce permanent effects in the lungs. No acute toxic effect has been observed; as indicated in the IARC (International Agency for Research on Cancer) monograph on talc: " *no acute mortality was observed in several species of animals following administration of high doses of talc by ingestion, inhalation or intratracheal, intrapleural, intraperitoneal or subcutaneous injection.*"	HSDB, 2013; ECHA, 2013
Chronic/repeat dose toxicity (oral, dermal, inhalation) Not classified as chronic/repeat does toxic.	ECHA, 2013;
Sensitisation of the skin or respiratory system Not classified as a skin or respiratory sensitiser.	ECHA 2013
Corrosion (irreversible)/irritation (reversible) effects on the skin or eye Not classified as a severe skin or eye irritant. May result in mild irritation of skin or eyes.	ECHA 2013

Physical Hazards	Reference
Flammable Potential Non-Flammable	HSDB, 2013, ECHA 2013
Explosive Potential Not classified as a substance with explosion potential**.**	ECHA 2013

Toxicity Values	Value	Reference

Human Toxicity Data		
High Chronic/Repeat Dose Toxicity		
LOAEC	NDF	
LOAEL	NDF	
Animal Toxicity Data		
Acute Toxicity		
LD_{50}		
Rat, oral	NDF	
Mouse, oral	NDF	
Rabbit, oral	NDF	
Rat, dermal	NDF	
Rabbit, dermal	NDF	
Mouse, dermal	NDF	
LC_{50}		
Rat	NDF	
High Chronic/Repeat Dose Toxicity		
LOAEL	NDF	
LOAEC	NDF	

Footnotes:
LD_{50} – lethal dose for 50% of experimental population
LC_{50} – lethal air concentration for 50% of experimental population
LOAEL – Lowest Observed Adverse Effect Level
LOAEC – Lowest Observed Adverse Effect Concentration

Human Health Toxicity Ranking*		
	Hazard data	**Comment**
Hazard Band 4		
Carcinogenicity (IARC Group 1 or 2A)		IARC Group 3 (IARC, 2010)
Mutagenicity/Genotoxicity (GHS Category 1A and 1B)	No	HSDB, 1993;
Reproductive Toxicity/Developmental toxicity (GHS Category 1, 1A and 1B)	No	
Endocrine Disruption[1]	No	EC, 2000
Hazard Band 3		
Carcinogenicity (IARC Group 2B)	No	IARC Group 3 (IARC, 2010)
Mutagenicity/Genotoxicity (GHS Category 2)	No	HSDB, 1993;
Reproductive Toxicity/Developmental toxicity (GHS Category 2)	No	
Acute Toxicity (oral, dermal or inhalation) Very Toxic/Toxic • oral LD_{50} ≤ 300 mg/kg[3] • dermal LD_{50} ≤ 1000 mg/kg inhalation LC_{50} ≤ 10 mg/L[4] (or mg/m^3) (vapour)	No	See Hazard Band 1
Possible carcinogenicity, mutagenicity, reproductive or High Chronic/repeat dose toxicity • oral LOAEL ≤ 10 mg/kg/d[3]; • dermal LOAEL ≤ 2 0 mg/kg/d; • inhalation LOAEC (6 h/d) ≤ 50 ppm/d for gases, ≤ 0.2 mg/L/d for vapours or ≤ 0.02 mg/L/d for dust/mists/fumes[4]	No	
Corrosive (irreversible effect)	No	See Irritant (reversible effect) Classed as Eye Irritant 2 (ECHA, 2013)
Respiratory sensitiser	No	
Hazard Band 2		
Harmful chronic/repeat dose toxicity • oral LOAEL > 10 mg/kg and ≤ 100 mg/kg/d • dermal LOAEL > 20 mg/kg/d and ≤ 200 mg/kg/d • inhalation (6-h/d) LOAEC > 50 mg/L ≤ 250 mg/L/d for gases, > 0.2 mg/L ≤ 1 .0 mg/L/d for vapours or > 0.02 mg/L ≤ 0.2 mg/L/d for dust/mists/fumes[4]	No	See Hazard Band 1
Skin Sensitiser	No	
Hazard Band 1		
Acute Toxicity-Harmful • oral LD_{50} > 300 mg/kg ≤ 2000 mg/kg • dermal LD_{50} >1 000 mg/kg ≤ 2000 mg/kg; • inhalation LC_{50} (6 h/d) > 10 mg/L ≤ 20 mg/L for vapours)[4]	No	No dose data found but classified on ECHA, 2013 as GHS Harmful if Swallowed Acute Toxic. 4 (H332) Oral Values for which are > 300 ≤ 2000 (UNECE, 2009, Annex 2. page 278)
Irritant (reversible effect)	Yes	Mild skin and eye

		irritation (ECHA 2013)
Hazard Band 0 **All indicators outside criteria listed in Hazards 1-4**		
Physical Hazards		
Flammable potential	No	
Explosive potential	No	
Hazard Evaluation (highest band) not including physical hazards	Band 1	
Uncertainty analysis /data confidence (out of 12 parameters)	12/12	

* Based on IMAP Framework [NICNAS (2013) Inventory Multi-tiered Assessment and Prioritisation (IMAP) Framework. National Industrial Chemicals Notification and Assessment Scheme. Department of Health and Aging, Canberra].

"[1]Based on list of endocrine disrupting chemicals from the European Commission's Endocrine Disrupters website.

[2] Neurotoxicity based on REACH assessments.

[3] milligrams per kilogram body mass(mg/kg) or milligrams per kilogram body mas per day (mg/kg/d)

[4] Based on GHS cut-offs for hazard classification. For chronic/repeat dose toxicity, GHS cut-offs are provided as guidance values (i.e. the dose/concentration at or below which significant health effects are observed"). (p 18, NICNAS 2013).

Human Health Guidelines		
Media	**Concentration (mg/m^3; mg/L; mg/kg)**	**Reference**
Occupational Exposure Limits		
Air (OEL)		
8-h TWA	2.5 mg/m^{3*}	HSIS, 2013
STEL	NDF	
Peak Limitation	NDF	
Environmental Exposure		
Air, ambient	NDF	
Air, indoor	NDF	
Water, potable	NDF	
Water, recreational	NDF	
Soil, residential	NDF	
Soil, commercial/industrial	NDF	

Footnotes:

OEL = Occupational Exposure Limit

TWA= 8 h Time-Weighted Average

STEL = (15 min) Short-term Exposure Limit

* For talc containing less than 1% quartz and no detectable asbestos fibres in the bulk material

Project number: 127666004
Project name: Hydraulic Stimulation Chemicals Assessment, Southwest Queensland
Client name: Santos Ltd

Qualifying Summary Comments

Talc that does not contain asbestiform/asbestos fibres exhibits a low to moderate level of concern as a hazard with the main routes of entry being inhalation or dermal contact, Talc has a low order of toxicity. It can be a mild skin and eye irritant. The toxicity ranking value is principally based on the irritant nature of talc to the skin and the lungs as a fine particulate. These are acute effects limited to occupational settings where exposure to the powder may occur due to dusting and handling.

References and Notes

European Chemicals Agency (ECHA), 2013. Summary of Classification a labelling for CAS Number 14807-96-6 Available at: http://clp-inventory.echa.europa.eu/SummaryOfClassAndLabelling.aspx?SubstanceID=55002&HarmOnly=no?DisclaimerAgr=Agree&Index=14807-96-6&ExecuteSearch=true&fc=true&lang=en [Accessed 28 November 2013].

European Commission (EC), 2000.Towards the establishment of a priority list of substances for further evaluation of their role in endocrine disruption, preparation of a candidate list of substances as a basis for priority setting, Final Report (Incorporating corrigenda to final report dated 21 June 2000).

Hazardous Substances Databank (HSDB), 2013. Toxicology Data Network, U.S. National Library of Medicine Available at: http://toxnet.nlm.nih.gov/cgi-bin/sis/search/r?dbs+hsdb:@term+@na+TALC [Accessed 28 November 2013].

Hazardous Substance Information System (HSIS),2013. Exposure Standard Documentation: Talc, containing no asbestos. Safe Work Australia. Available at: http://hsis.safeworkaustralia.gov.au/HazardousSubstance/Details?hazardousSubstanceID=1057 [accessed on 28 November 2013].

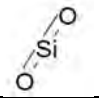
International Agency for Research on Cancer (IARC), 16 June 2013. Agents Classified by the *IARC Monographs*, Volumes 1–108. Available at: http://monographs.iarc.fr/ENG/Classification/index.php. [Accessed 28 November 2013]

United Nations Economic Commission for Europe (UNECE) , 2011. Globally Harmonized System of Classification and Labelling of Chemicals. Available at: http://www.unece.org/fileadmin/DAM/trans/danger/publi/ghs/ghs_rev04/English/ST-SG-AC10-30-Rev4e.pdf [Accessed on 28 November 2013)

NDF - No data found within the limits of the search strategy.

Created by:	AES	Date: 28/11/2013
Reviewed by:	JF	Date 02/12/2013

Project number: 127666004
Project name: Hydraulic Stimulation Chemicals Assessment, Southwest Queensland
Client name: Santos Ltd

Name	Crystalline silica, quartz
Synonyms	Crystalline silica, crystalline silicon dioxide, cristobalite
CAS number	14808-60-7
Molecular formula	SiO_2
Molecular Structure	

Overview	References
Silicon is the second most abundant chemical element, after oxygen, in the earth's crust accounting for 28.15% of its mass and quartz, is by far the most common form of silica in nature, comprising 12% by volume of the Earth's crust. It is a frequently occurring solid component of most natural mineral dusts. Quartz is a colourless, odourless, non-combustible solid, a component of many mineral dusts and is insoluble in water. Human exposures to crystalline silica occur mainly during occupational activities that involve the movement of earth, disturbance of silica-containing products (masonry, concrete, dolomite), or in the manufacturing of silica-containing products. Environmental exposure to ambient quartz dust may occur during natural, industrial and agricultural activities. Silicosis as a consequence of inhalation exposures to respirable dusts containing crystalline silica is the critical hazard identification in the occupational environment. In this assessment, some information is reported for cristobalite (14464-46-1) which is a polymorph of crystalline silica.	IARC (1997); INCHEM (2010)

Human Health Toxicity Summary	Reference
Carcinogenicity Silica dust, crystalline in the form of quartz or cristobalite is carcinogenic to humans via the respiratory route (Group 1). There is sufficient evidence in humans for the carcinogenicity of inhaled crystalline silica in the form of quartz or cristobalite from occupational sources. There is sufficient evidence in experimental animals for the carcinogenicity of quartz and cristobalite following inhalation exposure. Respirable quartz dust particles can be inhaled and deposited in the deep parts of the lung. There are many (epidemiological) cohort studies of workers exposed to respirable quartz dust. Silicosis, lung cancer and pulmonary tuberculosis are associated with occupational exposure to respirable quartz dust.	IARC (1997; 2013)
Mutagenicity/Genotoxicity Most cellular genotoxicity assays with crystalline silica have been performed with quartz samples and these have produced equivocal results. Mutation assays in rat alveolar epithelial cells, both *in vitro* and *in vivo,* were positive in response to quartz with concentrations of 3 and 50 mg/m^3 for crystalline and amorphous silica respectively.	OECD (2011)

The animals were exposed for 13 weeks. Mutation frequency was greatly increased only in the crystalline silica treated rats; no treatment-related increase was found in the rats treated with the amorphous form. In an 8-hydroxydeoxyguanosine (8-OHdG) assay conducted to monitor DNA damage by reactive oxygen species, female rats were exposed to 0, 0.3, 1.5 and 7.5 mg/animal of quartz via intra-tracheal instillation. Effects were observed 90 days post-exposure. A clear dose-response relationship was identified between quartz exposure and various inflammation markers. Similarly, in another study, 8-OHdG and DNA strand breaks were observed at concentrations of 10 µg/m^3 or above in rat lung epithelial cells.	
Reproductive Toxicity NDF.	
Developmental Toxicity/Teratogenicity NDF.	
Endocrine Disruption Not listed as an endocrine disruptor.	EC (2000)
Acute Toxicity (oral, dermal, inhalation) NDF.	
Chronic/repeat dose toxicity (oral, dermal, inhalation) A study of greater than 9 days conducted in mice identified a LOAEC of 10 mg/m^3. The conditions of the study were not reported but are said to be similar to the former study which exposed rats to 0, 10 or 100 mg/m^3 of cristobalite via inhalation for 6 hours/day over 3 days, with animals observed 3 months after exposure. In a 4-week inhalation study, female rats were exposed to 0, 0.1, 1 or 10 mg/m^3 of quartz, 6 hours/day, for 5 days in a week. A LOAEC of 1 mg/m^3 was reported following 24 weeks of exposure. In two separate studies, in which rats or hamsters were exposed to quartz via inhalation for at least 6 months, LOAECs of 2 and 3 mg/m^3 were identified, respectively. All the effects observed were related to inflammation and fibrosis of the lung tissue. Several chronic studies investigated exposure of rats, mice and hamsters to respirable dusts containing quartz and cristobalite. . In the study in which the lowest non-neoplastic LOAEC was observed, groups of 50 rats/sex were exposed 6 hr/day, 5 days/week for 24 months to filtered air or 1 mg/m^3 of DQ-12 quartz, containing 74% of respirable quartz. An additional 50 rats/sex were exposed to 5 mg/m^3 of titanium dioxide as positive controls. The mean mass of particle at the end of the exposure period was 0.91 mg/lung. The LOAEC identified was 0.74 mg/m^3 (adjusted for 74% respirable quartz). In studies relating to humans, LOAECs, based on the critical endpoint of radiographic confirmed silicosis were determined at 0.053 mg/m^3 (mean exposure) from a study of South African gold miners, and 0.064 mg/m^3 (mean exposure) from a study of a mining community in Colorado.	OECD (2011)
Sensitisation of the skin or respiratory system NDF.	
Corrosion (irreversible)/irritation (reversible) effects on the skin or eye NDF.	

Physical Hazards	Reference

Flammable Potential Not flammable.	HSDB (2004)
Explosive Potential Not explosive.	HSDB (2004)

Toxicity Values	Value	Reference
Human Toxicity Data		
High Chronic/Repeat Dose Toxicity		
LOAEC	0.053 mg/m^3 (mean exposure)	OECD (2011)
LOAEL	NDF	
Animal Toxicity Data		
Acute Toxicity		
LD_{50}		
Rat, oral	NDF	
Mouse, oral	NDF	
Rabbit, oral	NDF	
Rat, dermal	NDF	
Rabbit, dermal	NDF	
Mouse, dermal	NDF	
LC_{50}		
Rat	NDF	
High Chronic/Repeat Dose Toxicity		
LOAEL	NDF	
LOAEC	0.74 mg/m^3	For rats via the inhalation pathway - adjusted for 74% respirable quartz (OECD, 2011).

Footnotes:
LD_{50} – lethal dose for 50% of experimental population
LC_{50} – lethal air concentration for 50% of experimental population
LOAEL – Lowest Observed Adverse Effect Level

LOAEC – Lowest Observed Adverse Effect Concentration

NDF - No data found within the limits of the search strategy.

Human Health Toxicity Ranking*		
	Hazard data	**Comment**
Hazard Band 4		
Carcinogenicity (IARC Group 1 or 2A)	Yes	Classified as Group 1 carcinogen via respiratory route (IARC, 2013)
Mutagenicity/Genotoxicity (GHS Category 1A and 1B)	No	OECD (2011) Equivocal results
Reproductive Toxicity/Developmental toxicity (GHS Category 1, 1A and 1B)	NDF	
Endocrine Disruption[1]	No	EC (2000)
Hazard Band 3		
Carcinogenicity (IARC Group 2B)	No	IARC (2013)
Mutagenicity/Genotoxicity (GHS Category 2)	No	OECD (2011) Equivocal results
Reproductive Toxicity/Developmental toxicity (GHS Category 2)	NDF	
Acute Toxicity (oral, dermal or inhalation) Very Toxic/Toxic • oral LD_{50} ≤ 300 mg/kg[2] • dermal LD_{50} ≤ 1000 mg/kg inhalation LC_{50} ≤ 10 mg/L[3] (or mg/m[3]) (vapour)	NDF	
Possible carcinogenicity, mutagenicity, reproductive or High Chronic/repeat dose toxicity • oral LOAEL ≤ 10 mg/kg/d[2]; • dermal LOAEL ≤ 2 0 mg/kg/d; • inhalation LOAEC (6 h/d) ≤ 50 ppm/d for gases, ≤ 0.2 mg/L/d for vapours or ≤ 0.02 mg/L/d for dust/mists/fumes[3]	Yes	Mean exposure in a study of South African gold miners (OECD, 2011) LOAEC (Lung) at 0.053 mg/m[3]
Corrosive (irreversible effect)	NDF	
Respiratory sensitiser	NDF	
Hazard Band 2		
Harmful chronic/repeat dose toxicity • oral LOAEL > 10 mg/kg and ≤ 100 mg/kg/d • dermal LOAEL > 20 mg/kg/d and ≤ 200 mg/kg/d • inhalation (6-h/d) LOAEC > 50 mg/L ≤ 250 mg/L/d for gases, > 0.2 mg/L ≤ 1 .0 mg/L/d for vapours or > 0.02 mg/L ≤ 0.2 mg/L/d for dust/mists/fumes[3]	No	Categorised as Hazard Band 3 for repeat effects.
Skin Sensitiser	NDF	
Hazard Band 1		
Acute Toxicity-Harmful • oral LD_{50} > 300 mg/kg ≤ 2000 mg/kg • dermal LD_{50} >1 000 mg/kg ≤ 2000 mg/kg; • inhalation LC_{50} (6 h/d) > 10 mg/L ≤ 20 mg/L for vapours)[3]	NDF	
Irritant (reversible effect)	NDF	
Hazard Band 0 **All indicators outside criteria listed in Hazards 1-4**	No	
Physical Hazards		
Flammable potential	No	
Explosive potential	No	
Hazard Evaluation (highest band) not including physical hazards	4	Group 1 carcinogen
Uncertainty analysis /data confidence (out of 12 parameters)	6/12	**50%**

* Based on IMAP Framework [NICNAS (2013) Inventory Multi-tiered Assessment and Prioritisation (IMAP) Framework. National Industrial Chemicals Notification and Assessment Scheme. Department of Health and Aging, Canberra].

"[1]Based on list of endocrine disrupting chemicals from the European Commission's Endocrine Disrupters website.

[2] Based on list of neurotoxic chemicals from US Agency for Toxic Substances and Disease Registry (ATSDR).

[3] milligrams per kilogram body mass (mg/kg) or milligrams per kilogram body mass per day (mg/kg/d)

[4] Based on GHS cut-offs for hazard classification. For chronic/repeat dose toxicity, GHS cut-offs are provided as guidance values (i.e. the dose/concentration at or below which significant health effects are observed)". (p 18, NICNAS 2013).

Human Health Guidelines		
Media	**Concentration (mg/m^3; mg/L; mg/kg)**	**Reference**
Occupational Exposure Limits		
Air (OEL)		
8-h TWA	0.1 mg/m^3	Safe Work Australia (2010)
STEL	No	Safe Work Australia (2010)
Peak Limitation	No	Safe Work Australia (2010)
Environmental Exposure		
Air, ambient	NDF	
Air, indoor	NDF	
Water, potable	NDF	
Water, recreational	NDF	
Soil, residential	NDF	
Soil, commercial/industrial	NDF	

Footnotes:

OEL = Occupational Exposure Limit

TWA= 8 h Time-Weighted Average

STEL = (15 min) Short-term Exposure Limit

NDF - No data found within the limits of the search strategy.

Qualifying Summary Comments

Respirable crystalline silica is ubiquitous in its global distribution but presents a serious inhalation hazard for sustained exposures to elevated atmospheric concentrations of particulates. In terms of environmental distribution and persistence, silica does not degrade under standard temperature and pressure conditions and thus distribution is widespread. Crystalline silica, (quartz) has been given a Hazard Band 4 ranking due to the carcinogenicity of this mineral via the inhalation pathway. The primary concern for human health when using this mineral in hydraulic fracturing operations would be during use of dry material containing the mineral, i.e. when being used for the preparation of slurries. The use of relevant respiratory personal protective equipment is therefore recommended. It is not anticipated that subsurface introduction of a slurry will result in extensive surface deposition that exceeds background exposure potentials to crystalline silica (common in sand).

References

EC (2000) Towards the establishment of a priority list of substances for further evaluation of their role in endocrine disruption Final Report (Incorporating corrigenda to final report dated 21 June 2000) – Annex 10: List of 564 substances with their selection criteria - European Commission (EC). Available at: http://ec.europa.eu/environment/archives/docum/pdf/bkh_annex_10.pdf [Accessed 9 January 2014]

IARC (1997) Monographs on the Evaluation of the Carcinogenic Risk to Humans. Volume 68. International Agency for Research on Cancer, World Health Organization, Lyon. Available at: http://monographs.iarc.fr/ENG/Monographs/vol68/mono68-6.pdf. [Accessed 9 January 2014]

IARC (2013) Agents Classified by the *IARC Monographs*, Volumes 1–109. International Agency for Research on Cancer (IARC), 30 October 2013. Available at http://monographs.iarc.fr/ENG/Classification/ClassificationsCASOrder.pdf. [Accessed 9 January 2014]

INCHEM (2010) Quartz ICSC 0808. International Program on Chemical Safety (IPCS). Available at http://www.inchem.org/documents/icsc/icsc/eics0808.htm [Accessed 9 January 2014]

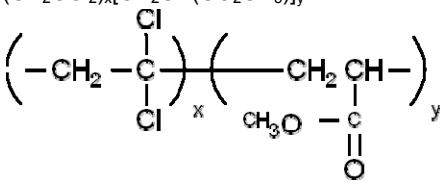
OECD (2011) Organization for Economic Cooperation and Development, SIAM 32, 19-21 April 2011, Initial Targeted Assessment Profile (Human Health) Quartz and Cristobalite. Available at http://webnet.oecd.org/Hpv/UI/handler.axd?id=4bac769f-732c-4136-ba97-3b87246d3b2f. [Accessed 9 January 2014]

Safe Work Australia (2010) Hazardous Substance Information System (HSIS). Available at http://hsis.safeworkaustralia.gov.au/HazardousSubstance. [Accessed 9 January 2014]

HSDB (2004) Hazardous Substances Data Bank. Toxicology Data Network (TOXNET) Available at http://toxnet.nlm.nih.gov/cgi-bin/sis/htmlgen?HSDB. [Accessed 9 January 2014].

Created by:	JC	9/01/2014
Reviewed by:	LT	16/01/2014 Rev0

Project number: 127666004
Project name: Hydraulic Stimulation Chemicals Assessment, Southwest Queensland
Client name: Santos Ltd

Name	Poly(vinylidene chloride-co-methyl acrylate)
Synonyms	2-Propenoic acid, methyl ester, polymer with 1,1-dichloroethene 1,1-Dichloroethene, methyl 2-propenoate polymer 1,1-Dichloroethene, polymer with methyl 2-propenoate 2-Propenoic acid, methyl ester, polymer with 1,1-dichloroethene Vinylidene chloride, methyl acrylate polymer 2-Propenoic acid, methyl ester, polymer with 1,1-dichloroethene Acrylic acid methyl ester, polymer with 1,1-Dichlo poly(methyl acrylate-co-vinylidene chloride
CAS number	25038-72-6
Molecular formula	$(CH_2CCl_2)_x[CH_2CH(CO_2CH_3)]_y$
Molecular Structure	

Overview	References
Poly(vinylidene chloride-co-methyl acrylate) (PVCCMA) is polymeric, granular substance, which has a melting point of 152 ºC, a density of 1.78 g/mL at 25 °C and is insoluble in water. I PVCCMA is a high molecular weight polymer. Residual monomers maybe present at low levels. Monomers such as vinylidene chloride, vinyl chloride and methyl acrylate are generally below 0.1%. PVCCMA contains acrylate functionality as well as acid chloride functional groups. PVCCMA is used and approved as an indirect additive used in food contact substances. PVCCMA is classified as a non hazardous polymer. It is unlikely to absorb through skin or be absorb across biological membranes due to its high molecular weight.	Sigma-Aldrich (2010) and Sigma-Aldrich (2011) FDA (2011)

Human Health Toxicity Summary	Reference
Carcinogenicity No component of this product present at levels greater than or equal to 0.1% is identified as probable, possible or confirmed human carcinogen by IARC.	Sigma-Aldrich (2013)
Mutagenicity/Genotoxicity Not a hazardous chemical according to GHS although it is noted that the substance has not yet been tested completely.	Sigma-Aldrich (2013)
Reproductive Toxicity No data found.	
Developmental Toxicity/Teratogenicity No data found.	
Endocrine Disruption No data found.	

Neurotoxicity No data found.	
Acute Toxicity (oral, dermal, inhalation) No data found.	
Chronic/repeat dose toxicity (oral, dermal, inhalation) No data found.	
Sensitisation of the skin or respiratory system No data found.	
Corrosion (irreversible)/irritation (reversible) effects on the skin or eye **Not expected to be a moderate or severe skin or eye irritant.**	Sigma-Aldrich (2010)

Physical Hazards	Reference
Flammable Potential No data found.	
Explosive Potential No data found.	

Toxicity Values	Value	Reference
Human Toxicity Data		
High Chronic/Repeat Dose Toxicity		
LOAEC	No data found.	
LOAEL	No data found.	
Animal Toxicity Data		
Acute Toxicity		
LD_{50}		
Rat, oral	No data found.	
Mouse, oral	No data found.	
Rabbit, oral	No data found.	
Rat, dermal	No data found.	
Rabbit, dermal	No data found.	
Mouse, dermal	No data found.	
LC_{50}		
Rat	No data found.	
High Chronic/Repeat Dose Toxicity		
LOAEL	No data found.	
LOAEC	No data found.	
	No data found.	

Footnotes:
LD_{50} – lethal dose for 50% of experimental population
LC_{50} – lethal air concentration for 50% of experimental population
LOAEL – Lowest Observed Adverse Effect Level
LOAEC – Lowest Observed Adverse Effect Concentration

Human Health Toxicity Ranking*		
	Hazard data	**Comment**
Hazard Band 4		
Carcinogenicity (IARC Group 1 or 2A)	No data found.	
Mutagenicity/Genotoxicity (GHS Category 1A and 1B)	No data found.	
Reproductive Toxicity/Developmental toxicity (GHS Category 1, 1A and 1B)	No data found.	
Endocrine Disruption[1]	No data found.	
Hazard Band 3		
Carcinogenicity (IARC Group 2B)	No data found.	
Mutagenicity/Genotoxicity (GHS Category 2)	No data found.	
Reproductive Toxicity/Developmental toxicity (GHS Category 2)	No data found.	
Acute Toxicity (oral, dermal or inhalation) Very Toxic/Toxic • oral LD_{50} ≤ 300 mg/kg[3] • dermal LD_{50} ≤ 1000 mg/kg inhalation LC_{50} ≤ 10 mg/L[4] (or mg/m^3) (vapour)	No data found.	
Possible carcinogenicity, mutagenicity, reproductive or High Chronic/repeat dose toxicity • oral LOAEL ≤ 10 mg/kg/d[3]; • dermal LOAEL ≤ 2 0 mg/kg/d; • inhalation LOAEC (6 h/d) ≤ 50 ppm/d for gases, ≤ 0.2 mg/L/d for vapours or ≤ 0.02 mg/L/d for dust/mists/fumes[4]	No data found.	
Corrosive (irreversible effect)	No data found.	
Respiratory sensitiser	No data found.	
Hazard Band 2		
Harmful chronic/repeat dose toxicity • oral LOAEL > 10 mg/kg and ≤ 100 mg/kg/d • dermal LOAEL > 20 mg/kg/d and ≤ 200 mg/kg/d • inhalation (6-h/d) LOAEC > 50 mg/L ≤ 250 mg/L/d for gases, > 0.2 mg/L ≤ 1 .0 mg/L/d for vapours or > 0.02 mg/L ≤ 0.2 mg/L/d for dust/mists/fumes[4]	No data found.	
Skin Sensitiser	No data found.	
Hazard Band 1		
Acute Toxicity-Harmful • oral LD_{50} > 300 mg/kg ≤ 2000 mg/kg • dermal LD_{50} >1 000 mg/kg ≤ 2000 mg/kg; • inhalation LC_{50} (6 h/d) > 10 mg/L ≤ 20 mg/L for vapours)[4]	No data found.	
Irritant (reversible effect)	May cause respiratory tract irritation. May cause skin irritation.	Sigma-Aldrich (2010)

	May cause eye irritation.	
Hazard Band 0 **All indicators outside criteria listed in Hazards 1-4**	No	
Physical Hazards		
Flammable potential	No data found.	
Explosive potential	No data found.	
Hazard Evaluation (highest band) not including physical hazards	1	Potential irritant
Uncertainty analysis /data confidence (out of 12 parameters)	8%	

* Based on IMAP Framework [NICNAS (2013) Inventory Multi-tiered Assessment and Prioritisation (IMAP) Framework. National Industrial Chemicals Notification and Assessment Scheme. Department of Health and Aging, Canberra].

"[1]Based on list of endocrine disrupting chemicals from the European Commission's Endocrine Disrupters website.
[2] Neurotoxicity based on REACH assessments.
[3] milligrams per kilogram body mass(mg/kg) or milligrams per kilogram body mas per day (mg/kg/d)

[4] Based on GHS cut-offs for hazard classification. For chronic/repeat dose toxicity, GHS cut-offs are provided as guidance values (i.e. the dose/concentration at or below which significant health effects are observed"). (p 18, NICNAS 2013).

Human Health Guidelines		
Media	**Concentration (mg/m^3; mg/L; mg/kg)**	**Reference**
Occupational Exposure Limits		
Air (OEL)	No data found.	
8-h TWA	No data found.	
STEL	No data found.	
Peak Limitation	No data found.	
Environmental Exposure		
Air, ambient	No data found.	
Air, indoor	No data found.	
Water, potable	No data found.	
Water, recreational	No data found.	
Soil, residential	No data found.	
Soil, commercial/industrial	No data found.	

Footnotes:

OEL = Occupational Exposure Limit

TWA= 8 h Time-Weighted Average

STEL = (15 min) Short-term Exposure Limit

Qualifying Summary Comments

There is a significant lack of toxicological data related to this polymer and suitable surrogates with similar physic-chemical properties are not readily available. Poly(vinylidene chloride-co-methyl acrylate) has been assigned a Hazard Band 1 ranking based on the potential for the substance to act as an irritant. The general fact that

polymers are relatively stable and inert and unlikely to present health concerns based on chemical considerations suggests that the risk to human health from exposure to this chemical is low. As this product is a granular substance, dusting potential and particulate inhalation (physical hazard) may warrant further investigation for occupational concerns and large-scale environmental release of the powder in close proximity to residential areas.

References and Notes

FDA (US Food and Drug Administration) (2011) List of Indirect Additives Used in Food Contact Substances, dated 14/11/2011. Available at http://www.accessdata.fda.gov/scripts/fcn/fcnNavigation.cfm?rpt=iaListing&displayAll=true [Accessed 5/12/2013]

Sigma-Aldrich Co., (2011) Product Identification: Poly(vinylidene chloride-co-methyl acrylate). Sigma-Aldrich 3050 Spruce St.St. Louis, MO 63103. Available at http://www.sigmaaldrich.com/catalog/ProductDetail.do?D7=0&N5=SEARCH_CONCAT_PNO|BRAND_KEY&N4=430404|ALDRICH&N25=0&QS=ON&F=SPEC [Accessed 6 July 2011].

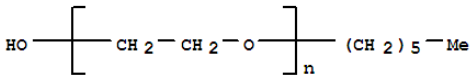
Sigma-Aldrich Co. (2010). Safety Data Sheet: Poly(vinylidene chloride-co-methyl acrylate) (Version 4). Sigma-Aldrich Pty. Ltd. Available at http://www.sigmaaldrich.com/catalog/DisplayMSDSContent.do [Accessed on 7 July 2011].

Sigma-Aldrich (2013) Safety Data Sheet: Poly(vinylidene chloride-*co*-methyl acrylate)Version 4.1 Dated 11/04/2013.
Available at http://www.sigmaaldrich.com/MSDS/MSDS/DisplayMSDSPage.do?country=AU&language=en&productNumber=430404&brand=ALDRICH&PageToGoToURL=http%3A%2F%2Fwww.sigmaaldrich.com%2Fcatalog%2Fsearch%3Finterface%3DCAS%2520No.%26term%3D25038-72-6%26lang%3Den%26region%3DAU%26focus%3Dproduct%26N%3D220003048%2B219853060%2B219853286%26mode%3Dpartialmax [Accessed 5/12/2013].

NDF - No data found within the limits of the search strategy.

Created by:	CM	Date 9/12/2013
Reviewed by:	JF	Date 17/12/2013

Project number: 127666004
Project name: Hydraulic Stimulation Chemicals Assessment, Southwest Queensland
Client name: Santos Ltd

Name	Polyethylene glycol monohexyl ether
Synonyms	Hexan-1-ol, ethoxylated, alpha.-Hexyl,.omega.-hydroxypoly(oxy-1,2-ethanediyl), Hexyl alcohol, ethoxylated, Hexyl poly(oxyethylene) ether, Poly(oxy-1,2-ethanediyl), .alpha.-hexyl-.omega.-hydroxy-, alpha-Hexyl,omega-hydroxypoly(oxy-1,2-ethanediyl), Crissanol A-55, EINECS 500-077-5, Hexyl alcohol, ethoxylated, Hexyl poly(oxyethylene) ether, Poly(oxy-1,2-ethanediyl), .alpha.-hexyl-.omega.-hydroxy-
CAS number	31726-34-8
Molecular formula	$(C_2H_4O)nC_6H_{14}O$
Molecular Structure	

Overview	References
Polyethylene glycol monohexyl ether is the reaction product of hexyl alcohol and ethylene oxide, It is soluble in water. It can be described as belonging to the chemical class known as alcohol ethoxylates.	SWA, 2013
Polyethylene glycol monohexyl ether (PEGMHE) is used as an additive in fracking operations, the manufacture of paper and paper products, architectural and engineering activities, adhesives and binding agents, reprographic agents, paints lacquers and varnishes, cleaning/washing agents, surface treatment, cosmetics, odour agents, impregnation materials, colouring agents, non-agricultural pesticides and preservatives, viscosity adjustors, corrosion inhibitors and aerosol propellants.	ECHA 2013a EPA, 2013
It has not been found on regulatory classification lists (i.e.Safework Australia, ECHA).	
Very little toxicology information is available for PEGMHE. Ethoxylated polyethylene glycols (alcohol ethoxylates) can be harmful if swallowed and via dermal contact irritating to the skin, eyes and respiratory tract. At high oral doses alcohol ethoxylates can cause liver toxicity.	

Human Health Toxicity Summary	Reference
Carcinogenicity Alcohol ethoxylates as a chemical class are not carcinogenic. This assessment is further supported by the absence of any mutagenic or genotoxic activity of this compound class.	HERA (2009)
Mutagenicity/Genotoxicity Not known to cause heritable genetic damage.	Schlumberger, 2012, HERA (2009)
Reproductive Toxicity Not known to adversely affect reproductive functions and organs.	Schlumberger, 2012, HERA (2009)

Developmental Toxicity/Teratogenicity Not known to cause birth defects or have a deleterious effect on a developing fetus.	Schlumberger, 2012, HERA (2009)
Endocrine Disruption Not listed as an endocrine disruptor.	EC (2000)
Acute Toxicity (oral, dermal, inhalation) No data found, although classification of chemical as irritant on MSDS indicates chemical is non-toxic.	Schlumberger, 2012
Chronic/repeat dose toxicity (oral, dermal, inhalation) Not classifiable based on specific target organ toxicity following repeat exposure. Animal toxicity studies indicate that alcohol ethoxylates can cause adaptive changes in the liver when given at high oral doses in repeat dose animal experiments.	HERA, 2009
Sensitisation of the skin or respiratory system Not known to cause allergic reaction.	Schlumberger, 2012
Corrosion (irreversible and reversible)/irritation of the skin or eye Risk of serious damage to eyes (R41). Irritant (Xi) Causes eye and skin irritation and/or dermatitis. May cause corneal inflammation. Irritating to respiratory system. Ingestion may cause gastrointestinal irritation, nausea, vomiting and diarrhoea.	ECHA 2013b Schlumberger, 2012 Sasol, 2010 and Sasol, 2013

Physiochemical Properties	References
Flammable Potential Not classified as a flammable liquid.	Schlumberger, 2012
Explosive Potential Not classified as an explosive hazard.	Schlumberger, 2012

Toxicity Values	Value	Reference
Human Toxicity Data		
Acute Toxicity		
	NDF	
	NDF	
High Chronic/Repeat Dose Toxicity		
LOAEC	No data found (NDF)	
LOAEL	NDF	
Animal Toxicity Data		
Acute Toxicity		
LD_{50}		
Rat, oral	5,100 mg/kg 1.2 – 10 g/kg	Sasol, 2010 Sasol, 2013
Mouse, oral	NDF	
Rabbit, oral	NDF	
Rat, dermal	NDF	
Rabbit, dermal	1,500 – 1,900 mg/kg >2g/kg	Sasol, 2010 Sasol, 2013
Mouse, dermal	NDF	
LOAEL	NDF	
LOAEC	NDF	
LC_{50}		
Rat (inhalation)	1 hour >3.2 mg/l, 4 hours >8.02 mg/l	Sasol 2010
Mice (inhalation)	NDF	
High Chronic/Repeat Dose Toxicity		
LOAEL	50 mg/kg (oral rat) for any alcohol ethoxylate	HERA (2009)
LOAEC	NDF	
NOAEL	NDF	

Footnotes:
LD_{50} – lethal dose for 50% of experimental population
LC_{50} – lethal air concentration for 50% of experimental population
LOAEL – Lowest Observed Adverse Effect Level
LOAEC – Lowest Observed Adverse Effect Concentration
NOAEL – No Observed Adverse Effect Level

Human Health Toxicity Ranking*		
	Hazard data	**Comment**
Hazard Band 4		
Carcinogenicity	No	HERA, 2009
Mutagenicity/Genotoxicity	No	Schlumberger, 2012
Reproductive Toxicity	No	Schlumberger, 2012
Developmental Toxicity/ Teratogenicity	No	Schlumberger, 2012
Endocrine Disruption[1]	No	EC, 2000
Neurotoxicity[2]	No	HERA 2009
Hazard Band 3		
Acute Toxicity (oral, dermal or inhalation) Very Toxic/Toxic • oral $LD_{50} \leq 300$ mg/kg[3] • dermal $LD_{50} \leq 1000$ mg/kg • inhalation $LC_{50} \leq 10$ mg/L[4] (or mg/m^3) (vapour)	No	Schlumberger, 2012 (classified as irritant)
High Chronic/repeat dose toxicity • oral LOAEL ≤ 10 mg/kg/d[3]; • dermal LOAEL ≤ 2 0 mg/kg/d; • inhalation LOAEC (6 h/d) ≤ 50 ppm/d for gases, ≤ 0.2 mg/L/d for vapours or ≤ 0.02 mg/L/d for dust/mists/fumes[4]	No	Schlumberger, 2012 (classified as irritant)
Corrosive (irreversible damage)	Yes	ECHA 2013b Schlumberger, 2012
Respiratory sensitiser	No	Schlumberger, 2012
Hazard Band 2		
Harmful chronic/repeat dose toxicity • oral LOAEL > 10 mg/kg and ≤ 100 mg/kg/d • dermal LOAEL > 20 mg/kg/d and ≤ 200 mg/kg/d • inhalation (6-h/d) LOAEC > 50 mg/L ≤ 250 mg/L/d for gases, > 0.2 mg/L ≤ 1 .0 mg/L/d for vapours or > 0.02 mg/L ≤ 0.2 mg/L/d for dust/mists/fumes[4]	No	
Skin Sensitiser	No	Sasol, 2013
Hazard Band 1		
Acute Toxicity-Harmful • oral $LD_{50} > 300$ mg/kg ≤ 2000 mg/kg • dermal LD_{50} >1 000 mg/kg ≤ 2000 mg/kg; • inhalation LC_{50} (6 h/d) > 10 mg/L ≤ 20 mg/L for vapours)[4]	No	No date found for 6 hr inhalation LC_{50}. Rat inhalation LC_{50}: 1 hour >3.2 mg/l, 4 hours >8.02 mg/l (Sasol 2010)
Irritant (reversible damage)	Yes Eye, skin irritation and respiratory system.	Sasol, 2010 & 2013
Hazard Band 0 All indicators outside criteria listed in Hazards 1-4	No	
Physical Hazards		
Flammable potential	No	Sasol, 2013
Explosive potential	No	
Hazard Evaluation (highest band) not including physical hazards	Hazard Band 3	
Uncertainty analysis /data confidence	14/14	**100%**

* Based on IMAP Framework [NICNAS (2013) Inventory Multi-tiered Assessment and Prioritisation (IMAP) Framework. National Industrial Chemicals Notification and Assessment Scheme. Department of Health and Aging, Canberra].

"[1]*Based on list of endocrine disrupting chemicals from the European Commission's Endocrine Disrupters website.*

[2] *Based on list of neurotoxic chemicals from US Agency for Toxic Substances and Disease Registry (ATSDR).*

[3] *milligrams per kilogram body mas s(mg/kg) or milligrams per kilogram body mas per day (mg/kg/d)*

[4] *Based on GHS cut-offs for hazard classification. For chronic/repeat dose toxicity, GHS cut-offs are provided as guidance values (i.e. the dose/concentration at or below which significant health effects are observed"). (p 18, NICNAS 2013).*

Human Health Guidelines		
Media	**Concentration (mg/m^3; mg/L; mg/kg)**	**Reference**
Occupational Exposure Limits		
Air (OEL)		
8-h TWA	NDF There are no exposure limits established for this product.	Sasol, 2010 Sasol, 2013
STEL	NDF There are no exposure limits established for this product.	Sasol, 2010 Sasol, 2013
Peak Limitation	NDF There are no exposure limits established for this product.	Sasol, 2010 Sasol, 2013
Environmental Exposure		
Air, ambient	NDF	
Air, indoor	NDF	
Water, potable	NDF	Readily biodegradable (Sasol, 2013).
Water, recreational	NDF	
Soil, residential	NDF	
Soil, commercial/industrial	NDF	

Footnotes:

OEL = Occupational Exposure Limit

TWA= 8 h Time-Weighted Average

STEL = (15 min) Short-term Exposure Limit

NDF - No data found within the limits of the search strategy.

Qualifying Summary Comments

The toxicity associated with polyethylene glycol monohexyl ether is principally related to the irritation of skin, eyes and the respiratory tract along with the potential to cause serious damage to the eyes, although limited data is available for studies on humans for dermal, oral and inhalation exposure pathways. Polyethylene glycol monohexyl ether falls into the Hazard Band 3category. The primary effect of exposure via usual occupational routes is considered to be irritation of the eyes, skin and respiratory tract. There was no evidence to suggest that polyethylene glycol monohexyl ether is considered carcinogenic. As chronic outcomes are limited and substantial dilution is anticipated, environmental distribution and adverse outcomes would be anticipated to be negligible. Occupational use should avoid skin, eye and respiratory system exposure.

References

United States Environmental Protection Agency (EPA) (2013) ACToR Chemical: Hexan-1-ol, ethoxylated. Available at http://actor.epa.gov/actor/GenericChemical?casrn=31726-34-8 [Accessed 14 August 2013]

European Chemicals Agency (ECHA) (2013a) Polyethylene glycol monohexyl ether. Available at http://echa.europa.eu/information-on-chemicals/registered-substances [Accessed 14 August 2013]

European Chemicals Agency (ECHAb) (2013b) Alkyl polyglycol ether. Available at http://echa.europa.eu/web/guest/information-on-chemicals/cl-inventory-database

European Commission (EC) (2000) Towards the establishment of a priority list of substances for further evaluation of their role in endocrine disruption, preparation of a candidate list of substances as a basis for priority setting, Final Report (Incorporating corrigenda to final report dated 21 June 2000).

Human and Environmental Risk Assessment (HERA) (2009) Alcohol Ethoxylates, Human & Environmental Risk Assessment on ingredients of European household cleaning products, Version 2.0, September 2009. Available at http://www.heraproject.com/files/34-F-09%20HERA%20AE%20Report%20Version%202%20-%203%20Sept%2009.pdf [Accessed 16 August 2013]

Schlumberger (2012) Safety Datasheet (Australia), Surfactant F112 (component: polyethylene glycol monohexyl ether), dated March 2012.

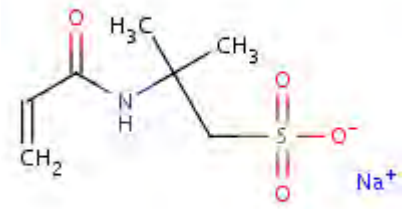
Safework Australia (SWA) (2013) Hazardous Substances Information System (HSIS). Available at http://hsis.safeworkaustralia.gov.au/HazardousSubstance [Accessed 14 August 2013].

Sasol (2010) MSDS for NOVOLFROTH® 234 Ethoxylate, Version 1.3 dated 18 June 2010. Available at http://www.sasoltechdata.com/MSDS/NOVELFROTH234.pdf [Accessed 14 August 2013]

Sasol (2013) MSDS for NOVEL® 6-6 Ethoxylate. Version 2.0 dated 22 July 2013. Available at http://www.sasoltechdata.com/MSDS/NV6-6.pdf [Accessed 14 August 2013]

Created by:	CM	Date 28 August 2013
Reviewed and edited by:	JF	30 August 2013

Project number: 127666004
Project name: Hydraulic Stimulation Chemicals Assessment, Southwest Queensland
Client name: Santos Limited

Name	2-Acrylamido-2-methylpropane sulfonic acid (SURROGATE FOR Acrylamide, 2-acrylamido-2-ethylpropanesulfonic acid, sodium salt polymer 38193-60-1)
Synonyms	
CAS number	5165-97-9, surrogate for 38193-60-1
Molecular formula	$C_7H_{12}NNaO_4S$
Molecular Structure	

Overview	References
2-Acrylamido-2-methylpropane sulfonate, sodium salt (Na-AMPS) is available as a crystalline solid or as an aqueous salt solution. This chemical is the monomer for Poly-AMPS. Poly-AMPS has limited available reference data. AMPSs (comprising sodium and ammonium salts of AMPS as well as the sulfonic acid) are prepared by reacting acrylonitrile, isobutylene, and oleum in the presence of water. The reactive sites on the monomer are the unsaturated vinyl group and the terminal sulfonic acid. The three members of the AMPS category (Na-AMPS, ammonia-AMPS, and AMPS-acid) are virtually homologous, characterized by a 2-acrylamido-2-methylpropanesulfonic parent anion, distinct only by the corresponding H+, Na+ or NH4+ counter-ion (Lubrizol Corp, 2000). While the only use of Na-AMPS as a monomer is, in a derivatised form, as a surfactant in fire-fighting foams, there are several thousand patents and publications involving use of poly-AMPS. These cover many areas including water treatment, oil field, construction chemicals, for medical applications, personal care products, emulsion coatings, adhesives, and rheology modifiers. The sodium and ammonium salts of AMPS monomer are prepared as 50% aqueous solutions. AMPS monomers are highly reactive and hydrophilic. AMPS monomers are primarily used for the preparation of high molecular weight water-soluble polymers. The monomers can be polymerized in solution using conventional vinyl moiety polymerization. No epidemiology studies have identified an association between the three AMPS monomers exposure and development of cancer. The International Agency for Research on Cancer (IARC)	US EPA (2009); IARC (2013); Lubrizol Corp (2000).

has not classified the carcinogenic potential of Na-AMPS or its polymer.	

Human Health Toxicity Summary	Reference
Carcinogenicity Not classified by IARC.	IARC (2013).
Mutagenicity/Genotoxicity Four mutagenic assays on similar compound (ammonium salt of AMPS) were negative. For similar compound (AMPS-acid), two negative results and one inconclusive result were obtained from genetic toxicity tests.	US EPA (2009).
Reproductive Toxicity In a combined reproductive/developmental toxicity screening test, CASRN 58374-69-9 (supporting chemical- ammonium salt) showed no evidence of systemic, reproductive, maternal, or developmental toxicity following oral exposure in rats; the NOAEL was 1000 mg/kg-bw/day (highest dose tested).	US EPA (2009); Lubrizol Corp (2000).
Developmental Toxicity/Teratogenicity In a combined reproductive/developmental toxicity screening test, CASRN 58374-69-9 (supporting chemical – ammonium salt) showed no evidence of systemic, reproductive, maternal, or developmental toxicity following oral exposure in rats; the NOAEL was 1000 mg/kg-bw/day (highest dose tested).	US EPA (2009); Lubrizol Corp (2000).
Endocrine Disruption No data found (NDF).	All proposed data sources.
Neurotoxicity NDF.	All proposed data sources.
Acute Toxicity (oral, dermal, inhalation) When administered to Sprague-Dawley rats in dosages ranging from 1000-8000 mg/kg, no unscheduled deaths were recorded and no unusual clinical or behavioral signs were observed. Animals receiving 16000 mg/kg appeared ruffled and lethargic within 3-4 hours of test material administration. All animals appeared normal by day 5.	US EPA (2013).
Chronic/repeat dose toxicity (oral, dermal, inhalation) No effects were seen in Sprague-Dawley rats exposed to similar compound ammonia-AMPS at up to 1000 mg/kg-bw/day 7 days/week for 28 days.	US EPA (2009).
Sensitisation of the skin or respiratory system NDF.	All proposed data sources.
Corrosion (irreversible and reversible)/irritation of the skin or eye Slight erythema was seen in New Zealand albino rabbits exposed to similar compound ammonia-AMPS at 2000 mg/kg-bw for 24 hours. The dermal irritation subsided after day 11.	All proposed data sources.
Flammable Potential NDF.	All proposed data sources.
Explosive Potential NDF.	All proposed data sources.

Toxicity Values	Value	Reference
Human Toxicity Data		
High Chronic/Repeat Dose Toxicity		
LOAEC	NDF	-
Animal Toxicity Data		
Acute Toxicity		
LD_{50}		
Rats (oral)	> 16000 mg/kg	US EPA 2009
LD_{100}		
	NDF	-
LC_{50}		
	NDF	-
High Chronic/Repeat Dose Toxicity		
LOAEL/NOAEL	1000 mg/kg/day	US EPA 2009

Footnotes:
LD_{50} – lethal dose for 50% of experimental population
LC_{50} – lethal air concentration for 50% of experimental population
LOAEL – Lowest Observed Adverse Effect Level
LOAEC – Lowest Observed Adverse Effect Concentration
NOAEL – No-Observed-Adverse-Effect-Level

Human Health Toxicity Ranking*		
	Hazard data	**Comment**
Hazard Band 4		
Carcinogenicity	NDF	-
Mutagenicity/Genotoxicity	No	US EPA (2009).
Reproductive Toxicity	No	US EPA (2009; Lubrizol Corp (2000). Based on analogous ammonium salt.
Developmental Toxicity/ Teratogenicity	No	US EPA (2009; Lubrizol Corp (2000). Based on analogous ammonium salt.
Endocrine Disruption[1]	NDF	-
Neurotoxicity[2]	NDF	-
Hazard Band 3		
Acute Toxicity (oral, dermal or inhalation) Very Toxic/Toxic oral LD_{50} ≤ 300 mg/kg[3] dermal LD_{50} ≤ 1000 mg/kg inhalation LC_{50} ≤ 10 mg/L[4] (or mg/m^3) (vapour)	No	Oral LD_{50} in rats >16,000 mg/kg body weight. For similar compounds AMPS-acid, oral LD_{50} in rats 1,830 mg/kg body weight. US EPA (2009; Lubrizol Corp (2000).
High Chronic/repeat dose toxicity oral LOAEL ≤ 10 mg/kg/d[3]; dermal LOAEL ≤ 2 0 mg/kg/d; inhalation LOAEC (6 h/d) ≤ 50 ppm/d for gases, ≤ 0.2 mg/L/d for vapours or ≤ 0.02 mg/L/d for dust/mists/fumes[4]	NDF	-
Corrosive (irreversible damage)	NDF	-
Respiratory sensitiser	NDF	-
Hazard Band 2		
Harmful chronic/repeat dose toxicity oral LOAEL > 10 mg/kg and ≤ 100 mg/kg/d dermal LOAEL > 20 mg/kg/d and ≤ 200 mg/kg/d inhalation (6-h/d) LOAEC > 50 mg/L ≤ 250 mg/L/d for gases, > 0.2 mg/L ≤ 1 .0 mg/L/d for vapours or > 0.02 mg/L ≤ 0.2 mg/L/d for dust/mists/fumes[4]	No	Oral NOAEL of 1000 mg/kg/day. US EPA (2009). Based on supporting chemical.
Skin Sensitiser	NDF	-
Hazard Band 1		
Acute Toxicity-Harmful oral LD_{50} > 300 mg/kg ≤ 2000 mg/kg	No	Oral LD_{50} in rats >16,000 mg/kg body weight. For

dermal LD_{50} >1 000 mg/kg ≤ 2000 mg/kg; inhalation LC_{50} (6 h/d) > 10 mg/L ≤ 20 mg/L for vapours)[4]		similar compounds AMPS-acid, oral LD_{50} in rats 1,830 mg/kg body weight.
Irritant (reversible damage)	Yes	US EPA (2009; Lubrizol Corp (2000).
Hazard Band 0 **All indicators outside criteria listed in Hazards 1-4**		
Physical Hazards		
Flammable potential	NDF	-
Explosive potential	NDF	-
Hazard Evaluation (highest band) not including physical hazards	Hazard Band 1	Low toxicity implied by available data.
Uncertainty analysis /data confidence	14 parameters, 6/14 x 100 =	**43%**

* Based on IMAP Framework [NICNAS (2013) Inventory Multi-tiered Assessment and Prioritisation (IMAP) Framework. National Industrial Chemicals Notification and Assessment Scheme. Department of Health and Aging, Canberra].

"[1] *Based on list of endocrine disrupting chemicals from the European Commission's Endocrine Disrupters website.*

[2] *Based on list of neurotoxic chemicals from US Agency for Toxic Substances and Disease Registry (ATSDR).*

[3] *milligrams per kilogram body mass (mg/kg) or milligrams per kilogram body mass per day (mg/kg/d)*

[4] *Based on GHS cut-offs for hazard classification. For chronic/repeat dose toxicity, GHS cut-offs are provided as guidance values (i.e. the dose/concentration at or below which significant health effects are observed"). (p 18, NICNAS 2013).*

Human Health Guidelines		
Media	**Concentration (mg/m^3; mg/L; mg/kg)**	**Reference**
Occupational Exposure Limits		
Air (OEL)		
8-h TWA	NDF	All proposed data sources
STEL	NDF	All proposed data sources
Peak Limitation	NDF	All proposed data sources
Environmental Exposure		
Air, ambient	NDF	All proposed data sources
Air, indoor	NDF	All proposed data sources
Water, potable	NDF	NEPM (1999; amended 2013)
Water, recreational	NDF	All proposed data sources
Soil, residential	NDF	NEPM (1999; amended 2013)
Soil, commercial/industrial	NDF	NEPM (1999; amended 2013)

Footnotes:
OEL = Occupational Exposure Limit
TWA= 8 h Time-Weighted Average
STEL = (15 min) Short-term Exposure Limit
NDF - No data found within the limits of the search strategy.

Qualifying Summary Comments

2-Acrylamido-2-methylpropane sulfonate, sodium salt (Na-AMPS) exhibits a Hazard Band Rating of 1 based on limited data supporting a position of low acute and chronic toxicity in animal studies with some evidence of skin irritancy in rabbits. These data have been based on the monomer as a surrogate for acrylamide, 2-acrylamido-2-ethylpropanesulfonic acid, sodium salt polymer based on structure activity relationships provided in the OECD QSAR Toolkit. Note that the polymer would degrade to its monomeric units which subsequently exhibit a low degree of biodegradation. There are no data on its flammable or explosive potential but this would be expected to be low in aqueous solutions. Based on evidence of skin irritant properties occupational exposures should limit dermal contact through suitable transport and handling management methods.

References

IARC (2013). Agents Classified by the *IARC Monographs*, Volumes 1–107. Available at http://monographs.iarc.fr/ENG/Classification/ClassificationsAlphaOrder.pdf. [Accessed 26 June 2013].
Lubrizol Corporation (2000). Test Plan for AMPS category, August 1, 2000. Available at http://www.epa.gov/oppt/chemrtk/pubs/summaries/amps/c12958.pdf. [Accessed 28 June 2013].
NICNAS (2013) Inventory Multi-tiered Assessment and Prioritisation (IMAP) Framework. National Industrial Chemicals Notification and Assessment Scheme. Department of Health and Aging, Canberra.
SCEW (2013). National Environment Protection (Assessment of Site Contamination) Measure 1999. As Amended. COAG Standing Council on Environment and Water, Canberra.
US EPA (2009). Hazard Characterization Document. Screening-Level Hazard Characterization AMPS® Category. Accessed 28 June 2013. Available at http://www.epa.gov/hpvis/hazchar/Category_AMPS_Sept2009.pdf. [Accessed 28 June 2013].
US EPA (2013) Aggregated Computational Toxicology Resource (ACToR) database. Chemical: sodium 2-methyl-2-[(1-oxoallyl)amino]propanesulphonate. [Accessed 28 June 2013].

Created by:	**MER**	Date: **28/06/2013**
Reviewed and edited by:	**LT**	Date: Rev0 **07/11/2013**

Project number: 127666004
Project name: Hydraulic Stimulation Chemicals Assessment, Southwest Queensland
Client name: Santos Ltd

Name	Dicoco dimethyl quaternary ammonium chloride
Synonyms	Quaternary ammonium compounds, dicoco alkyldimethyl, chlorides, dicocodimethylammonium chloride
CAS number	61789-77-3
Molecular formula	-
Molecular Structure	

Overview	References
Quaternary ammonium compounds are cationic surfactants and their uses include pesticides, detergents (in cleaning products and shampoos), emulsifying agents (in creams and lotions) and wetting agents. Principles health effects include acute, maternal and developmental toxicity, severe skin burns and eyes damage.	US EPA, 2006 ECHA, 2013

Human Health Toxicity Summary	Reference
Carcinogenicity Not carcinogenic	US EPA, 2006
Mutagenicity/Genotoxicity Not classified as genotoxic	ECHA, 2013
Reproductive Toxicity No adverse reproductive effects observed	US EPA, 2006
Developmental Toxicity/Teratogenicity An oral developmental study on rats showed maternal toxicity effects at 20 and 30 mg/kg and developmental toxicity effects (skeletal variations) at 30 mg/kg. The maternal LOAEL was 10 mg/kg/day and the developmental 20mg/kg/day. An oral developmental study on rabbits showed maternal toxicity effects at 3 and 10 mg/kg and developmental toxicity effects (decreased fetal weight and an increased number of dead foetuses) at 10 mg/kg.	US EPA, 2006
Endocrine Disruption Not listed as an endocrine disruptor	EC, 2000
Acute Toxicity (oral, dermal, inhalation) Harmful if swallowed LD50 for rats (gavage) is 960 mg/kg	ECHA, 2013 US EPA, 2013
Chronic/repeat dose toxicity (oral, dermal, inhalation) Oral: no chronic effects observed at 100 mg/kg/day in a dog study using a read-across (Quaternary ammonium compounds, bis(hydrogenated tallow alkyl)dimethyl, chlorides – CAS No 61789-80-8) Derrmal: no chronic effects observed at 140 mg/kg/day in a rabbit study (except for skin irritation) using a read-across (Quaternary ammonium compounds, bis(hydrogenated tallow alkyl)dimethyl, chlorides – CAS No 61789-80-8)	US EPA, 2013
Sensitisation of the skin or respiratory system Data lacking regarding respiratory sensitisation Not classified as a skin sensitiser	ECHA, 2013

Corrosion (irreversible and reversible)/irritation of the skin or eye Causes severe skin burns and eye damage	ECHA, 2013
Physical Hazards	**Reference**
Flammable Potential Flammable liquid and vapour.	ECHA, 2013
Explosive Potential Not classified as explosive.	ECHA, 2013

Toxicity Values	Value	Reference
Human Toxicity Data		
Acute Toxicity		
	NDF	
High Chronic/Repeat Dose Toxicity		
LOAEC	NDF	
LOAEL	NDF	
Animal Toxicity Data		
Acute Toxicity		
LD_{50}		
Rat, oral	960 mg/kg	US EPA 2013
Mouse, oral	NDF	
Rabbit, oral	NDF	
Rat, dermal	NDF	
Rabbit, dermal	NDF	
Mouse, dermal	NDF	
LOAEL	NDF	
LOAEC	NDF	
LC_{50}		
Rat	NDF	
High Chronic/Repeat Dose Toxicity		
LOAEL (dog)	50 mg/kg/day	US EPA 2006
LOAEL (rat)	175 mg/kg/day (male) and 225.5 mg/kg/day (female)	US EPA 2006
LOAEC	NDF	
NOAEL (dog)	Oral NOAEL > 100 mg/kg/day with a read-across	US EPA 2013
NOAEL (rabbit)	Dermal NOAEL > 140 mg/kg/day (except for skin irritation) with a read-across	US EPA 2013

Footnotes:
LD_{50} – lethal dose for 50% of experimental population
LC_{50} – lethal air concentration for 50% of experimental population
LOAEL – Lowest Observed Adverse Effect Level
LOAEC – Lowest Observed Adverse Effect Concentration

Project number: 127666004
Project name: Hydraulic Stimulation Chemicals Assessment, Southwest Queensland
Client name: Santos Ltd

Human Health Toxicity Ranking*		
	Hazard data	**Comment**
Hazard Band 4		
Carcinogenicity	NO	
Mutagenicity/Genotoxicity	NO	
Reproductive Toxicity	NDF	
Developmental Toxicity/ Teratogenicity	NO	
Endocrine Disruption[1]	NO	
Hazard Band 3		
Acute Toxicity (oral, dermal or inhalation) Very Toxic/Toxic • oral $LD_{50} \leq 300$ mg/kg[3] • dermal $LD_{50} \leq 1000$ mg/kg • inhalation $LC_{50} \leq 10$ mg/L[4] (or mg/m[3]) (vapour)	YES	
Possible carcinogenicity, mutagenicity, reproductive or High Chronic/repeat dose toxicity • oral LOAEL ≤ 10 mg/kg/d[3]; • dermal LOAEL ≤ 2 0 mg/kg/d; • inhalation LOAEC (6 h/d) ≤ 50 ppm/d for gases, ≤ 0.2 mg/L/d for vapours or ≤ 0.02 mg/L/d for dust/mists/fumes[4]	YES	
Corrosive (irreversible damage)	YES	
Respiratory sensitiser	NDF	
Hazard Band 2		
Harmful chronic/repeat dose toxicity • oral LOAEL > 10 mg/kg and ≤ 100 mg/kg/d • dermal LOAEL > 20 mg/kg/d and ≤ 200 mg/kg/d • inhalation (6-h/d) LOAEC > 50 mg/L ≤ 250 mg/L/d for gases, > 0.2 mg/L ≤ 1 .0 mg/L/d for vapours or > 0.02 mg/L ≤ 0.2 mg/L/d for dust/mists/fumes[4]	YES	LOAEL (dog) = 50 mg/kg/day – US EPA, 2006
Skin Sensitiser	NO	
Hazard Band 1		
Acute Toxicity-Harmful • oral $LD_{50} > 300$ mg/kg ≤ 2000 mg/kg • dermal $LD_{50} > 1\,000$ mg/kg ≤ 2000 mg/kg; • inhalation LC_{50} (6 h/d) > 10 mg/L ≤ 20 mg/L for vapours)[4]	YES	
Irritant (reversible damage)	NDF	
Hazard Band 0 **All indicators outside criteria listed in Hazards 1-4**		
Physical Hazards		
Flammable potential	YES	
Explosive potential	NO	
Hazard Evaluation (highest band) not including physical hazards	**Band 3**	
Uncertainty analysis /data confidence	10/13	**76.9%**

* Based on IMAP Framework [NICNAS (2013) Inventory Multi-tiered Assessment and Prioritisation (IMAP) Framework. National Industrial Chemicals Notification and Assessment Scheme. Department of Health and Aging, Canberra].

"[1]Based on list of endocrine disrupting chemicals from the European Commission's Endocrine Disrupters website.

[2] Based on list of neurotoxic chemicals from US Agency for Toxic Substances and Disease Registry (ATSDR).
[3] milligrams per kilogram body mass(mg/kg) or milligrams per kilogram body mas per day (mg/kg/d)

[4] Based on GHS cut-offs for hazard classification. For chronic/repeat dose toxicity, GHS cut-offs are provided as guidance values (i.e. the dose/concentration at or below which significant health effects are observed"). (p 18, NICNAS 2013).

Human Health Guidelines		
Media	**Concentration (mg/m^3; mg/L; mg/kg)**	**Reference**
Occupational Exposure Limits		
Air (OEL)		
8-h TWA	NDF	
STEL	NDF	
Peak Limitation	NDF	
Environmental Exposure		
Air, ambient	Residential exposure (inhalation) not of concern as not expected to occur when used as an inert ingredient in pesticides formulation	US EPA, 2006
Air, indoor		
Water, potable	Measurable concentrations are not expected in drinking water when used as an inert ingredient in pesticides formulation	US EPA, 2006
Water, recreational	NDF	
Soil, residential	Not expected to occur when used as an inert ingredient in pesticides formulation	US EPA, 2006
Soil, commercial/industrial	NDF	

Footnotes:

OEL = Occupational Exposure Limit

TWA= 8 h Time-Weighted Average

STEL = (15 min) Short-term Exposure Limit

NDF - No data found within the limits of the search strategy.

Qualifying Summary Comments

Dicoco dimethyl quaternary ammonium chloride is an acute and corrosive substance. It can cause severe skin burns and eye damage. Animal studies (rats and rabbits) showed developmental toxicity effects at maternally toxic doses. Dicoco dimethyl quaternary ammonium chloride falls into the Hazard Band 3 category. Because Dicoco dimethyl quaternary ammonium chloride strongly binds to soil, it is not expected to enter surface and groundwater.

References and Notes

European Chemicals Agency (ECHA, 2013). Classification and Labelling Inventory database Search. Available at http://echa.europa.eu/web/guest/information-on-chemicals/cl-inventory-database [Accessed 23 August 2013]

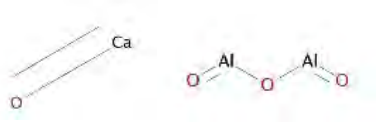
European Commission (EC) (2000) Towards the establishment of a priority list of substances for further evaluation of their role in endocrine disruption, preparation of a candidate list of substances as a basis for priority setting, Final Report (Incorporating corrigenda to final report dated 21 June 2000).

United States Environmental Protection Agency (US EPA 2013). High Production Volume Information System (HPVIS). Available at http://iaspub.epa.gov/oppthpv/public_search.publiclist?wChemicalName=61789-77-3&programFlags= [Accessed 23 August 2013]

United States Environmental Protection Agency (US EPA 2006). Inert Reassessments: Three Exemptions from the Requirement of a Tolerance for Dialkyl (C_8-C_{18}) Dimethyl Ammonium Chloride and Mono and Dialkyl (C_8-C_{18}) Methylated Ammonium Chloride Compounds.

Created by:	JC	Date: 29/08/2013
Reviewed and edited by:	JF	Date 11/09/2013

Project number: 127666004
Project name: Hydraulic Stimulation Chemicals Assessment, Southwest Queensland
Client name: Santos Ltd

Name	Ceramic materials and wares, chemicals
Synonyms	
CAS number	66402-68-4 Calcium oxide (CAS number: 1305-78-8) Aluminium oxide (CAS number: 1344-28-1)
Molecular formula	CaO Al_2O_3
Molecular Structure	

Overview	References
'Ceramic materials and wares, chemicals' comprise of numerous chemical substances manufactured in the production of ceramics. For purposes of this category, a ceramic is defined as a crystalline or partially crystalline, inorganic, non-metallic, usually opaque substance consisting principally of combinations of inorganic oxides of aluminum, calcium, chromium, iron, magnesium, silicon, titanium, or zirconium which conventionally is formed first by fusion or sintering at very high temperatures, then by cooling, generally resulting in a rigid, brittle monophase or multiphase structure. Other than by-products or impurities, other chemical substances are formed during the production of various ceramics and therefore incorporated into the ceramic mixture.	
As the composition may contain any one or a combination of the chemical substances mentioned above the human health assessment has been conservatively based on calcium oxide and aluminum oxide.	ECHA (2013)
For reaction product of thermal process between 1000°C and 2000°C aluminum oxide and calcium oxide are the raw materials combined in various proportions which contribute to more than 80% of the multiphase crystalline matrix. However, surrogates of calcium oxide and aluminum oxide have also been used to infer toxicological data from.	IARC (1999)
Calcium oxide is odourless and can take several forms including colourless cubic crystals, white or grayish white lumps, or granular powder. It has a molecular weight of 56.08 g/mol with a melting and boiling point of 2572ºC and 2850 ºC respectively. It is strongly caustic and is soluble in water forming calcium hydroxide and generating large a quantity of heat. Because it can react violently with water it can cause severe irritation when in contact with moist skin or eyes.	HSDB (2013a) HSDB (2013b)
Aluminum oxide is an odourless white crystalline powder. It has a molecular weight of 101.961 g/mol, a specific gravity of 3.4-4 and a melting point of 2030 ºC. Unlike calcium oxide it is insoluble in water but it is soluble in acid and slightly soluble in alkaline solutions. Aluminium oxide is on EPA's Toxics Release Inventory list if it is a fibrous form.	ACS (2013)
Ceramics have an extensive use within the industry, from the very early applications in pottery through to the more advanced medical applications in joint replacements and dental prostheses. Due to the specific mechanical/electrical/ optical/biomedical/chemical properties of ceramic materials its use has found its way in other industries including aerospace, construction, electronics, military, optical materials, sports and transportation.	

Human Health Toxicity Summary	Reference
Carcinogenicity Based on the GHS classification 'Ceramic materials and wares, chemicals' are not classifiable as to its carcinogenicity to humans. A study undertake by IARC has concluded that ceramic implants are *not classifiable as to their carcinogenicity to humans* (Group 3). *Notes:* A human study had investigated the associations between alumina and bauxite dust exposure and circulatory disease mortality, respiratory disease mortality and cancer incidence in a cohort of employees from four bauxite mines and three alumina refineries in. The median, mean and maximum cumulative exposures to bauxite among the bauxite-exposed workers were 5.7, 13.4, and 187 mg/m³-yr, respectively. The median, mean and maximum cumulative exposures to alumina among the alumina-exposed workers were 2.8, 14.5, and 210 mg/m³-yr, respectively. The conclusion of the study was that neither bauxite nor alumina exposure was associated with increased cancer risk. A rat (male/females) study reported no evidence of fibrosis in a repeated dose inhalation study that administered alumina fibres at levels between 2 and 3 mg/m³ for 86 weeks. Exposure to both types of alumina fibres used produced minimal pulmonary reaction and no fibrosis. The authors concluded that the pulmonary reaction to the fibres observed in the study is consistent with their classification as biologically inert materials. Another rat study using calcium lactate did not cause toxicity or carcinogenic activity.	ECHA (2013) IARC (2013)
Mutagenicity/Genotoxicity Not classified as a mutagenic/genotoxic chemical. *Notes:* An in-vitro mutagenicity test was undertaken for calcium oxide. Under the experimental conditions reported, calcium oxide did not induce gene mutations by base pair changes or frameshifts in the genome of the strains used up to and including the highest testable concentration. An in-vivo study involved the administration of aluminium hydroxide to out-bred male rats with the conclusion that aluminium hydroxide did not induce micronuclei in the polychromatic erythrocytes of the bone marrow of male rats treated up to 2000 mg/kg/day (the maximum recommended dose for the study).	ECHA (2013)
Reproductive Toxicity Not classified as having reproductive toxicity effects. *Notes:* A developmental toxicity screening study was undertaken which involved oral administration of aluminium chloride (basic) at short-term and sub-chronic exposure dose levels of 40, 200, and 1000 mg/kg before mating and at a critical period of embryo- , organogenesis and development. No adverse effects on reproductive behavior, mating criteria and histological structure of examined reproductive organs in males and females of rats exposed. The study adds to the weight of evidence for the absence of reproductive/breeding, mating impairment and early postnatal developmental effects due to short-term exposure to high doses of aluminium chloride (basic). No mortality or clinical signs of intoxication were observed in male and female rats due to treatment Suggested NOAEL for reproductive toxicity (lack of reproductive /breeding, mating impairment and early postnatal developmental effects) of 1000 mg/kg.	ECHA (2013)
Developmental Toxicity/Teratogenicity Not classified as having developmental toxic/teratogenic effects. *Notes:* Administration of up to 680 mg/kg of calcium oxide to pregnant rats for 10 consecutive days had no clearly discernible effect on foetal survival. The number of abnormalities seen in either soft or skeletal tissues of test groups did not differ from the number occuring spontaneously in sham-treated controls, resulting in a NOAEL of 680 mg/kg.	ECHA (2013)

Another study assessed the developmental toxicity and embryotoxic/teratogenic potential of high doses of target compound aluminium hydroxide orally administered to rats during the period of active organogenesis. No significant general/maternal toxicity was observed in any Al treated groups that were orally exposed to Al hydroxide at doses 66.5, 133 and 266 mg Al/kg, resulting in a NOAEL of 266 mg/kg.	
Endocrine Disruption Neither 'Ceramic materials and wares, chemicals', calcium oxide or aluminum oxide have been included in the European Commission's Endocrine Disrupters Priority List.	ECED (2013)
Neurotoxicity No information found.	All proposed data sources
Acute Toxicity (oral, dermal, inhalation) Not classified as having acute toxic effects when administered orally, applied to the skin or when inhaled. *Notes:* Calcium oxide was administrated (oral) to female rats and observed over a period of 14 days. No deaths occurred during the study resulting with an LD50 greater than 2000 mg/kg. Aluminium oxide administrated (oral) to female and male rats did not cause mortality after an acute exposure to 10000 mg/kg. At the10000 mg/kg dose no clinical signs of intoxication were observed during the post-administration observation period. Animals appeared healthy through the observation period. Rats (female and males) were exposed to fumed alumina (aluminum oxide) in an inhalation chamber for four hours. No mortality was observed during this study, clinical signs were minor and only one animal showed lung abnormalities on necropsy. A detrimental effect on weight gain was observed in females only. The LC50 for fumed alumina is therefore greater than 2.3 mg/L. Another study conducted on male rats to investigate and compare the acute inhalation toxicity of aluminum flake concluded LC0 and LC50 of 0.888 mg/L air and >0.888 mg/L air respectively A study on female/male rabbits involved dermal application of lime paste for 24 hours resulting in a LD50 (dermal) of > 2500 mg/kg. The available data showed that the tested white lime paste caused no acute toxic effect after dermal application. However, the test did show skin irritating effects from the test sample.	ECHA (2013)
Chronic/repeat dose toxicity (oral, dermal, inhalation) Not classified as having chronic oral, dermal or inhalation effects. *Notes:* *Oral Administration* Aluminum hydroxide and basic food grade sodium aluminum phosphate (KASAL and KASAL II) were administered to male rats during a 28-study at daily doses up to approximately 300 mg Al/kg. The results of this study provide no evidence for significant deposition of aluminum in the bone and for toxicity of the substances, resulting in a NOAEL up to 302 mg/kg diet. Treatment with aluminum chloride revealed paternal toxicity (irritation effect on glandular stomach mucosa, local effect) at 1000 mg/kg in both the male and female rats. No Observed Adverse Effect Level (NOAEL) for local toxic effects on stomach was established at 200 mg/kg and LOAEL at level 1000 mg/kg for both male and female rates. Sodium aluminium phosphate was administered to beagle dogs with diet at concentrations 0% (control), 0.3%, 1.0% and 3.0% for 6 months. A the results of this study provided no evidence for toxicity of acidic form of sodium aluminum phosphate during 6-month administration at concentrations up to 3% in the diet n a NOAEL of 90 mg/kg was inferred. *Inhalation* A study had investigated the pulmonary toxicity of two calcined agglomerated aluminium oxyhydroxide (boehmite) nanoparticles in rats exposed by inhalation for 6 hrs/day, 5 days/week	ECHA (2013)

for 4 weeks. In conclusion, an inflammatory pulmonary response was observed only at the end of the 4 week exposure period in the animals receiving the highest dose (28 mg/m³). The NOAEC from this study is 3 mg/m³ and the LOAEC is 28 mg/m³. Another study had exposed rats, guinea pigs and hamsters to three different aluminium powders in the form of Al_2O_3 via intratracheal injection. The aluminium powder caused nodular pulmonary fibrosis in the lungs of the rats only at the highest dose administered (100 mg). All three species developed widespread alveolar proteinosis, rats exhibiting the most severe response. The proteinosis resolved progressively after cessation of exposure. A NOAEC of 70 mg/m³ air for Al_2O_3 was adopted.	
Sensitisation of the skin or respiratory system Not classified as a skin or respiratory sensitiser.	ECHA (2013)
Corrosion (irreversible and reversible)/irritation of the skin or eye Causes serious eye irritation (GHS Eye Irritation Category 1). Classified as a non-irritant to the skin. In a primary dermal irritation study, the skin irritation/corrosion potential of LDSF® LT[1] was tested where 0.5 g of the inferred titanium calcium aluminate was applied on the skin of 3 rabbits. The application of the test item did not induce colouring of the application site and did not interfere with grading of any skin lesion. After the application two animals presented a slight erythema for the 4 -hour exposure time. No other cutaneous lesion was observed. Under the experimental conditions adopted, the test item was found to be a non-skin irritant. In a primary eye irritation study, 0.1 g of LDSF® RG[2], inferred calcium aluminate, was introduced into the conjunctival sac of the left eye of four rabbits. The untreated right eye served as a control. Although chemosis with lacrimation and slight redness of the conjunctivae were observed at all of the animals no ocular lesion persisted in any animal at the end of the exposure period. Under the experimental conditions adopted, the test item was therefore found to be a non-eye irritant. However, in a second eye irritation study, under same experimental conditions 0.1 g of LDSF® LT, inferred titanium calcium aluminate, was introduced into the conjunctival sac of the left eye to one of the rabbits only. As LSDF® LT caused local pain and was probably severely irritating or corrosive. Therefore, exposure of two additional animals was not done. Because ocular lesions and animal pain increased during the reversibility period and under the experimental conditions adopted, LSDF®LT has been classif ed as an eye irritant; hence the Category 1 classification.	ECHA (2013)

Physical Hazards	Reference
Flammable Potential Not classified as a flammable/combustible chemical.	ECHA (2013)
Explosive Potential Not classified as an explosive chemical.	ECHA (2013)

Toxicity Values	Value	Reference
Human Toxicity Data		
Acute Toxicity		

[1] The ECHA database states that for LDSF® LT there was 'lack of detail on substance' and therefore the chemical composition was not defined. A general search on the internet defined LDSF® LT as low titanium calcium aluminate flux. Website reference: http://www.kerneos.com/content/en/Our-solutions/Products/LDSF-&-OPTIMET/

[2] The ECHA database states that for LDSF® RG there was 'lack of detail on substance' and therefore the chemical composition was not defined. A general search on the internet defined LDSF® RG as calcium aluminate flux. Website reference: http://www.kerneos.com/content/en/Our-solutions/Products/LDSF-&-OPTIMET/

High Chronic/Repeat Dose Toxicity		
LOAEC		
LOAEL		
Animal Toxicity Data		
Acute Toxicity		
LD_{50}		
Rat, oral	>2000 mg/kg (based on calcium oxide)	ECHA (2013)
Mouse, oral		
Rabbit, oral		
Rat, dermal		
Rabbit, dermal	>2500 mg/kg (lime paste, i.e. calcium oxide)	ECHA (2013)
Mouse, dermal		
LOAEL		
LOAEC		
LC_{50}		
Rat	>0.888 mg/L (based on aluminium oxide)	ECHA (2013)
High Chronic/Repeat Dose Toxicity		
LOAEL, rat, inhalation	28 mg/m^3 (based on aluminium oxyhydroxide)	ECHA (2013)
LOAEC		

Footnotes:
LD_{50} – lethal dose for 50% of experimental population
LC_{50} – lethal air concentration for 50% of experimental population
LOAEL – Lowest Observed Adverse Effect Level
LOAEC – Lowest Observed Adverse Effect Concentration

Human Health Toxicity Ranking*		
	Hazard data	**Comment**
Hazard Band 4		
Carcinogenicity	NO	
Mutagenicity/Genotoxicity	NO	
Reproductive Toxicity	NO	
Developmental Toxicity/ Teratogenicity	NO	
Endocrine Disruption[1]	-	Not listed on the endocrine disrupting chemicals
Hazard Band 3	NO	
Acute Toxicity (oral, dermal or inhalation) Very Toxic/Toxic • oral LD_{50} ≤ 300 mg/kg[3] • dermal LD_{50} ≤ 1000 mg/kg • inhalation LC_{50} ≤ 10 mg/L[4] (or mg/m^3) (vapour)	NO	
Possible carcinogenicity, mutagenicity, reproductive or High Chronic/repeat dose toxicity • oral LOAEL ≤ 10 mg/kg/d[3]; • dermal LOAEL ≤ 2 0 mg/kg/d; • inhalation LOAEC (6 h/d) ≤ 50 ppm/d for gases, ≤ 0.2 mg/L/d for vapours or ≤ 0.02 mg/L/d for dust/mists/fumes[4]	NO	
Corrosive (irreversible damage)	YES	GHS Eye Damage 1 Classification as it causes serious eye damage. Even though this study was based neither on calcium oxide or aluminum oxide the fact that calcium oxide can react violently with water it can cause severe irritation when in contact with moist skin or eyes. However, the acute toxicity (oral, dermal, inhalation) studies were all based on either calcium oxide or aluminium oxide and these did not classify as having any acute toxic effects.
Respiratory sensitiser	NO	
Hazard Band 2		
Harmful chronic/repeat dose toxicity • oral LOAEL > 10 mg/kg and ≤ 100 mg/kg/d • dermal LOAEL > 20 mg/kg/d and ≤ 200 mg/kg/d • inhalation (6-h/d) LOAEC > 50 mg/L ≤ 250 mg/L/d for gases, > 0.2 mg/L ≤ 1 .0 mg/L/d for vapours or > 0.02 mg/L ≤ 0.2 mg/L/d for dust/mists/fumes[4]	NO	

Skin Sensitiser	NO	
Hazard Band 1		
Acute Toxicity-Harmful • oral LD_{50} > 300 mg/kg ≤ 2000 mg/kg • dermal LD_{50} >1 000 mg/kg ≤ 2000 mg/kg; • inhalation LC_{50} (6 h/d) > 10 mg/L ≤ 20 mg/L for vapours)[4]	NO	
Irritant (reversible damage)	NO	
Hazard Band 0 **All indicators outside criteria listed in Hazards 1-4**	YES	
Physical Hazards		
Flammable potential	NO	
Explosive potential	NO	
Hazard Evaluation (highest band) not including physical hazards	**Band 3**	
Uncertainty analysis /data confidence	13/13	**100%**

* Based on IMAP Framework [NICNAS (2013) Inventory Multi-tiered Assessment and Prioritisation (IMAP) Framework. National Industrial Chemicals Notification and Assessment Scheme. Department of Health and Aging, Canberra].

"[1]Based on list of endocrine disrupting chemicals from the European Commission's Endocrine Disrupters website.

[2] Based on list of neurotoxic chemicals from US Agency for Toxic Substances and Disease Registry (ATSDR).

[3] milligrams per kilogram body mass(mg/kg) or milligrams per kilogram body mas per day (mg/kg/d)

[4] Based on GHS cut-offs for hazard classification. For chronic/repeat dose toxicity, GHS cut-offs are provided as guidance values (i.e. the dose/concentration at or below which significant health effects are observed"). (p 18, NICNAS 2013).

Human Health Guidelines		
Media	**Concentration (mg/m^3; mg/L; mg/kg)**	**Reference**
Occupational Exposure Limits		
Air (OEL)	No data found.	All proposed data sources.
8-h TWA	2 mg/m^3 (calcium oxide)	HSIS (2013a)
	10 mg/m^3 (aluminium oxide)	HSIS (2013b)
STEL	No data found.	All proposed data sources.
Peak Limitation	No data found.	All proposed data sources.
Environmental Exposure		
Air, ambient	No data found.	All proposed data sources.
Air, indoor	No data found.	All proposed data sources.
Water, potable	No data found.	All proposed data sources.
Water, recreational	No data found.	All proposed data sources.
Soil, residential	No data found.	All proposed data sources.
Soil, commercial/industrial	No data found.	All proposed data

		sources.

Footnotes:

OEL = Occupational Exposure Limit

TWA= 8 h Time-Weighted Average

STEL = (15 min) Short-term Exposure Limit

Qualifying Summary Comments

'Ceramic materials and wares, chemicals' comprise of numerous chemical substances manufactured in the production of ceramics. For purposes of this category, a ceramic is defined as a crystalline or partially crystalline, inorganic, non-metallic, usually opaque substance consisting principally of combinations of inorganic oxides. As the composition may contain any one or a combination of numerous chemical substances the human health toxicology data has been on calcium oxide and aluminum oxides as they contribute to more than 80% of the multiphase crystalline matrix (for reaction product of thermal process between 1000°C and 2000°C). However, surrogates of calcium oxide and aluminum oxide have also been used to infer toxicological data from.

'Ceramic materials and wares, chemicals' are not classifiable as to its carcinogenicity to humans and is not considered as having acute or chronic health effects when administered via oral, dermal and inhalation exposure pathways. Furthermore it is not classified as having any reproductive, development/teratogenicity and mutagenicity/genotoxicity effects. Amorphous silica is not classified as a skin or respiratoty sensitiser. Although not classified as a non-irritant to the skin it is classified as causing serious eye irritation (GHD Eye Damage 1 Classification). Even though it is inferred that the eye study wasn't based on either calcium oxide or aluminum oxide the fact that calcium oxide can react violently with water means that it can cause severe irritation when in contact with moist skin or eyes. However, the acute toxicity (oral, dermal, inhalation) studies were all based on either calcium oxide or aluminium oxide neither of which is classified as hazardous for acute toxicity. Given the potential for serious eye irritation ceramic materials have been categorised as hazard band 3.

References and Notes

ACS (2013). The American Ceramic Society. Ceramic Resources, Ceramic Science-Engineering'. Available at http://ceramics.org/knowledge-center/learn-about-ceramics [Accessed 6 September 2013]

ECED (2013) European Commission's Endocrine Disrupters Priority List http://ec.europa.eu/environment/endocrine/strategy/substances_en.htm#priority_list/ [Accessed 6 September 2013]

ECHA (2013) European Chemicals Agency) Registered Substances List. Available at http://apps.echa.europa.eu/registered/data/dossiers/DISS-76fd35e0-69c4-29a3-e044-00144f26965e/AGGR-21acd42f-67ed-4528-ac36-6e19c3ca4c37_DISS-76fd35e0-69c4-29a3-e044-00144f26965e.html#L-8329d5cf-ef41-48c1-80a0-c20e9193038e [Accessed 6 September 2013]

HSDB (2013a). *CALCIUM OXIDE*. Hazardous Substance Data Bank (HSDB), U.S. National Library of Medicine Accessed at http://toxnet.nlm.nih.gov/cgi-bin/sis/search/f?./temp/~4SqNvK:1. [Accessed 6 September 2013]

HSDB (2013b). *ALUMINIUM OXIDE*. Hazardous Substance Data Bank (HSDB), U.S. National Library of Medicine Accessed at http://toxnet.nlm.nih.gov/cgi-bin/sis/search/f?./temp/~J7KnB9:1. [Accessed 6 September 2013]

HSIS (2013a) *CALCIUM OXIDE* Hazardous Substances Information System ,Safe Work Australia. Accessed from http://hsis.safeworkaustralia.gov.au/ExposureStandards/Details?exposureStandardID=**97** [Accessed 6 September 2013]

HSIS (2013b) *ALUMINIUM OXIDE* Hazardous Substances Information System ,Safe Work Australia. Accessed from http://hsis.safeworkaustralia.gov.au/ExposureStandards/Details?exposureStandardID=20 [Accessed 6 September 2013]

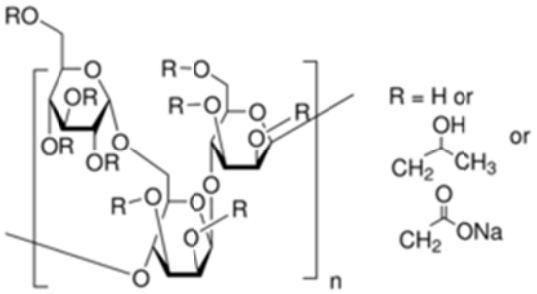
IARC (1999). International Agency for Research on *Cancer Monographs on the Evaluation of Carcinogenic Risks to Humans, Volume 74. Surgical Implants and Other Foreign Bodies Summary of Data Reported and Evaluation.* Available at http://monographs.iarc.fr/ENG/Monographs/vol74/volume74.pdf. [Accessed 6 September 2013]

US EPA (2012). *ALUMINIUM OXIDE (FIBROUS FORM) Toxics Release Inventory.* Available at http://yosemite.epa.gov/oswer/lol.nsf/9628f01801ed88d085256ed200780173/d5849529256e136285257abb0064c5b3!OpenDocument [Accessed 6 September 2013]

NDF - No data found within the limits of the search strategy.

Created by:	JH	Date 6/9/13
Reviewed and edited by:	JF	Date 11/09/2013

Project number: 127666004
Project name: Hydraulic Stimulation Chemicals Assessment, Southwest Queensland
Client name: Santos Ltd

Name	Sodium carboxylmethylhydroxylpropyl guar
Synonyms	-
CAS number	68130-15-4
Molecular formula	-
Molecular Structure	 (Gum guar carboxymethyl ether 2-hydroxypropyl ether sodium salt)

Overview	Reference
The Daily Journal of the Unite States Government – Federal Register Information: Exemption This regulation establishes an exemption from the requirement of a tolerance for residues of carboxymethyl guar gum sodium salt (CAS Reg. No. 39346-76-4) and carboxymethyl-hydroxypropyl guar (CAS Reg. No. 68130-15-4); when used as an inert ingredient (thicker/drift reduction agent) in pesticide formulations applied to growing crops. SciReg Inc., on behalf of Rhodia Inc., submitted a petition to EPA under the Federal Food, Drug, and Cosmetic Act (FFDCA), requesting establishment of an exemption from the requirement of a tolerance. This regulation eliminates the need to establish a maximum permissible level for residues of carboxymethyl guar gum sodium salt and carboxymethyl-hydroxypropyl guar. EPA establishes exemptions from the requirement of a tolerance only in those cases where it can be clearly demonstrated that the risks from aggregate exposure to pesticide chemical residues under reasonably foreseeable circumstances will pose no appreciable risks to human health. In order to determine the risks from aggregate exposure to pesticide inert ingredients, the Agency considers the toxicity of the inert in conjunction with possible exposure to residues of the inert ingredient through food, drinking water, and through other exposures that occur as a result of pesticide use in residential settings. If EPA is able to determine that a finite tolerance is not necessary to ensure that there is a reasonable certainty that no harm will result from aggregate exposure to the inert ingredient, an exemption from the requirement of a tolerance may be established. Carboxymethyl guar and carboxymethyl-hydroxypropyl guar are slightly modified forms of guar gum (CAS 9000-30-0), a natural polymer that has been affirmed as generally recognized as safe (GRAS) and a substance of low toxicity. Carboxymethyl guar and carboxymethyl-hydroxypropyl guar are also structurally similar to hydroxypropyl guar, another slightly modified form of guar gum. They all have same toxicity pattern but the exact mode of action is not known. Based upon the structural similarities between carboxymethyl guar gum, carboxymethyl-hydroxypropyl guar, guar gum, and hydroxypropyl guar, the risk assessment for carboxymethyl guar and carboxymethyl-hydroxypropyl guar relies upon available data on all four substances.	FR 2011

Sub-chronic, reproductive and developmental, and carcinogenicity studies with guar gum showed no long term, reproductive/developmental, or carcinogenic effects. Overall, a low toxicity profile is expected with both carboxymethyl guar and carboxymethyl-hydroxypropyl guar because of likelihood of low absorption via any route of exposure due to their high molecular weights.	

Human Health Toxicity Summary	Reference
Carcinogenicity No evidence of carcinogenicity was found in male and female F344 rats and B6C3F1 mice administered diets containing 25,000 or 50,000 ppm (approximately 3,570 or 7,140 mg/kg/day) guar gum for 103 weeks. A reduction in the mean body weight of the higher dose females and of the feed consumption was observed, as compared with the controls. No compound-related clinical signs of adverse effects on survival were observed. There was no increase in the incidence of tumors that could be related to the test substance.	FR 2011
Mutagenicity/Genotoxicity Results of mutagenicity studies performed with guar gum, hydroxypropyl guar, and carboxymethyl-hydroxypropyl guar were all negative.	FR 2011
Reproductive Toxicity The NOAEL for developmental and reproductive toxicity is 7,500 mg/kg/day for Osborne-Mendel rats fed guar gum.	FR 2011
Developmental Toxicity/Teratogenicity Teratogenicity studies with guar gum in mice, rats, and hamsters did not indicate that guar gum is a teratogen; in mice at doses up to 800 mg/kg/day, in rats up to 900 mg/kg/day and in hamsters up to 600 mg/kg/day. Male and female Osborne-Mendel rats were fed guar gum at 0, 1, 2, 4, 5, 7, or 15% (approximately 0, 500, 1,000, 2,000, 3,750 or 7,500 mg/kg/day) in the diet for 13 weeks before mating, during mating, and throughout gestation. No effects on parental fertility, fetal development, sex distribution, and no malformations of the pups were observed.	FR 2011
Endocrine Disruption Not listed as an endocrine disruptor by the European Commission.	EC 2000
Acute Toxicity (oral, dermal, inhalation) Acute oral toxicity studies conducted with guar, hydroxypropyl guar, and carboxymethyl guar resulted in oral LD_{50} values ranging from 7,060 milligrams per kilogram of body weight (mg/kg bw) to 17,800 mg/kg bw.	FR 2011
Chronic/repeat dose toxicity (oral, dermal, inhalation) There are three 90-day toxicity studies available for guar gums. In one study, the LOAEL of guar gum in a diet was 1% (equivalent to 580 mg/kg/day) based on effects on body weight gains, and dose related decrease in kidney weights. The NOAEL was not established in this study. In the second study, no effects were observed in male rats at doses up to 6% (equivalent to 3,000 mg/kg/day). In the third study in rats, decreases in body weight gains, decreases in food efficiency, increases in blood urea nitrogen and thyroid toxicity (males only) were observed at a dietary concentration of 2 and 5%. The NOAEL in this study was 1% (equivalent to 500 mg/kg/day). No adverse effects were reported in dogs that were fed 0, 1, 5, or 10% (approximately 0, 250, 1,250, or 2,500 mg/kg/day) of a precooked mixture of guar and carob bean for 30 weeks. No effects were observed in monkeys that were fed 1 gram (equal to 10 mg/kg/day) of guar flour for 2 months.	FR 2011

Sensitisation of the skin or respiratory system Results of skin sensitization studies performed with guar gum, hydroxypropyl guar, and carboxymethyl-hydroxypropyl guar were all negative. Occupational asthma has been reported in subjects working with industrial production of guar gum.	FR 2011 HSDB 2002
Corrosion (irreversible)/irritation (reversible) of the skin or eye Dermal irritation studies conducted with guar, hydroxypropyl guar, and carboxymethyl guar resulted in no irritation to slight irritation. Eye irritation studies conducted with guar, hydroxypropyl guar, and carboxymethyl-hydroxypropyl guar demonstrated a range of results from non-irritation to severe irritation.	FR 2011

Physical Hazards	Reference
Flammable Potential NDF.	
Explosive Potential NDF.	

Toxicity Values	Value	Reference
Human Toxicity Data		
Acute Toxicity		
	NDF	
	NDF	
High Chronic/Repeat dose Toxicity		
Animal Toxicity Data		
Acute Toxicity		
LD_{50}		
Rat, oral	6770 mg/kg	HSDB, 2002 (Guar Gum)
Mouse, oral	8100 mg/kg	HSDB, 2002 (Guar Gum)
Rabbit, oral	7000 mg/kg	HSDB, 2002 (Guar Gum)
Rat, dermal	NDF	
Rabbit, dermal	NDF	
LOAEL	NDF	
LOAEC	NDF	
LC_{50}		
Rat	NDF	
High Chronic/Repeat dose Toxicity		
LOAEL	NDF	
LOAEC	NDF	
NOAEL, rats, parental, developmental and reproductive	7,500 mg/kg/day	FR, 2011 (Guar Gum)

Footnotes:
LD_{50} – lethal dose for 50% of experimental population
LC_{50} – lethal air concentration for 50% of experimental population
LOAEL – Lowest Observed Adverse Effect Level
LOAEC – Lowest Observed Adverse Effect Concentration
NOAEL – No Observed Adverse Effect Level

Human Health Toxicity Ranking*		
	Hazard data	**Comment**
Hazard Band 4		
Carcinogenicity	No	FR, 2011
Mutagenicity/Genotoxicity	No	FR, 2011
Reproductive Toxicity	No	FR, 2011
Developmental Toxicity/ Teratogenicity	No	FR, 2011
Endocrine Disruption[1]	No	EC, 2000
Hazard Band 3		
Acute Toxicity (oral, dermal or inhalation) Very Toxic/Toxic • oral LD_{50} ≤ 300 mg/kg[2] • dermal LD_{50} ≤ 1000 mg/kg • inhalation LC_{50} ≤ 10 mg/L^3 (or mg/m^3) (vapour)	No	HSDB, 2002
Possible carcinogenicity, mutagenicity, reproductive or High Chronic/repeat dose toxicity • oral LOAEL ≤ 10 mg/kg/d[3]; • dermal LOAEL ≤ 2 0 mg/kg/d; • inhalation LOAEC (6 h/d) ≤ 50 ppm/d for gases, ≤ 0.2 mg/L/d for vapours or ≤ 0.02 mg/L/d for dust/mists/fumes[3]	No	HSDB, 2002
Corrosive (irreversible damage)	No	
Respiratory sensitiser	Yes	Occupational asthma has been reported in subject working with industrial production of guar gum
Hazard Band 2		
Harmful chronic/repeat dose toxicity • oral LOAEL > 10 mg/kg and ≤ 100 mg/kg/d • dermal LOAEL > 20 mg/kg/d and ≤ 200 mg/kg/d • inhalation (6-h/d) LOAEC > 50 mg/L ≤ 250 mg/L/d for gases, > 0.2 mg/L ≤ 1 .0 mg/L/d for vapours or > 0.02 mg/L ≤ 0.2 mg/L/d for dust/mists/fumes[3]	No	HSDB, 2002
Skin Sensitiser	No	FR, 2011
Hazard Band 1		
Acute Toxicity-Harmful • oral LD_{50} > 300 mg/kg ≤ 2000 mg/kg • dermal LD_{50} >1 000 mg/kg ≤ 2000 mg/kg; • inhalation LC_{50} (6 h/d) > 10 mg/L ≤ 20 mg/L for vapours)[3]	No	HSDB, 2002
Irritant (reversible damage)	Yes	FR, 2011
Hazard Band 0 **All indicators outside criteria listed in Hazards 1-4**		
Physical Hazards		
Flammable potential	NDF	
Explosive potential	NDF	

Hazard Evaluation (highest band) not including physical hazards	**3**	
Uncertainty analysis /data confidence	11/13= 87%	**Data based on surrogate compounds**

* Based on IMAP Framework [NICNAS (2013) Inventory Multi-tiered Assessment and Prioritisation (IMAP) Framework. National Industrial Chemicals Notification and Assessment Scheme. Department of Health and Aging, Canberra].

"[1]Based on list of endocrine disrupting chemicals from the European Commission's Endocrine Disrupters website.

[2]milligrams per kilogram body mass(mg/kg) or milligrams per kilogram body mas per day (mg/kg/d)

[3] Based on GHS cut-offs for hazard classification. For chronic/repeat dose toxicity, GHS cut-offs are provided as guidance values (i.e. the dose/concentration at or below which significant health effects are observed"). (p 18, NICNAS 2013).

Human Health Guidelines		
Media	**Concentration (mg/m^3; mg/L; mg/kg)**	**Reference**
Occupational Exposure Limits		
Air (OEL)		
8-h TWA	NDF	
STEL	NDF	
Peak Limitation	NDF	
Environmental Exposure		
Air, ambient	NDF	
Air, indoor	NDF	
Water, potable	NDF	
Water, recreational	NDF	
Soil, residential	NDF	
Soil, commercial/industrial	NDF	

Footnotes:

OEL = Occupational Exposure Limit

TWA= 8 h Time-Weighted Average

STEL = (15 min) Short-term Exposure Limit

NDF - No data found within the limits of the search strategy.

Qualifying Summary Comments

Sodium carboxymethyl-hydroxypropyl guar and related guar gums exhibit limited human health hazards across a diverse range of toxicological parameters and subsequently have been excepted in the US from the need for tolerance thresholds as additives in pesticides used for crop protection. The Hazard Band 3 rating is a reflection of reported occupational asthma suggestive of Type 1 hypersensitivity responses while dermal and eye irritancy is the other main consideration. The potential for dust generation with such a product may result in both of these adverse outcomes under conditions of occupational exposure and subsequently warrant management measures.

In addition, as the product is an organic dust, ignition and explosion are further concerns related to worker safety during on-site use of this product during chemical stimulation activities.

References

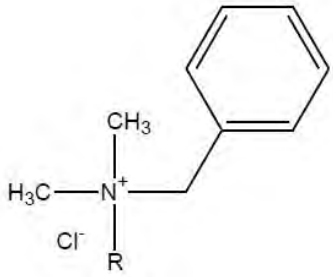
EC (2000). Towards the establishment of a priority list of substances for further evaluation of their role in endocrine disruption, preparation of a candidate list of substances as a basis for priority setting, Final Report (Incorporating corrigenda to final report dated 21 June 2000). European Commission.

FR, 2011. Carboxymethyl Guar Gum Sodium Salt and Carboxymethyl-Hydroxypropyl Guar; Exemption From the Requirement of a Tolerance - A Rule by the Environmental Protection Agency on 07/27/2011. The Daily Journal of the United States Government – Federal Register, United States Government. Available at https://www.federalregister.gov/articles/2011/07/27/2011-18588/carboxymethyl-guar-gum-sodium-salt-and-carboxymethyl-hydroxypropyl-guar-exemption-from-the#h-13 [Accessed 20 October 2013]

HSDB, 2002. Guar Gum. Hazardous Substance Data Base , U.S. National Library of Medicine, National Institute of Health, Department of Health and Human Services, U.S. Government. Last date of revision: 12/05/2002.

Created by:	MGT	Date: 31/10/2013
Reviewed and edited by:	LT	Date: 11/12/2013

Project number: 127666004
Project name: Hydraulic Stimulation Chemicals Assessment, Southwest Queensland
Client name: Santos Ltd

Name	Alkyl(C12-16) dimethylbenzyl ammonium chloride
Synonyms	Quaternary ammonium compounds, benzyl-C12-16-alkyldimethyl, chlorides, ADBAC
CAS number	68424-85-1
Molecular formula	$C_9H_{13}NCl^-R$ (R = $C_{12}H_{25}$, $C_{14}H_{29}$ or $C_{16}H_{33}$)
Molecular Structure	

Overview	Reference
Alkyl(C12-16) dimethylbenzyl ammonium chloride (ADBAC) is a quaternary ammonium compound. It is a clear yellow to straw liquid and has an amine odour. It is soluble in water and alcohol. It is used as an antimicrobial, insecticide and fungicide with applications in food handling, medical settings, agriculture, swimming pools, wood preservation, and industrial water systems such as recirculating cooling water, pulp and paper, drilling muds, oil well injection, and saltwater disposal. Principal health effects include acute toxicity (via all routes) and severe skin burns and eye damage.	US EPA(2006) USNLM (2013)

Human Health Toxicity Summary	Reference
Carcinogenicity Not assessed by IARC. Not reported as a carcinogenic substance by the US EPA.	IARC (2013); US EPA (2006).
Mutagenicity/Genotoxicity Not reported as mutagenic or genotoxic (based on the review of the required target database)	US EPA (2006).
Reproductive Toxicity Not reported as a reproductive toxicant (based on a two-generation reproductive study)	US EPA (2006).
Developmental Toxicity/Teratogenicity Not reported as a developmental toxicant (based on *in utero* exposure prenatal development studies review)	US EPA (2006).
Endocrine Disruption Not listed as an endocrine disruptor.	EC(2000).
Acute Toxicity (oral, dermal, inhalation) Toxic in contact with skin, if swallowed or inhaled.	ECHA (2013).
Chronic/repeat dose toxicity (oral, dermal, inhalation) NOAEL has been established at 14 mg/kg/day (chronic dog study))	US (2011).

Sensitisation of the skin or respiratory system Not reported as a dermal sensitiser based on a guinea pig study.	US EPA (2006).
Corrosion (irreversible and reversible)/irritation of the skin or eye Causes severe skin burns and eye damage.	ECHA (2013)

Physical Hazards	Reference
Flammable Potential Flammable liquid (flashpoint ≥23°C and initial boiling ≤60°C) and vapour.	ECHA(2013)
Explosive Potential No data found (NDF).	

Toxicity Values	Value	Reference
Human Toxicity Data		
Acute Toxicity		
	NDF	
High Chronic/Repeat Dose Toxicity		
LOAEC	NDF	
LOAEL	NDF	
Animal Toxicity Data		
Acute Toxicity		
LD_{50}		
Rat, oral	344 mg/kg	US EPA (2011)
Rat, dermal	930 mg/kg	US EPA (2006)
Rabbit, dermal	2848 mg/kg	US EPA (2011)
LOAEL	NDF	
LOAEC	NDF	
LC_{50}		
Rat	0.054 to 0.51 mg/L	US EPA (2006)
High Chronic/Repeat Dose Toxicity		
LOAEL (rat, oral)	88 mg/kg/day	US EPA (2006)
LOAEC	NDF	
NOAEL (rat, oral)	44 mg/kg/day	US EPA (2006)
LOAEL (dog, oral)	48 mg/kg/day	US EPA (2011)
NOAEL (dog, oral)	31 mg/kg/day	US EPA (2011)

Footnotes:
LD_{50} – lethal dose for 50% of experimental population
LC_{50} – lethal air concentration for 50% of experimental population
LOAEL – Lowest Observed Adverse Effect Level
LOAEC – Lowest Observed Adverse Effect Concentration
NOAEL – No Observed Adverse Effect Level

Human Health Toxicity Ranking*		
	Hazard data	**Comment**
Hazard Band 4		
Carcinogenicity	NDF	Not assessed by IARC
Mutagenicity/Genotoxicity	No	US EPA (2006)
Reproductive Toxicity	No	US EPA (2006)
Developmental Toxicity/ Teratogenicity	No	US EPA (2006)
Endocrine Disruption[1]	No	EC (2000)
Hazard Band 3		
Acute Toxicity (oral, dermal or inhalation) Very Toxic/Toxic • oral LD_{50} ≤ 300 mg/kg[2] • dermal LD_{50} ≤ 1000 mg/kg • inhalation LC_{50} ≤ 10 mg/L[3] (or mg/m[3]) (vapour)	Yes	LC_{50} between 0.054 and 0.51 mg/L (US EPA, 2006)
Possible carcinogenicity, mutagenicity, reproductive or High Chronic/repeat dose toxicity • oral LOAEL ≤ 10 mg/kg/d[2]; • dermal LOAEL ≤ 2 0 mg/kg/d; • inhalation LOAEC (6 h/d) ≤ 50 ppm/d for gases, ≤ 0.2 mg/L/d for vapours or ≤ 0.02 mg/L/d for dust/mists/fumes[3]	No	
Corrosive (irreversible damage)	Yes	ECHA (2013)
Respiratory sensitiser	NDF	
Hazard Band 2		
Harmful chronic/repeat dose toxicity • oral LOAEL > 10 mg/kg and ≤ 100 mg/kg/d • dermal LOAEL > 20 mg/kg/d and ≤ 200 mg/kg/d • inhalation (6-h/d) LOAEC > 50 mg/L ≤ 250 mg/L/d for gases, > 0.2 mg/L ≤ 1 .0 mg/L/d for vapours or > 0.02 mg/L ≤ 0.2 mg/L/d for dust/mists/fumes[3]	Yes	Rat oral LOAEL 88mg/kg/day (US EPA, 2006) Dog oral LOAEL 48 mg/kg/day (US EPA, 2011)
Skin Sensitiser	No	
Hazard Band 1		
Acute Toxicity-Harmful • oral LD_{50} > 300 mg/kg ≤ 2000 mg/kg • dermal LD_{50} >1 000 mg/kg ≤ 2000 mg/kg; • inhalation LC_{50} (6 h/d) > 10 mg/L ≤ 20 mg/L for vapours)[3]	Yes	Rat oral LD_{50} 344 mg/kg (US EPA, 2011)
Irritant (reversible damage)	No	
Hazard Band 0 **All indicators outside criteria listed in Hazards 1-4**		
Physical Hazards		
Flammable potential	Yes	Flammable liquid (ECHA, 2013)
Explosive potential	NDF	
Hazard Evaluation (highest band) not including physical hazards	**Band 3**	
Uncertainty analysis /data confidence	10/13	**77%**

* Based on IMAP Framework [NICNAS (2013) Inventory Multi-tiered Assessment and Prioritisation (IMAP) Framework. National Industrial Chemicals Notification and Assessment Scheme. Department of Health and Aging, Canberra].

"[1]Based on list of endocrine disrupting chemicals from the European Commission's Endocrine Disrupters website.

[2] milligrams per kilogram body mass(mg/kg) or milligrams per kilogram body mas per day (mg/kg/d)

[3]Based on GHS cut-offs for hazard classification. For chronic/repeat dose toxicity, GHS cut-offs are provided as guidance values (i.e. the dose/concentration at or below which significant health effects are observed"). (p 18, NICNAS 2013).

Human Health Guidelines		
Media	**Concentration (mg/m^3; mg/L; mg/kg)**	**Reference**
Occupational Exposure Limits		
Air (OEL)		
8-h TWA	NDF	
STEL	NDF	
Peak Limitation	NDF	
Environmental Exposure		
Air, ambient	NDF	
Air, indoor	NDF	
Water, potable	NDF	ADWG, 2011
Water, recreational	NDF	NEPM, 1999 - amended
Soil, residential	NDF	NEPM, 1999 - amended
Soil, commercial/industrial	NDF	NEPM, 1999 - amended

Footnotes:

OEL = Occupational Exposure Limit

TWA= 8 h Time-Weighted Average

STEL = (15 min) Short-term Exposure Limit

NDF - No data found within the limits of the search strategy.

Qualifying Summary Comments

Alkyl (C12-16) dimethylbenzyl ammonium chloride is an acute inhalation hazard and corrosive substance. It can result in severe skin burns and eye damage and on this basis is considered in Hazard Band 3. This hazard is subsequently a reflection of its concern as a pure product and not reflecting that posed under greatly diluted end-use concentrations. Key hazards are thus those posed within occupational settings and where large scale product spill may impact on public health. The environmental persistence suggests some potential distribution due to limited aqueous microbial degradation and this warrants some further exploration in terms of sustained available concentrations and aqueous degradation pathways.

References

ADWG (2011). Australian Drinking Water Guidelines National Health and Medical Research Council. Available from http://www.nhmrc.gov.au/_files_nhmrc/publications/attachments/eh52_aust_drinking_water_guidelines.pdf

ECHA (2013) European Chemicals Agency Classification & Labelling Database. Available at http://echa.europa.eu/web/guest/information-on-chemicals/cl-inventory-database [Accessed 10 October 2013].

EC (2000) European Commission Towards the establishment of a priority list of substances for further evaluation of their role in endocrine disruption, preparation of a candidate list of substances as a basis for priority setting, Final Report (Incorporating corrigenda to final report dated 21 June 2000).

IARC (2013) International Agency for Research on Cancer Agents classified by IARC Monographs, Volumes 1-108. Available at http://monographs.iarc.fr/ENG/Classification/ClassificationsGroupOrder.pdf.

NEPM (1999 – amended) National Environment Protection (Assessment of Site Contamination) Measure 1999

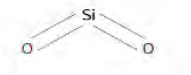
US EPA (2006) United States Environmental Protection Agency. Reregistration Eligibility Decision for Alkyl Dimethyl Benzyl Ammonium Chloride (ADBAC). Available at http://www.epa.gov/oppsrrd1/REDs/adbac_red.pdf

US (2011).Alkyldimethulbenzylammonium Chloride (ADBAC) Category High Production Volume (HPV) Chemicals Challenge Final Test Status and Data Review submitted to United States Environmental Protection Agency Available at http://www.epa.gov/hpv/pubs/summaries/adbac/c16856.pdf

US NLM (2013) United States National Library of Medicine Haz-Map Database. Available at **Error! Hyperlink reference not valid.**http://hazmap.nlm.nih.gov/category-details?id=18780&table=copytblagents [Accessed 10 October 2013].

Created by:	JC	Date: 14/10/13
Reviewed and edited by:	LT	Date 22/10/13 Rev0

Project number: 127666004
Project name: Hydraulic Stimulation Chemicals Assessment, Southwest Queensland
Client name: Santos Ltd

Name	Diatomaceous earth, calcined
Synonyms	Kieselguhr, calcined; Diatomaceous silica, calcined; calcinated diatomaceous earth
CAS number	91053-39-3
Molecular formula	O_2-Si
Molecular Structure	

Overview	References
Diatomite or diatomaceous earth (DE) is a natural, porous, high surface area form of hydrous silica. DE products are classified based on the manufacturing method. There are three different types: natural or uncalcined DE (Cas No 61790-53-2), flux-calcined DE (CAS No 68855-54-9) and calcined DE (91053-39-3). Calcined diatomaceous earth (DE) is produced by heating natural DE in a rotary furnace to 600°C. At this temperature, the water evaporates and the iron becomes oxidized. Calcined DE consists mostly of oxides of aluminum, iron and silicon. In the process, DE transformed partially into crystalline silica. The crystalline content of calcined DE is typically less than 35% cristobalite and less than 20% quartz. Flux-calcined DE is obtained from heating the natural product in the presence of a fluxing agent (generally soda ash). The flux-calcined product can contain up to 65% cristobalite. Small amounts of quartz and tridymite (quartz polymorph) can also be present in both the calcined and flux-calcined DE. The amount of crystalline silica (cristobalite, quartz and tridymite) in calcined and flux-calcined DE depends on the time and temperature and the calcining method. Flux-calcined DE consists of white crystals, powder or granules while calcined DE consists of pink or yellowish to dark brown powder or granules. Uses for calcined and flux-calcined DE include as filtration agents and functional fillers in paints, plastics, rubber, adhesives, catalysts, agricultural chemicals, pharmaceuticals, toothpastes, polishes and other chemicals. They are also used as thermal insulators and absorbents. Amorphous silica has been studied less than crystalline silica. They are generally less hazardous than crystalline silica and are cleared more rapidly from the lung. Furthermore, amorphous silica is chemically and biologically inert when ingested in any of its many physical forms, such as amorphous siliceous earth (diatomaceous earth, diatomite, kieselguhr) or colloidal silica gels. This explains why overall it is not considered as hazardous to humans. The hazardous potential of calcined DE and flux calcined DE will be dependent on its crystalline fraction. Limited data are available for calcined DE. The human health toxicity information discussed below are primarily based on flux-calcined DE (CAS No 68855-54-9).	ESIS (2000); EPA (2013); CCOHS (2001); Gosselin *et al.*(1984)

Human Health Toxicity Summary	Reference
Carcinogenicity Calcined DE or flux-calcined DE have not been assessed by IARC but the IARC rating for *014808-60-7 Silica dust, crystalline, in the form of quartz or cristobalite* is Group 1 - *carcinogenic to humans*. IARC evaluation for silica, amorphous (CAS No 7631-86-9): Group 3 (Amorphous silica *is not classifiable as to its carcinogenicity to humans).* *Notes:* The evaluations for amorphous silica pertain to inhalation resulting from workplace exposures. Very little epidemiological evidence was available to the Working Group. No association was detected for mesothelioma with biogenic amorphous silica fibres in the three community-based case-control studies. Separate analyses were not performed for cancer risks among a subset of diatomaceous earth industry workers exposed predominantly to amorphous silica. There is *inadequate evidence* in humans for the carcinogenicity of amorphous silica.	IARC (2013)
Mutagenicity/Genotoxicity Flux-calcined DE is not classified as a mutagenic/genotoxic chemical The genotoxic potential of flux-calcined DE (cristoballite content not specified) was assessed in a gene mutation study (Ames test) which produced negative results.	ECHA (2013)
Reproductive Toxicity NDF.	
Developmental Toxicity/Teratogenicity NDF.	
Endocrine Disruption Not listed as an endocrine disruptor.	EC (2000)
Neurotoxicity NDF.	
Acute Toxicity (oral, dermal, inhalation) Flux-calcined DE is not classified as having acute toxic effects when administered orally, applied to the skin or when inhaled. *Notes:* For rats (male/females) an oral LD_{50} > 2000 mg/kg has been determined. For rats (male/female) an LC_{50} > 2.6 mg/L air has been reported for a four hour exposure duration study.	ECHA (2013)
Chronic/repeat dose toxicity (oral, dermal, inhalation) Flux-calcined DE (cristalline fraction > 10%) is classified as STOT RE (repeated exposure) 1 H372: causes damage to lungs through prolonged or repeated exposure via inhalation, according to CLP (Classification, Labelling and Packaging). This classification is based on a rat study where animals were exposed (nose only) to various concentrations of calcined DE (45% cristobalite) - 0.044 mg/L, 0.207 mg/L and 0.700 mg/L - for 6 hours/exposure, 5 days/week at 24-hour intervals for four consecutive weeks. Following the treatment period there was a 9 week recovery period. Following microscopic examination, the lungs and tracheobronchial lymph nodes were considered as target organs but no NOAEL could be established.	ECHA (2013)

Notes: An oral NOAEL of 3737.9 mg/kg bw/day has been determined for rats (male/female)	
Sensitisation of the skin or respiratory system Flux-calcined DE is not classified as a skin sensitiser. No data found regarding sensitisation of the respiratory system.	ECHA (2013)
Corrosion (irreversible)/irritation (reversible) effects on the skin or eye Flux-calcined DE is not classified as irritating or corrosive to the skin or eye.	ECHA (2013)

Physical Hazards	Reference
Flammable Potential Flux-calcined DE is not classified as a flammable substance.	ECHA (2013)
Explosive Potential Flux-calcined DE is not classified as an explosive substance.	ECHA (2013)

Toxicity Values	Value	Reference
Human Toxicity Data		
High Chronic/Repeat Dose Toxicity		
LOAEC	NDF	
LOAEL	NDF	
Animal Toxicity Data		
Acute Toxicity		
LD_{50}		
Rat, oral	> 2000 mg/kg (flux-calcined DE)	ECHA (2013)
Mouse, oral	NDF	
Rabbit, oral	NDF	
Rat, dermal	NDF	
Rabbit, dermal	NDF	
Mouse, dermal	NDF	
LC_{50}		
Rat	> 2.6 mg/L (flux-calcined DE)	ECHA (2013)
High Chronic/Repeat Dose Toxicity		
LOAEL	NDF	
LOAEC	NDF	
NOAEL (rat, oral)	3738 mg/kg bw/day	ECHA (2013)

Footnotes:
LD_{50} – lethal dose for 50% of experimental population
LC_{50} – lethal air concentration for 50% of experimental population
LOAEL – Lowest Observed Adverse Effect Level
LOAEC – Lowest Observed Adverse Effect Concentration

Human Health Toxicity Ranking*		
	Hazard data	**Comment**
Hazard Band 4		
Carcinogenicity (IARC Group 1 or 2A)	Yes	Not specifically assessed by IARC however, the crystalline fraction (cristobalite and quartz) falls in the Group 1 category: *carcinogenic to humans* (IARC, 2013). Based on an uncertainty of the crystalline fraction the carcinogenicity is recorded as consistent with crystalline silica.
Mutagenicity/Genotoxicity (GHS Category 1A and 1B)	No	ECHA (2013)
Reproductive Toxicity/Developmental toxicity (GHS Category 1, 1A and 1B)	NDF	
Endocrine Disruption[1]	No	EC (2000)
Hazard Band 3		
Carcinogenicity (IARC Group 2B)	No	Not specifically assessed by IARC however, the crystalline fraction (cristobalite and quartz) falls in the Group 1 category: *carcinogenic to humans* (IARC, 2013). Based on an uncertainty of the crystalline fraction the carcinogenicity is recorded as consistent with crystalline silica.
Mutagenicity/Genotoxicity (GHS Category 2)	No	ECHA (2013)
Reproductive Toxicity/Developmental toxicity (GHS Category 2)	NDF	
Acute Toxicity (oral, dermal or inhalation) Very Toxic/Toxic • oral $LD_{50} \leq 300$ mg/kg[2] • dermal $LD_{50} \leq 1000$ mg/kg inhalation $LC_{50} \leq 10$ mg/L[4] (or mg/m^3) (vapour)	No	For rats oral $LD_{50} >$ 2000 mg/kg and $LC_{50} > 2.6$ mg/L (ECHA, 2013)
Possible carcinogenicity, mutagenicity, reproductive or High Chronic/repeat dose toxicity • oral LOAEL ≤ 10 mg/kg/d[2]; • dermal LOAEL ≤ 2 0 mg/kg/d; • inhalation LOAEC (6 h/d) ≤ 50 ppm/d for gases, ≤ 0.2 mg/L/d for vapours or ≤ 0.02 mg/L/d for dust/mists/fumes[3]	No	Classified as STOT RE 1 H372: causes damage to lungs through prolonged or repeated exposure via inhalation (ECHA, 2013) An inhalation NOAEC has not been established.
Corrosive (irreversible effect)	No	ECHA (2013)
Respiratory sensitiser	NDF	
Hazard Band 2		
Harmful chronic/repeat dose toxicity	No	Classified as STOT

• oral LOAEL > 10 mg/kg and ≤ 100 mg/kg/d • dermal LOAEL > 20 mg/kg/d and ≤ 200 mg/kg/d • inhalation (6-h/d) LOAEC > 50 mg/L ≤ 250 mg/L/d for gases, > 0.2 mg/L ≤ 1 .0 mg/L/d for vapours or > 0.02 mg/L ≤ 0.2 mg/L/d for dust/mists/fumes [3]		RE 1 H372: causes damage to lungs through prolonged or repeated exposure via inhalation (ECHA, 2013)
Skin Sensitiser	No	ECHA (2013)
Hazard Band 1		
Acute Toxicity-Harmful • oral LD_{50} > 300 mg/kg ≤ 2000 mg/kg • dermal LD_{50} >1 000 mg/kg ≤ 2000 mg/kg; • inhalation LC_{50} (6 h/d) > 10 mg/L ≤ 20 mg/L for vapours)[3]	No	For rats oral LD_{50} > 2000 mg/kg and LC_{50} > 2.6 mg/L (ECHA, 2013)
Irritant (reversible effect)	No	ECHA (2013)
Hazard Band 0 **All indicators outside criteria listed in Hazards 1-4**		
Physical Hazards		
Flammable potential	No	ECHA (2013)
Explosive potential	No	ECHA (2013)
Hazard Evaluation (highest band) not including physical hazards	**4**	
Uncertainty analysis /data confidence (out of 12 parameters)	10/12	**83%**

* Based on IMAP Framework [NICNAS (2013) Inventory Multi-tiered Assessment and Prioritisation (IMAP) Framework. National Industrial Chemicals Notification and Assessment Scheme. Department of Health and Aging, Canberra].

"[1]Based on list of endocrine disrupting chemicals from the European Commission's Endocrine Disrupters website.

[2] milligrams per kilogram body mass(mg/kg) or milligrams per kilogram body mas per day (mg/kg/d)

[3] Based on GHS cut-offs for hazard classification. For chronic/repeat dose toxicity, GHS cut-offs are provided as guidance values (i.e. the dose/concentration at or below which significant health effects are observed"). (p 18, NICNAS 2013)".

Human Health Guidelines		
Media	**Concentration (mg/m^3; mg/L; mg/kg)**	**Reference**
Occupational Exposure Limits		
Air (OEL)		
8-h TWA	MAK value: 0.3 mg/m^3 (crystalline fraction not specified) MEL values: 0.10 mg/m^3 (quartz) and 0.05 mg/m^3 (cristobalite)	ESIS (2000)
STEL	NDF	
Peak Limitation	NDF	
Environmental Exposure		
Air, ambient	NDF	
Air, indoor	NDF	
Water, potable	NDF	
Water, recreational	NDF	
Soil, residential	NDF	
Soil, commercial/industrial	NDF	

Footnotes:

OEL = Occupational Exposure Limit

TWA= 8 h Time-Weighted Average

STEL = (15 min) Short-term Exposure Limit

NDF = No data found within the limits of the search strategy

Qualifying Summary Comments

Calcined DE, as flux-calcined DE, is the product of the calcination of naturally occurring DE (diatomite). Flux-calcined DE is differentiated from calcined DE by the addition of a fluxing agent during the heating process. Flux-calcined and calcined DE are often considered as a type of amorphous silica, however during the calcination process, they are partially transformed into cristobalite. Amorphous silica has been studied less than crystalline silica and is considered generally less toxic than crystalline silica being cleared more rapidly from the lung. Amorphous silica is chemically and biologically inert when ingested in any of its many physical forms, such as amorphous siliceous earth (diatomaceous earth**,** diatomite, kieselguhr) or colloidal silica gels. Therefore, the hazardous potential of calcined DE resides in its crystalline fraction. The carcinogenic potential of calcined DE has not been assessed by IARC, however the IARC rating for *014808-60-7 Silica dust, crystalline, in the form of quartz or cristobalite* is Group 1 - *carcinogenic to humans*. Moreover, according to ECHA, mixtures and substances containing cristobalite as an individual constituent, shall be classified as STOT RE 1 H372 (causes damage to lungs through prolonged or repeated exposure via inhalation) if the cristobalite respirable fraction is equal to, or greater than 10%. No information is available regarding the potential effects of calcined DE to reproduction and development but it has a low order of acute toxicity. Based on the classifications and data considered, calcined DE is classified as a Hazard Band 4 substance due to the presence of the crystalline silica fraction. WorkSafe Australia has not listed calcined DE as a hazardous substance under the respective legislation and developed an exposure standard for it. Due to its low solubility, calcined DE in aqueous solution and as introduced during chemical stimulation activities would settle into soils and sediments and become indistinguishable from those materials. The principle hazard is subsequently the generation of dusts under occupational settings which would require management.

References

CCOHS (2001) CHEMINFO record for Diatomaceous earth, calcined. Canadian Centre for Occupational Health and Safety (CCOHS). Available at http://www.sfm.state.or.us/CR2K_SubDB/MSDS/003518.txt . [Accessed 11 December 2013].

EPA (2013) Substance Registry Services Substance Details – Kieselguhr, calcined. US Environmental Protection Agency (EPA) Available at http://iaspub.epa.gov/sor_internet/registry/substreg/searchandretrieve/advancedsearch/externalSearch.do?p_type=SRSITN&p_value=602375. [Accessed 11 December 2013].

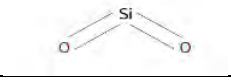
ESIS (2000) Chemical Data Sheet (in IUCLID software) Kieselguhr, calcined. European chemical Substance Information System (ESIS). Available at http://esis.jrc.ec.europa.eu/doc/IUCLID/data_sheets/91053393.pdf . [Accessed 11 December 2013].

Gosselin et al. (1984) Clinical Toxicology of Commercial Products. 5th ed. Baltimore: Williams and Wilkins, 1984., p. II-95. Available at http://toxnet.nlm.nih.gov/cgi-bin/sis/search/f?./temp/~BKqIKF:1 [Accessed 11 December 2013].

IARC (2013) Agents Classified by the *IARC Monographs*, Volumes 1–109. International Agency for Research on Cancer (IARC), Available at http://monographs.iarc.fr/ENG/Classification/ClassificationsCASOrder.pdf . . [Accessed 11 December 2013].

Created by:	JC	Date: 11/12/13
Reviewed by:	LT/JF	Date: 12/12/2013 Rev0

Project number: 127666004
Project name: Hydraulic Stimulation Chemicals Assessment, Southwest Queensland
Client name: Santos Ltd

Name	Silica gel
Synonyms	Precipitated silica; amorphous silica
CAS number	112926-00-8
Molecular formula	O_2-Si
Molecular structure	

Overview	References
Silica gel is part of a larger group of chemicals referred to as synthetic amorphous silica (SAS) registered under the overarching CAS No 7631-86-9. SAS (including silica gels) are white, fluffy and/or powdery amorphous forms of silicon dioxide (silica, SiO_2). It has a molecular weight of 60.08g/mol, a density of 2.2 at 20ºC and a melting point of approximately 1700 ºC. Commercialised since the 1950s, SAS are used in a wide variety of industrial applications and they are usually tailor-made to meet the users' requirements. Main uses of SAS include reinforcement and thickening agent in various systems such as elastomers, resins, inks and water for instance. Due to their high porosity, SAS is also used as an adsorbing agent. SAS is also used in consumers' products such as cosmetics, pharmaceuticals and foods. SAS have been studied less than crystalline silica. They are generally less toxic than crystalline silica and are cleared more rapidly from the lung. Furthermore, amorphous silica is chemically and biologically inert when ingested in any of its many physical forms such as amorphous siliceous earth (diatomaceous earth**,** diatomite, kieselguhr) or colloidal *silica gels*. This explains why overall it is not considered as hazardous to humans. The human health toxicity information discussed below is based on SAS.	ECETOC (2006); IARC (1997); SIDS (2004); Gosselin *et al.*(1984)

Human Health Toxicity Summary	Reference
Carcinogenicity IARC rating for silica, amorphous (CAS No 7631-86-9): Group 3 (Amorphous silica *is not classifiable as to its carcinogenicity to humans)* *Notes:* The evaluations for amorphous silica pertain to inhalation resulting from workplace exposures. Very little epidemiological evidence was available to the Working Group. No association was detected for mesothelioma with biogenic amorphous silica fibres in the three community-based case-control studies. Separate analyses were not performed for cancer risks among a subset of diatomaceous earth industry workers exposed predominantly to amorphous silica. There is *inadequate evidence* in humans for the carcinogenicity of amorphous silica.	IARC (1997); IARC (2013)
Mutagenicity/Genotoxicity No mutations were observed when SAS was tested in *in vitro* and *in vivo* standard methods. No evidence for mutagenic activity was found in an ex-vivo gene-mutation assays on isolated alveolar	SIDS (2004)

type-II cells after long-term inhalation exposure of rats to a distinctly noxious/inflammatory SAS concentration of 50 mg/m^3 (13 weeks).	
Reproductive Toxicity The reproductive toxicity properties of SAS were assessed with a one-generation on rats where animals were fed SAS at a dose of 500 mg/kg bw/day for a premating period of 4.5 months with continued exposure up to 6 months. While no adverse effects were observed, however, it was reported that the study had some shortcomings regarding the low number of pregnant animals used and that the mating ratio was too low according to current standards.	SIDS (2004)
Developmental Toxicity/Teratogenicity The potential for developmental effects of SAS were assessed in a comprehensive and reliable testing programme where various animal species (rat, mouse, rabbit, and hamster) were administered SAS orally at doses up to 1600 mg/kg bw/day. No significant signs of maternal or developmental toxic effects were observed in any species tested. Abnormalities noted in soft or skeletal tissues of the test groups were comparable to the frequencies occurring in the control groups.	FDA (1972, 1973a,b) as cited in SIDS (2004)
Endocrine Disruption Not listed as an endocrine disruptor.	EC (2000)
Neurotoxicity NDF.	
Acute Toxicity (oral, dermal or inhalation) SAS (aqueous suspension or gel) administered orally (gavage or in diet) and dermally did not cause mortality at the highest doses tested. LD_{50} values ranged from > 3100 to > 20000 mg/kg in rats and mice. One study established an oral LD_{50} for rats to be > 10000 mg/kg bw. Based on a rabbit study, a dermal LD_{50} > 5000 mg/kg bw was established for rabbits. No clinically or pathologically meaningful effects were observed after 4-hour exposure of rats to either pyrogenic or precipitated SAS. However, in the study where animals were exposed to precipitated SAS, signs of some discomfort and stress were observed and body weight of females was retarded for two days post-exposure.	SIDS (2004)
Chronic/repeat dose toxicity (oral, dermal, inhalation) **Oral** The chronic toxic effects of silica gel were assessed in a rat study. In this study, animals received an amorphous silica gel (Syloid 244) at dietary levels of 3.2 and 10% for 6 months, corresponding to average doses of 2170 to 2420 mg/kg bw/day and 7950 to 8980 mg/kg bw/day respectively. No adverse effects were observed. Isolated pathological findings were assessed to be unrelated to dosing and common in untreated rats. The microscopic examination did not show any changes in the kidneys or reproductive organs. **Dermal** No information was found regarding the chronic toxicity of silica gel or SAS via the dermal route. **Inhalation** No evidence of pneumoconiosis or silicosis was observed in occupational exposures to SAS. Other disorders of the respiratory tract could not be correlated to exposure to SAS alone. However, it is noted that the available epidemiological data base on workers is too limited to be able to draw firm conclusions.	Grace (1975) as cited in SIDS (2004); SIDS (2004)
Sensitisation of the skin or respiratory system There are no experimental data available on sensitisation. There is no evidence of skin sensitisation in workers over decades of practical experience.	SIDS (2004)
Corrosion (irreversible)/irritation (reversible) effects on the skin or eye **Effects on skin** Based on experimental data, SAS is not irritating to rabbit skin. However, it is noted that cases of dryness or degenerative eczema of the skin in workers with chronic contact have been reported by occupational physicians.	SIDS (2004)

When tested on the rabbit eye as a powder, SAS showed no or only weak and non-permanent irritating effects on the conjunctivae but neither the iris nor the cornea were affected.	

Physical Hazards	Reference
Flammable Potential Non flammable solid.	
Explosive Potential Not classified as an explosive substance.	

Toxicity Values	Value	Reference
Human Toxicity Data		
High Chronic/Repeat Dose Toxicity		
LOAEC	NDF	
LOAEL	NDF	
Animal Toxicity Data		
Acute Toxicity		
LD_{50}		
Rat, oral (gavage)	> 3100 to > 20000 mg/kg (aqueous suspension and gel SAS)	SIDS (2004)
Mouse, oral	> 3100 to > 20000 mg/kg (aqueous suspension and gel SAS)	SIDS (2004)
Rabbit, oral	NDF	
Rat, dermal	NDF	
Rabbit, dermal	> 5000 mg/kg (precipitated SAS)	SIDS (2004)
Mouse, dermal	NDF	
LC_{50}		
Rat	>0.14 - >2.0 mg/l (pyrogenic and precipitated SAS)	SIDS (2004)
High Chronic/Repeat Dose Toxicity		
LOAEL		
LOAEC	5 mg/m^3 (precipitated and gel SAS)	SIDS (2004)

Footnotes:
LD_{50} – lethal dose for 50% of experimental population
LC_{50} – lethal air concentration for 50% of experimental population
LOAEL – Lowest Observed Adverse Effect Level
LOAEC – Lowest Observed Adverse Effect Concentration

Human Health Toxicity Ranking*		
	Hazard data	**Comment**
Hazard Band 4		
Carcinogenicity (IARC Group 1 or 2A)	No	IARC Group 3 – inadequate evidence to classify
Mutagenicity/Genotoxicity (GHS Category 1A and 1B)	No	SIDS, 2004
Reproductive Toxicity/Developmental toxicity (GHS Category 1, 1A and 1B)	No	Based on a study with some limitations (SIDS, 2004)
Endocrine Disruption[1]	No	EC, 2000
Hazard Band 3		
Carcinogenicity (IARC Group 2B)	No	
Mutagenicity/Genotoxicity (GHS Category 2)	No	SIDS, 2004
Reproductive Toxicity/Developmental toxicity (GHS Category 2)	No	Based on a study with some limitations (SIDS, 2004)
Acute Toxicity (oral, dermal or inhalation) Very Toxic/Toxic • oral LD_{50} ≤ 300 mg/kg[2] • dermal LD_{50} ≤ 1000 mg/kg • inhalation LC_{50} ≤ 10 mg/L[3] (or mg/m^3) (vapour)	No	SIDS, 2004
Possible carcinogenicity, mutagenicity, reproductive or High Chronic/repeat dose toxicity • oral LOAEL ≤ 10 mg/kg/d[2]; • dermal LOAEL ≤ 2 0 mg/kg/d; • inhalation LOAEC (6 h/d) ≤ 50 ppm/d for gases, ≤ 0.2 mg/L/d for vapours or ≤ 0.02 mg/L/d for dust/mists/fumes[3]	No	SIDS (2004)
Corrosive (irreversible effect)	No	SIDS (2004)
Respiratory sensitiser	No	Based on widespread exposure and few reports of allergic responses.
Hazard Band 2		
Harmful chronic/repeat dose toxicity • oral LOAEL > 10 mg/kg and ≤ 100 mg/kg/d • dermal LOAEL > 20 mg/kg/d and ≤ 200 mg/kg/d • inhalation (6-h/d) LOAEC > 50 mg/L ≤ 250 mg/L/d for gases, > 0.2 mg/L ≤ 1 .0 mg/L/d for vapours or > 0.02 mg/L ≤ 0.2 mg/L/d for dust/mists/fumes[3]	No	SIDS (2004)
Skin Sensitiser	No	Based on widespread exposure and few reports of allergic responses.
Hazard Band 1		
Acute Toxicity-Harmful • oral LD_{50} > 300 mg/kg ≤ 2000 mg/kg • dermal LD_{50} >1 000 mg/kg ≤ 2000 mg/kg; • inhalation LC_{50} (6 h/d) > 10 mg/L ≤ 20 mg/L for vapours)[3]	No	SIDS (2004)

Irritant (reversible effect)	No	SIDS (2004)
Hazard Band 0 **All indicators outside criteria listed in Hazards 1-4**		
Physical Hazards		
Flammable potential	No	SIDS (2004)
Explosive potential	No	SIDS (2004)
Hazard Evaluation (highest band) not including physical hazards	**0**	
Uncertainty analysis /data confidence (out of 12 parameters)	**12/12**	**83%**

* Based on IMAP Framework [NICNAS (2013) Inventory Multi-tiered Assessment and Prioritisation (IMAP) Framework. National Industrial Chemicals Notification and Assessment Scheme. Department of Health and Aging, Canberra].

"[1]Based on list of endocrine disrupting chemicals from the European Commission's Endocrine Disrupters website.

[2]milligrams per kilogram body mass(mg/kg) or milligrams per kilogram body mas per day (mg/kg/d)

[3] Based on GHS cut-offs for hazard classification. For chronic/repeat dose toxicity, GHS cut-offs are provided as guidance values (i.e. the dose/concentration at or below which significant health effects are observed"). (p 18, NICNAS 2013)".

Human Health Guidelines		
Media	**Concentration (mg/m^3; mg/L; mg/kg)**	**Reference**
Occupational Exposure Limits		
Air (OEL)		
8-h TWA	10 mg/m^3	HSIS (2013)
STEL	NDF	
Peak Limitation	NDF	
Environmental Exposure		
Air, ambient	NDF	
Air, indoor	NDF	
Water, potable	NDF	
Water, recreational	NDF	
Soil, residential	NDF	
Soil, commercial/industrial	NDF	

Footnotes:

OEL = Occupational Exposure Limit

TWA= 8 h Time-Weighted Average

STEL = (15 min) Short-term Exposure Limit

NDF - No data found within the limits of the search strategy.

Qualifying Summary Comments

Silica gel is a type of synthetic amorphous silica (SAS). Amorphous silica has been studied less than crystalline silica as they are generally less toxic than crystalline silica and are cleared more rapidly removed from the lung. It is noted that although effects on the lung have been observed at high concentrations these have been reversible following cessation of exposure. Amorphous silica is chemically and biologically inert when ingested in any of its many physical forms such as amorphous siliceous earth (diatomaceous earth, diatomite, kieselguhr) or colloidal silica gels and is not classifiable as to its carcinogenicity to humans. SAS is not considered as having

acute or chronic health effects when administered via oral, dermal and inhalation exposure pathways nor as having any reproductive, development/teratogenicity and mutagenicity/genotoxicity effects. SAS is not classified as a skin sensitiser nor does it cause irreversible irritation of the skin or eye. For this reason it is categorized as Hazard Band 0. WorkSafe Australia has listed amorphous silica as a hazardous substance under the respective legislation and developed an exposure standard for amorphous silica dust which is the generic standard for dusts. Due to its low solubility, amorphous silica in aqueous solution and as introduced during chemical stimulation activities would settle into soils and sediments and become indistinguishable from those materials. The principle hazard is subsequently the generation of dusts under occupational settings which would require management.

References

EC (2000) Towards the establishment of a priority list of substances for further evaluation of their role in endocrine disruption, preparation of a candidate list of substances as a basis for priority setting, Final Report. European Commission. (Incorporating corrigenda to final report dated 21 June 2000).

ECETOC (2005) Report No. 51 Synthetic Amorphous Silica (CAS No. 7631-86-9). ECETOC (European Centre for Ecotoxicology and Toxicology of Chemicals) JACC (Joint Assessment of Commodity Chemicals). Available at http://members.ecetoc.org/Documents/Document/JACC%20051.pdf . [Accessed 11 December 2013].

Gosselin et al. (1984) Clinical Toxicology of Commercial Products. 5th ed. Baltimore: Williams and Wilkins, 1984., p. II-95. Available at http://toxnet.nlm.nih.gov/cgi-bin/sis/search/f?./temp/~BKqIKF:1 [Accessed 10 December 2013].

HSIS (2013) Hazardous Substances Information System (HSIS), Safe Work Australia. Available at http://hsis.safeworkaustralia.gov.au/ExposureStandards . [Accessed 10 December 2013].

IARC (1997) *IARC Summary & Evaluation: Silica.* International Agency for Research on Cancer Accessed from http://www.inchem.org/documents/iarc/vol68/silica.html *(*International Programme on Chemical Safety Database (2010)), on 10 December 2013. Volume 68, p 41.

IARC (2013) Agents Classified by the *IARC Monographs*, Volumes 1–109. International Agency for Research on Cancer (IARC), 30 October 2013. Available at http://monographs.iarc.fr/ENG/Classification/ClassificationsCASOrder.pdf . . [Accessed 10 December 2013].

SIDS (2004) Organization for Economic Cooperation and Development (OECD) Screening Information Dataset (SIDS) Initial Assessment Report as maintained by United Nations Environment Programme (UNEP) Chemicals . Available at http://www.chem.unep.ch/irptc/sids/OECDSIDS/Silicates.pdf . [Accessed 10 December 2013].

Updated by:	JC	11/12/2013
Reviewed by:	LT	12/12/2013 Rev0

APPENDIX F

Chemical Information Sheets

Name	Potassium hydroxide
Synonyms	Caustic potash, Hydroxyde de potassium, Potassium hydrate
CAS Number	1310-58-3
Molecular Formula	KOH

Physical Properties	Value	Reference
PhaseState:		
Molecular Weight (g/mol):	56.11	ECHA 2013
Melting Point (°C):	380.00	ECHA 2013
Boiling Point (°C):	1327	ECHA 2013
Solubility (mg/L):	1,120,000.00	ECHA 2013

Other Relevant Factors	Value	Reference
Reactivity		
Species:		
Reaction type:		
pH / Acidity		
acid / alkaline		
pH (10% solution)		

Aquatic Ecotoxicological Data

Acute toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc mg/L**	**Reference**
Lepomis macrochirus	Blue gill	Fish LC50	MOR	Mortality	4	80	ECHA 2013

Project number: 127666004

INORGANIC

Terrestrial Ecotoxicological Data

Common Name	Endpoint	Effect	Effect Measure	Test Time (Days)	Conc	Reference	Units
Rat	Mammalian LD50	MOR	Mortality		273	HSDB 1999	mg/kg

Created By: Naomi Cooper Date: 9/09/2013

Checked By: Kirsten Broadgate Date: 10/09/2013

Name	Sodium Hydroxide
Synonyms	Sodium hydroxide
CAS Number	1310-73-2
Molecular Formula	NaOH

Physical Properties	Value	Reference
PhaseState:	White orthogonal crystals	HSDB 2012
Molecular Weight (g/mol):	40	HSDB 2012
Melting Point (°C):	323.00	HSDB 2012
Boiling Point (°C):	1388	HSDB 2012
Solubility (mg/L):	1,110,000.00	HSDB 2012

Other Relevant Factors	Value	Reference
Reactivity		
Species:	OH-/NaOH	HSDB 2011
Reaction type:	Acid/base	HSDB 2011
pH / Acidity		
acid / alkaline	Alkaline	HSDB 2011
pH (10% solution)	11	HSDB 2011

Aquatic Ecotoxicological Data

Acute toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc mg/L**	**Reference**
Ceriodaphnia dubia	Water flea	Invertebrate EC50	Intoxication	Immobilisation	2	40.38	HSDB 2011
Gambusia affinis	Western mosquitofish	Fish LC50	Mortality	Mortality	1	125	ECOTOX 2012

Project number: 127666004

INORGANIC

Terrestrial Ecotoxicological Data

Common Name	Endpoint	Effect	Effect Measure	Test Time (Days)	Conc	Reference	Units
Rat	Mammalian LD50	MOR	Mortality		140	HSDB 2012	mg/kg
Rabbit	Mammalian LD50	MOR	Mortality		325	OECD SIDS 200	mg/kg bw

Created By: Lisa Brookes Date: 31/07/2012

Checked By: Kirsten Broadgate Date: 15/07/2013

Name	Sodium tetraborate
Synonyms	Disodium Tetraborate, Sodium Borate, Borax Glass
CAS Number	1330-43-4
Molecular Formula	B4O7.2Na

Physical Properties	Value	Reference
PhaseState:	Colourless glassy solid	HSDB 2007
Molecular Weight (g/mol):		0
Melting Point (°C):	743.00	HSDB 2007
Boiling Point (°C):	1575	HSDB 2007
Solubility (mg/L):	31,000.00	HSDB 2007

Other Relevant Factors	Value	Reference
Reactivity		
Species:		
Reaction type:		
pH / Acidity		
acid / alkaline		
pH (10% solution)		

Aquatic Ecotoxicological Data

Acute toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc mg/L**	**Reference**
Lepomis macrochirus	Bluegill	Fish LC50	MOR	Mortality	1	15	ECOTOX 2012
Daphnia magna	Water flea	Invertebrate LC50	MOR	Mortality	2	141	HSDB 2007
Pseudokirchneriella subcapitata	Green algae	Plant EC50	GRO	Growth	4	15.4	ECOTOX 2012

Project number: 127666004

INORGANIC

Terrestrial Ecotoxicological Data

Common Name	Endpoint	Effect	Effect Measure	Test Time (Days)	Conc	Reference	Units
Rat	Mammalian LD50	MOR	Mortality		2660	HSDB 2007	mg/kg

Created By: Naomi Cooper Date: 8/11/2013

Checked By: Carolyn Brumley Date: 11/11/2013

Name	Hydrochloric Acid
Synonyms	Anhydrous hydrochloric acid, chlorohydric acid, dilute hydrochloric acid, hydrochloric acid gas, muriatic acid
CAS Number	7647-01-0
Molecular Formula	HCl

Physical Properties	Value	Reference
PhaseState:	Liquid	HSDB 2009
Molecular Weight (g/mol):	36.46	HSDB 2009
Melting Point (°C):	-114.22	HSDB 2009
Boiling Point (°C):	-85.05	HSDB 2009
Solubility (mg/L):	823,000.00	HSDB 2009

Other Relevant Factors	Value	Reference
Reactivity		
Species:		
Reaction type:		
pH / Acidity		
acid / alkaline		
pH (10% solution)		

Aquatic Ecotoxicological Data

Acute toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc mg/L**	**Reference**
Gambusia affinis	Western Mosquito fish	Fish LC50	Mortality	Mortality	1	282	ECOTOX 2012

Chronic toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc mg/L**	**Reference**
Lemna minor	Duckweed	Plant EC50	Growth	Weight	10	182.3	ECOTOX 2012

Project number: 127666004

INORGANIC

Terrestrial Ecotoxicological Data

Common Name	Endpoint	Effect	Effect Measure	Test Time (Days)	Conc	Reference	Units
Rat	Mammalian LD50	Mortality	Mortality		50 mg/kg/bw	INCHEM 2012	

Created By: Chelsea Papadopoulos Date: 16/08/2012

Checked By: Kirsten Broadgate Date: 18/07/2013

Name	Zirconium dichloride oxide (Surrogate for)
Synonyms	zirconyl chloride, chlorozirconyl
CAS Number	7699-43-6
Molecular Formula	Cl2OZr

Physical Properties	Value	Reference
PhaseState:	Solid	HSDB 2006
Molecular Weight (g/mol):		0
Melting Point (°C):	-15.00	HSDB 2006
Boiling Point (°C):		
Solubility (mg/L):	163,000,000.00	ECHA 2013

Other Relevant Factors	Value	Reference
Reactivity		
Species:		
Reaction type:		
pH / Acidity		
acid / alkaline		
pH (10% solution)		

Aquatic Ecotoxicological Data

Acute toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc mg/L**	**Reference**
Lepomis macrochirus	Bluegill	Fish LC50	MOR	Mortality	4	15	ECOTOX 2012
Tubifex tubifex	Tubificid Worm	Invertebrate LC50	MOR	Mortality	4	221.2	HSDB 2006

Project number: 127666004

INORGANIC

Terrestrial Ecotoxicological Data

Common Name	Endpoint	Effect	Effect Measure	Test Time (Days)	Conc	Reference	Units
Rat	Mammalian LD50	MOR	Mortality		2950	ChemIDPlus2013	mg/kg
Mouse	Mammalian LD50	MOR	Mortality		1227	ChemIDPlus2013	mg/kg

Created By: Naomi Cooper Date: 8/11/2013

Checked By: Carolyn Brumley Date: 11/11/2013

Name	Hydrogen peroxide
Synonyms	Albone, Inibine, Peroxaan
CAS Number	7722-84-1
Molecular Formula	H2O2

Physical Properties	Value	Reference
PhaseState:	Liquid	HSDB 2005
Molecular Weight (g/mol):	34.01	HSDB 2005
Melting Point (°C):	-0.43	HSDB 2005
Boiling Point (°C):	152	HSDB 2005
Solubility (mg/L):	1,000,000.00	HSDB 2005

Other Relevant Factors	Value	Reference
Reactivity		
Species:		
Reaction type:		
pH / Acidity		
acid / alkaline		
pH (10% solution)		

Aquatic Ecotoxicological Data

Acute toxicity data

SpeciesName	Common Name	Endpoint	Effect	Effect Measure	Test Time (Days)	Conc mg/L	Reference
Danio rerio	Zebra fish	Fish LC50	MOR	Mortality	4	18.3	USEPA 2009
Gammarus sp	Amphipod	Invertebrate LC50	MOR	Mortality	4	4.32	USEPA 2009

Chronic toxicity data

SpeciesName	Common Name	Endpoint	Effect	Effect Measure	Test Time (Days)	Conc mg/L	Reference
Oncoryhynchus mykiss	Rainbow trout	Fish NOEC	REP	Hatching	14	1112	USEPA 2009
Daphnia magna	Water flea	Invertebrate NOEC	REP	Reproduction	21	0.63	USEPA 2009
Ceratophyllum demersum	Coon Tail	Plant NOEC	GRO	Growth	14	34	USEPA 2009
Daphnia magna	Water flea	Invertebrate LOEC	GRO	Growth	21	0.34	USEPA 2009

Project number: 127666004

INORGANIC

Created By: Naomi Cooper Date: 13/11/2013

Checked By: Carolyn Brumley Date: 15/11/2013

Name	Nitrogen, liquid form
Synonyms	Nitrogen elemental,
CAS Number	7727-37-9
Molecular Formula	N2

Physical Properties	Value	Reference
PhaseState:	Liquid	HSDB 2011
Molecular Weight (g/mol):	28.013	HSDB 2011
Melting Point (°C):	-210.01	HSDB 2011
Boiling Point (°C):	-195.79	HSDB 2011
Solubility (mg/L):	18,100.00	HSDB 2011

Other Relevant Factors	Value	Reference
Reactivity		
Species:		
Reaction type:		
pH / Acidity		
acid / alkaline		
pH (10% solution)		

Aquatic Ecotoxicological Data

Acute toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc mg/L**	**Reference**
Cloeon dipterum	Mayfly	Invertebrate LC50	MOR	Mortality	2	>40	ECOTOX 2012
	Fish	Fish LC50	MOR	Mortality	4	360	ECOSAR 2012
	Daphnid	Invertebrate LC50	MOR	Mortality	2	181	ECOSAR 2012
	Green algae	Plant EC50	MOR	Mortality	4	81	ECOSAR 2012

Project number: 127666004

INORGANIC

Created By: Naomi Cooper Date: 14/01/2014

Checked By: Kirsten Broadgate Date: 14/01/2014

Name	Sodium thiosulfate
Synonyms	Disodium thiosulfate, Sodium hyposulfite
CAS Number	7772-98-7
Molecular Formula	Na2O3S2

Physical Properties	Value	Reference
PhaseState:	Solid - crystals, powder	HSDB 2003
Molecular Weight (g/mol):	158.13	HSDB 2003
Melting Point (°C):		
Boiling Point (°C):		
Solubility (mg/L):	500,000.00	HSDB 2003

Other Relevant Factors	Value	Reference
Reactivity		
Species:		
Reaction type:		
pH / Acidity		
acid / alkaline		
pH (10% solution)		

Aquatic Ecotoxicological Data

Acute toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc mg/L**	**Reference**
Daphnia magna	Water flea	Invertebrate LC50	MOR	Mortality	4.2	805	ECOTOX 2012
Gambusia affinis	Western Mosquitofish	Fish LC50	MOR	Mortality	4	24000	ECOTOX 2012

Project number: 127666004

INORGANIC

Created By: Naomi Cooper Date: 7/09/2013

Checked By: Kirsten Broadgate Date: 9/09/2013

Name	Magnesium chloride
Synonyms	Magnesium dichloride
CAS Number	7786-30-3
Molecular Formula	MgCl2

Physical Properties	Value	Reference
PhaseState:	Granules or flakes	
Molecular Weight (g/mol):	95.21	HSDB 2011
Melting Point (°C):	118.00	HSDB 2011
Boiling Point (°C):	712	HSDB 2011
Solubility (mg/L):	550,000.00	HSDB 2011

Other Relevant Factors	Value	Reference
Reactivity		
Species:		
Reaction type:		
pH / Acidity		
acid / alkaline		
pH (10% solution)		

Aquatic Ecotoxicological Data

Acute toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc mg/L**	**Reference**
Daphnia hyalina	Water flea	Invertebrate LC50	MOR	Mortality	2	32	ECOTOX 2012
Pimephales promelas	Fathead minnow	Fish LC50	MOR	Mortality	4	2120	ECOTOX 2012

Project number: 127666004

INORGANIC

Terrestrial Ecotoxicological Data

Common Name	Endpoint	Effect	Effect Measure	Test Time (Days)	Conc	Reference	Units
Rat	Mammalian LD50	MOR	Mortality		2800	HSDB 2003	mg/kg

Created By: Naomi Cooper Date: 17/12/2013

Checked By: Kirsten Broadgate Date: 17/12/2013

Project number: 127666004

INORGANIC

Name	Sodium bromate
Synonyms	Dyetone
CAS Number	7789-38-0
Molecular Formula	BrH03.Na

Physical Properties	Value	Reference
PhaseState:	Solid - crystals	ChemIDPlus 2012,
Molecular Weight (g/mol):	150.892	ChemIDPlus 2012,
Melting Point (°C):	381.00	ChemIDPlus 2012,
Boiling Point (°C):		
Solubility (mg/L):	364,000.00	ChemIDPlus 2012,

Other Relevant Factors	Value	Reference
Reactivity		
Species:		
Reaction type:		
pH / Acidity		
acid / alkaline		
pH (10% solution)		

Project number: 127666004

INORGANIC

Terrestrial Ecotoxicological Data

Common Name	Endpoint	Effect	Effect Measure	Test Time (Days)	Conc	Reference	Units
Rat	Mammalian LD50	MOR	Mortality		301	ECHA 2012	mg/kg/bw

Created By: Naomi Cooper Date: 7/09/2013

Checked By: Kirsten Broadgate Date: 9/09/2013

Name	Boric acid
Synonyms	Orthoboric acid, Boron trihydroxide, Trihydroxyborane
CAS Number	10043-35-3
Molecular Formula	BH3O3

Physical Properties	Value	Reference
PhaseState:	Solid - granules or powder	HSDB 2012
Molecular Weight (g/mol):	61.833	HSDB 2012
Melting Point (°C):	170.90	HSDB 2012
Boiling Point (°C):	300	HSDB 2012
Solubility (mg/L):	50,000.00	HSDB 2012

Other Relevant Factors	Value	Reference
Reactivity		
Species:		
Reaction type:		
pH / Acidity		
acid / alkaline		
pH (10% solution)		

Aquatic Ecotoxicological Data

Acute toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc mg/L**	**Reference**
Oncorhynchus mykiss	Rainbow trout	Fish LC50	MOR	Mortality	4	79	ECOTOX 2012
Ceriodaphnia pulchella	Water flea	Invertebrate LC50	MOR	Mortality	1	101.2	ECOTOX 2012

Chronic toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc mg/L**	**Reference**
Oncorhynchus mykiss	Rainbow trout	Fish LOEC	MOR	Mortality	32	0.1	ECOTOX 2012
Daphnia magna	Water flea	Invertebrate MATC	GRO	Growth	21	9.33	ECOTOX 2012
Chlorella pyrenoidosa	Green algae	Plant LOEC	POP	Growth	14	0.08	ECOTOX 2012
Micropterus salmoidea	Largemouth bass	Fish NOEC	MOR	Mortality	11	1.390	ECOTOX 2012
Daphnia magna	Water flea	Invertebrate NOEC	REP	Reproduction	21	6	ECOTOX 2012

Chlorella pyrenoidosa	Green algae	Plant NOEC	POP	Growth	14	0.4	ECOTOX 2012

Project number: 127666004

INORGANIC

Terrestrial Ecotoxicological Data

Common Name	Endpoint	Effect	Effect Measure	Test Time (Days)	Conc	Reference	Units
Rat	Mammalian LD50	MOR	Mortality		2660	HSDB 2012	mg/kg

Created By: Naomi Cooper Date: 14/01/2014

Checked By: Kirsten Broadgate Date: 14/01/2014

Name	Magnesium nitrate
Synonyms	Magnesium dinitrate
CAS Number	10377-60-3
Molecular Formula	Mg(NO3)2

Physical Properties	Value	Reference
PhaseState:	Solid - white crystals	HSDB 2003
Molecular Weight (g/mol):	148.31	HSDB 2003
Melting Point (°C):	95.00	HSDB 2003
Boiling Point (°C):		
Solubility (mg/L):	712,000.00	HSDB 2003

Other Relevant Factors	Value	Reference
Reactivity		
Species:		
Reaction type:		
pH / Acidity		
acid / alkaline		
pH (10% solution)		

Aquatic Ecotoxicological Data

Acute toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc mg/L**	**Reference**
Caenorhabditis elegans	Nematode	Invertebrate LC50	MOR	Mortality	1	25213	ECOTOX 2012

Project number: 127666004

INORGANIC

Created By: Naomi Cooper Date: 14/01/2014

Checked By: Kirsten Broadgate Date: 14/01/2014

Name	Magnesium silicate hydrate (talc) (Surrogate for Magnesium silicate hydrate (talc))
Synonyms	Magnesium silicate hydrate, talc, talcum
CAS Number	14807-96-6
Molecular Formula	H2O3Si3/4Mg

Physical Properties	Value	Reference
PhaseState:	White to greyish white, very fine crystalline powder	HSDB 2011
Molecular Weight (g/mol):		
Melting Point (°C):	800.00	IUCLID 2000a
Boiling Point (°C):		
Solubility (mg/L):	1,000,000.00	EPISUITE 2011 v4.

Other Relevant Factors	Value	Reference
Reactivity		
Species:	Insoluble and degradable in soil or water	IUCLID 2000a
Reaction type:		
pH / Acidity		
acid / alkaline		
pH (10% solution)		

Aquatic Ecotoxicological Data

Acute toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc mg/L**	**Reference**
Brachydanio rerio	Zebra fish	Fish LC50	MOR	Mortality	1	> 1000	HSDB 2011

Project number: 127666004

INORGANIC

Created By: Lisa Brookes Date: 27/08/2012

Checked By: Kirsten Broadgate Date: 14/06/2013

Project number: 127666004

ORGANIC

Name	L-Glutamic Acid
Synonyms	Glusate, Aciglut
CAS Number	56-86-0
Molecular Formula	C5H9NO4

Physical Properties	Value	Reference
PhaseState:	Solid	ECHA 2012
Molecular Weight (g/mol):	147.13	ECHA 2012
Melting Point (°C):	213.00	ECHA 2012
Boiling Point (°C):		
Density / Specific Gravity (g/L at 20oC	1,540.00	ECHA 2012
Vapour Pressure (mm Hg at 25°C):	1.10E-05	ECHA 2012
Solubility (mg/L):	8.57E+03	ECHA 2012
Henry's Law Constant (atm m³/mole):	1.47E-14	EPISUITE 2011 v4.1
Organic carbon partition coefficient (Koc):	13.40	EPISUITE 2011 v4.1
Log organic carbon partition coefficient (log Koc):	1.13	EPISUITE 2011 v4.1
Log octanol - water partition coefficient (log Kow):	-3.69	EPISUITE 2011 v4.1

Persistance / Bioaccumulation	Value	Reference
Biowin 3 (Ultimate Survey Biodegradation):	3.6277	EPISUITE 2011 v4.1
Biowin 4 (Primary Biodegradation):	4.4499	EPISUITE 2011 v4.1
EPISUITE Ready Biodegradability:	Biodegrades fast	EPISUITE 2011 v4.1
Biowin 7 (Anaerobic Model Prediction):	1.273	EPISUITE 2011 v4.1
Fugacity_Air: (%)	0.000000482	EPISUITE 2011 v4.1
Fugacity_Water: (%)	27	EPISUITE 2011 v4.1
Fugacity_Soil: (%)	73	EPISUITE 2011 v4.1
Fugacity_Sediment: (%)	0.0601	EPISUITE 2011 v4.1
Bioconcentration factor (BCF):	3.162	EPISUITE 2011 v4.1
Biotransformation half - life (Days):	0.0095	

Project number: 127666004

ORGANIC

Aquatic Ecotoxicological Data

Acute toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc mg/L**	**Reference**
Cyrpinus carpio	Carp	Fish LC50	MOR	Mortality	4	>100	ECHA 2012
Daphnia magna	Water flea	Invertebrate LC50	MOR	Mortality	2	>100	ECHA 2012

Chronic toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc mg/L**	**Reference**
Pseudokirchnerella subcapitata	Green algae	Plant NOEC	GRO	Growth rate	3	16	QSAR 2013

Terrestrial Ecotoxicological Data

Common Name	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc**	**Reference**	**Units**
Rat	Mammalian LD50	MOR	Mortality		>30000	ChemIDPlus2013	mg/kg
Rabbit	Mammalian LD50	MOR	Mortality		>2300	ChemIDPlus2013	mg/kg

Created By: Naomi Cooper Date: 10/11/2013

Checked By: Carolyn Brumley Date: 11/11/2013

Project number: 127666004

ORGANIC

Name	Tetrasodium ethylenediaminetetraacetate
Synonyms	Tetrasodium EDTA
CAS Number	64-02-8
Molecular Formula	C10H16N2O8Na4

Physical Properties	Value	Reference
PhaseState:	White powder	HSDB 2011
Molecular Weight (g/mol):	380.2	HSDB 2011
Melting Point (°C):	300.00	HSDB 2011
Boiling Point (°C):	572.7	EPISUITE 2011 v4.1
Density / Specific Gravity (lb/gal):	6.90	EPISUITE 2011 v4.1
Vapour Pressure (mm Hg at 25°C):	1.49E-12	EPISUITE 2011 v4.1
Solubility (mg/L):	1.00E+06	EPISUITE 2011 v4.1
Henry's Law Constant (atm m³/mole):	1.18E-23	HSDB 2011
Organic carbon partition coefficient (Koc):	312.70	EPISUITE 2011 v4.1
Log organic carbon partition coefficient (log Koc):	2.50	EPISUITE 2011 v4.1
Log octanol - water partition coefficient (log Kow):	-13.17	EPISUITE 2011 v4.1

Persistance / Bioaccumulation	Value	Reference
Biowin 3 (Ultimate Survey Biodegradation):	3.5022	EPISUITE 2011 v4.1
Biowin 4 (Primary Biodegradation):	4.3924	EPISUITE 2011 v4.1
EPISUITE Ready Biodegradability:	Biodegrades fast	EPISUITE 2011 v4.1
Biowin 7 (Anaerobic Model Prediction):	-0.4106	EPISUITE 2011 v4.1
Fugacity_Air: (%)	0.00000000000136	EPISUITE 2011 v4.1
Fugacity_Water: (%)	19	EPISUITE 2011 v4.1
Fugacity_Soil: (%)	81	EPISUITE 2011 v4.1
Fugacity_Sediment: (%)	0.198	EPISUITE 2011 v4.1
Bioconcentration factor (BCF):	3.162	EPISUITE 2011 v4.1
Biotransformation half - life (Days):	0.000007617	EPISUITE 2011 v4.1

Project number: 127666004

ORGANIC

Aquatic Ecotoxicological Data

Acute toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc mg/L**	**Reference**
Lepomis	Bluegill	Fish LC50	MOR	Mortality	4	486	ECOTOX 2012
Daphnia magna	Water flea	Invertebrate LC50	MOR	Mortality	1	610	ECOTOX 2012

Created By: Naomi Cooper Date: 17/12/2013

Checked By: Kirsten Broadgate Date: 17/12/2013

Project number: 127666004

ORGANIC

Name	Ethanol
Synonyms	Ethyl alcohol, Ethyl hydrate
CAS Number	64-17-5
Molecular Formula	C2H6O

Physical Properties	Value	Reference
PhaseState:	Liquid	HSDB 2012
Molecular Weight (g/mol):	46.07	HSDB 2012
Melting Point (°C):	-114.14	HSDB 2012
Boiling Point (°C):	78.3	HSDB 2012
Density / Specific Gravity (g/cu):	0.79	HSDB 2012
Vapour Pressure (mm Hg at 25°C):	5.93E+01	HSDB 2012
Solubility (mg/L):	1.00E+06	HSDB 2012
Henry's Law Constant (atm m³/mole):	5.00E+06	HSDB 2012
Organic carbon partition coefficient (Koc):	2.75	HSDB 2012
Log organic carbon partition coefficient (log Koc):	0.44	HSDB 2012
Log octanol - water partition coefficient (log Kow):	-0.31	HSDB 2012

Persistance / Bioaccumulation	Value	Reference
Biowin 3 (Ultimate Survey Biodegradation):	3.2573	EPISUITE 2011 v4.1
Biowin 4 (Primary Biodegradation):	3.9107	EPISUITE 2011 v4.1
EPISUITE Ready Biodegradability:	Biodegrades fast	EPISUITE 2011 v4.1
Biowin 7 (Anaerobic Model Prediction):	0.9153	EPISUITE 2011 v4.1
Fugacity_Air: (%)	7.4	EPISUITE 2011 v4.1
Fugacity_Water: (%)	41	EPISUITE 2011 v4.1
Fugacity_Soil: (%)	52	EPISUITE 2011 v4.1
Fugacity_Sediment: (%)	0.0718	EPISUITE 2011 v4.1
Bioconcentration factor (BCF):	3	EPISUITE 2011 v4.1
Biotransformation half - life (Days):	0.02866	EPISUITE 2011 v4.1

Project number: 127666004

ORGANIC

Aquatic Ecotoxicological Data

Acute toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc mg/L**	**Reference**
Oncorhynchus mykis	Rainbow Trout	Fish LC50	MOR	Mortality	4	42	ECOTOX 2012
Daphnia magna	Water flea	Invertebrate LC50	MOR	Mortality	4	100	ECOTOX 2012

Chronic toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc mg/L**	**Reference**
Gambusia holbrooki	Eastern Mosquitofish	Fish NOEC	GRO	Growth	84	0.375	ECOTOX 2012
Daphnia magna	Water flea	Invertebrate NOEC	REP	Reproduction	35	0.008	ECOTOX 2012
Biomarphalaria tenagophila	Snail	Invertebrate LOEC	REP	Hatching	196	19.8	ECOTOX 2012

Terrestrial Ecotoxicological Data

Common Name	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc**	**Reference**	**Units**
Rat	Mammalian LD50	MOR	Mortality		6200	HSDB 2012	mg/kg
Guinea pig	Mammalian LD50	MOR	Mortality		5600	HSDB 2012	mg/kg

Common Name	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc**	**Reference**	**Units**
Earthworm	1	MOR	Mortality	14	134	ECOSAR 2012	mg/L

Created By: Naomi Cooper Date: 8/11/2013

Checked By: Carolyn Brumley Date: 11/11/2013

Project number: 127666004

ORGANIC

Name	Choline Chloride
Synonyms	Hepacholine, Neocolina, Bilineurin chloride, Choline Chlorhydrate
CAS Number	67-48-1
Molecular Formula	C5H14NO.Cl

Physical Properties	Value	Reference
PhaseState:	White Crystals	HSDB 2012
Molecular Weight (g/mol):	139.63	HSDB 2012
Melting Point (°C):	305.00	HSDB 2012
Boiling Point (°C):		
Density / Specific Gravity (Enter Unit):		
Vapour Pressure (mm Hg at 25°C):	4.93E-10	OECD SIDS 2004
Solubility (mg/L):	6.50E+05	OECD SIDS 2004
Henry's Law Constant (atm m^3/mole):	2.08E-13	OECD SIDS 2004
Organic carbon partition coefficient (Koc):	2.34	OECD SIDS 2004
Log organic carbon partition coefficient (log Koc):	0.37	OECD SIDS 2004
Log octanol - water partition coefficient (log Kow):	-3.77	OECD SIDS 2004

Persistance / Bioaccumulation	Value	Reference
Biowin 3 (Ultimate Survey Biodegradation):	3.0506	EPISUITE 2011 v4.1
Biowin 4 (Primary Biodegradation):	3.7757	EPISUITE 2011 v4.1
EPISUITE Ready Biodegradability:	Biodegrades fast	EPISUITE 2011 v4.1
Biowin 7 (Anaerobic Model Prediction):	0.3444	EPISUITE 2011 v4.1
Fugacity_Air: (%)	0.000000659	EPISUITE 2011 v4.1
Fugacity_Water: (%)	37	EPISUITE 2011 v4.1
Fugacity_Soil: (%)	63	EPISUITE 2011 v4.1
Fugacity_Sediment: (%)	0.0704	EPISUITE 2011 v4.1
Bioconcentration factor (BCF):	3.162	HSDB 2012
Biotransformation half - life (Days):		

Project number: 127666004

ORGANIC

Aquatic Ecotoxicological Data

Acute toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc mg/L**	**Reference**
Daphnia magna	Water flea	Invertebrate EC50	MOR	MORT	2	349	ECOTOX 2012
Oryzias latipes	Japanese medaka	Fish LC50	MOR	MORT	4	>100	ECOTOX 2012

Chronic toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc mg/L**	**Reference**
Daphnia magna	Water flea	Invertebrate NOEC	MOR	MORT	21	30.2	ECOTOX 2012
Pseudokircheriella subcapitata	Algae	Plant NOEC	GRO	GROWTH	72	32	OECD SIDS 2004

Terrestrial Ecotoxicological Data

Common Name	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc**	**Reference**	**Units**
Rat	Mammalian LD50	MOR	MORT		3400	HSDB 2012	
Mouse	Mammalian LD50	MOR	MORT		3900	HSDB 2012	

Common Name	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc**	**Reference**	**Units**
Earthworm	1	MOR	MORT	14	1340	ECOSAR 2012	

Created By: Naomi Cooper Date: 13/07/2013

Checked By: Kirsten Broadgate Date: 15/07/2013

Project number: 127666004

ORGANIC

Name	Propan-2-ol
Synonyms	Isopropyl alcohol; secondary propyl alcohol; dimethyl carbinol; petrohol; IPA
CAS Number	67-63-0
Molecular Formula	C3H8O

Physical Properties	Value	Reference
PhaseState:	Liquid	HSDB 2012
Molecular Weight (g/mol):	60.1	HSDB 2012
Melting Point (°C):	-87.90	HSDB 2012
Boiling Point (°C):	82.3	HSDB 2012
Density / Specific Gravity (Not given):	0.79	HSDB 2012
Vapour Pressure (mm Hg at 25°C):	4.54E+01	HSDB 2012
Solubility (mg/L):	4.02E+05	HSDB 2012
Henry's Law Constant (atm m³/mole):	8.10E-06	EPISUITE 2011 v4.0
Organic carbon partition coefficient (Koc):	1.53	EPISUITE 2011 v4.0
Log organic carbon partition coefficient (log Koc):	0.19	EPISUITE 2011 v4.0
Log octanol - water partition coefficient (log Kow):	0.05	HSDB 2012

Persistance / Bioaccumulation	Value	Reference
Biowin 3 (Ultimate Survey Biodegradation):	3.2263	EPISUITE 2011 v4.0
Biowin 4 (Primary Biodegradation):	3.8905	EPISUITE 2011 v4.0
EPISUITE Ready Biodegradability:	Biodegrades fast	EPISUITE 2011 v4.0
Biowin 7 (Anaerobic Model Prediction):	0.6439	EPISUITE 2011 v4.0
Fugacity_Air: (%)	4.6	EPISUITE 2011 v4.0
Fugacity_Water: (%)	45	EPISUITE 2011 v4.0
Fugacity_Soil: (%)	50	EPISUITE 2011 v4.0
Fugacity_Sediment: (%)	0.086	EPISUITE 2011 v4.0
Bioconcentration factor (BCF):	3	HSDB 2011
Biotransformation half - life (Days):	0.036	EPISUITE 2011 v4.0

Project number: 127666004

ORGANIC

Aquatic Ecotoxicological Data

Acute toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc mg/L**	**Reference**
Rasbora heteromorpha	Harlequin Fish	Fish LC50	MOR	Mortality	4	4200	ECOTOX 2012
Daphnia magna	Water flea	Invertebrate EC50	MOR	Mortality	1	1000	HSDB 2012

Terrestrial Ecotoxicological Data

Common Name	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc**	**Reference**	**Units**
Mouse	Mammalian LD50	Mortality	Mortality		3600 mg/kg	HSDB 2012	
Earthworm	QSAR Earthworm LC50	Mortality	Mortality	14	157.684 mg/L	ECOSAR 2012	

Created By: Chelsea Papadopoulos Date: 16/08/2012

Checked By: Carolyn Brumley Date: 31/08/2012

Project number: 127666004

ORGANIC

Name	Tetramethylammonium chloride
Synonyms	N,N,N-trimethylmethanaminium chloride
CAS Number	75-57-0
Molecular Formula	C4H12NCl

Physical Properties	Value	Reference
PhaseState:	Solid	HSDB 2012
Molecular Weight (g/mol):	109.6	HSDB 2012
Melting Point (°C):	420.00	HSDB 2012
Boiling Point (°C):		
Density / Specific Gravity (g/L):	1.17	HSDB 2012
Vapour Pressure (mm Hg at 25°C):	1.20E-08	HSDB 2012
Solubility (mg/L):	5.90E+05	HSDB 2012
Henry's Law Constant (atm m³/mole):	4.20E-12	HSDB 2012
Organic carbon partition coefficient (Koc):	8.00	HSDB 2012
Log organic carbon partition coefficient (log Koc):	0.90	HSDB 2012
Log octanol - water partition coefficient (log Kow):	-4.18	HSDB 2012

Persistance / Bioaccumulation	Value	Reference
Biowin 3 (Ultimate Survey Biodegradation):	2.9570	EPISUITE 2011 v4.1
Biowin 4 (Primary Biodegradation):	3.9896	EPISUITE 2011 v4.1
EPISUITE Ready Biodegradability:	Does not biodegrade fast	EPISUITE 2011 v4.0
Biowin 7 (Anaerobic Model Prediction):	0.0801	EPISUITE 2011 v4.1
Fugacity_Air: (%)	0.00123	EPISUITE 2011 v4.0
Fugacity_Water: (%)	3	EPISUITE 2011 v4.0
Fugacity_Soil: (%)	68	EPISUITE 2011 v4.0
Fugacity_Sediment: (%)	0.0687	EPISUITE 2011 v4.0
Bioconcentration factor (BCF):	3.2	HSDB 2012
Biotransformation half - life (Days):	0.007535	EPISUITE 2011 v4.0

Project number: 127666004

ORGANIC

Aquatic Ecotoxicological Data

Acute toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc mg/L**	**Reference**
Pimephales promelas	Fathead minnow	Fish LC50	MOR	Mortality	4	462	ECHA 2013
Daphnia magna	Water flea	Invertebrate LC50	MOR	Mortality	2	3.6	ECHA 2013
Pseudokirchnerella subcapitata	Green algae	Plant EC50	GRO	Growth	3	115	ECHA 2013

Chronic toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc mg/L**	**Reference**
Daphnia magna	Water flea	Invertebrate NOEC	REP	Reproduction	11	0.03	ECHA 2013
Pseudokirchnerella subcapitata	Green algae	Plant NOEC	GRO	Biomass	3	7.5	ECHA 2013

Terrestrial Ecotoxicological Data

Common Name	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc**	**Reference**	**Units**
Earthworm	QSAR Earthworm LC50	MOR	Mortality	14	833.78	ECOSAR 2012	mg/L
Rat	Mammalian LD50	MOR	Mortality		50	ChemIDPlus201	mg/kg

Created By: Naomi Cooper Date: 7/11/2013

Checked By: Carolyn Brumley Date: 8/11/2013

Project number: 127666004

ORGANIC

Name	Cetylethylmorpholinium ethyl sulfate
Synonyms	Cetylethylmorpholinium ethosulfate, N-Cetyl-N-ethymorpholinium ethosulfate
CAS Number	78-21-7
Molecular Formula	C24H51N1O5S1

Physical Properties	Value	Reference
PhaseState:		
Molecular Weight (g/mol):	465.74	EPISUITE 2011 v4.1
Melting Point (°C):	291.55	EPISUITE 2011 v4.1
Boiling Point (°C):	669.02	EPISUITE 2011 v4.1
Density / Specific Gravity (Enter Unit):		
Vapour Pressure (mm Hg at 25°C):	1.22E-15	EPISUITE 2011 v4.1
Solubility (mg/L):	6.36E-03	EPISUITE 2011 v4.1
Henry's Law Constant (atm m³/mole):	3.56E-16	EPISUITE 2011 v4.1
Organic carbon partition coefficient (Koc):	224,700.00	EPISUITE 2011 v4.1
Log organic carbon partition coefficient (log Koc):	5.35	EPISUITE 2011 v4.1
Log octanol - water partition coefficient (log Kow):	6.17	EPISUITE 2011 v4.1

Persistance / Bioaccumulation	Value	Reference
Biowin 3 (Ultimate Survey Biodegradation):	2.4596	EPISUITE 2011 v4.1
Biowin 4 (Primary Biodegradation):	3.4351	EPISUITE 2011 v4.1
EPISUITE Ready Biodegradability:	Does not biodegrade fast	EPISUITE 2011 v4.1
Biowin 7 (Anaerobic Model Prediction):	-0.4535	EPISUITE 2011 v4.1
Fugacity_Air: (%)	0.00257	EPISUITE 2011 v4.1
Fugacity_Water: (%)	4	EPISUITE 2011 v4.1
Fugacity_Soil: (%)	54	EPISUITE 2011 v4.1
Fugacity_Sediment: (%)	42.1	EPISUITE 2011 v4.1
Bioconcentration factor (BCF):	70.79	EPISUITE 2011 v4.1
Biotransformation half - life (Days):	5.1	EPISUITE 2011 v4.1

Project number: 127666004

ORGANIC

Aquatic Ecotoxicological Data

Acute toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc mg/L**	**Reference**
	Fish	Fish LC50	MOR	Mortality		269000	ECOSAR 2012
	Daphnid	Invertebrate LC50	MOR	Mortality		117.49	ECOSAR 2012

Common Name	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc**	**Reference**	**Units**
Earthworm	1	MOR	Mortality	14	299	ECOSAR 2012	mg/L

Created By: Naomi Cooper Date: 9/09/2013

Checked By: Kirsten Broadgate Date: 10/09/2013

Name	2,2',2"-nitrilotriethanol
Synonyms	Biafine, Mobisyl, Sterolamide, Triethanolamine
CAS Number	102-71-6
Molecular Formula	C6H15NO3

Physical Properties	Value	Reference
PhaseState:	Liquid	HSDB 2009
Molecular Weight (g/mol):	149.19	HSDB 2009
Melting Point (°C):	20.50	HSDB 2009
Boiling Point (°C):	335.4	HSDB 2009
Density / Specific Gravity (g/L at 20oC	1.12	HSDB 2009
Vapour Pressure (mm Hg at 25°C):	3.59E-06	HSDB 2009
Solubility (mg/L):	1.00E+06	EPISUITE 2011 v4.1
Henry's Law Constant (atm m³/mole):	7.05E-13	EPISUITE 2011 v4.1
Organic carbon partition coefficient (Koc):	7.00	HSDB 2009
Log organic carbon partition coefficient (log Koc):	0.85	HSDB 2009
Log octanol - water partition coefficient (log Kow):	-1	HSDB 2009

Persistance / Bioaccumulation	Value	Reference
Biowin 3 (Ultimate Survey Biodegradation):	3.0946	EPISUITE 2011 v4.1
Biowin 4 (Primary Biodegradation):	3.7328	EPISUITE 2011 v4.1
EPISUITE Ready Biodegradability:	Biodegrades fast	EPISUITE 2011 v4.1
Biowin 7 (Anaerobic Model Prediction):	0.3155	EPISUITE 2011 v4.1
Fugacity_Air: (%)	0.0000161	EPISUITE 2011 v4.1
Fugacity_Water: (%)	31	EPISUITE 2011 v4.1
Fugacity_Soil: (%)	69	EPISUITE 2011 v4.1
Fugacity_Sediment: (%)	0.0688	EPISUITE 2011 v4.1
Bioconcentration factor (BCF):	3	HSDB 2009
Biotransformation half - life (Days):	0.0008924	EPISUITE 2011 v4.1

Project number: 127666004

ORGANIC

Aquatic Ecotoxicological Data

Acute toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc mg/L**	**Reference**
Scenedesmus subspicatus	Green algae	Plant EC50	GRO	Growth	2	470	ECOTOX 2012
Ceriodaphnia dubia	Water flea	Invertebrate EC50	IMB	Immobilization	2	609.98	ECOTOX 2012
Pimephales promelas	Fathead minnow	Fish LC50	MOR	Mortality	4	11800	ECOTOX 2012

Chronic toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc mg/L**	**Reference**
Scenedesmus quadricauda	Green algae	Plant LOEC	GRO	Growth		1.8	ECOTOX 2012
Daphnia magna	Water flea	Invertebrate NOEC	REP	Reproduction	21	16	ECOTOX 2012

Terrestrial Ecotoxicological Data

Common Name	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc**	**Reference**	**Units**
Mouse	Mammalian LD50	MOR	Mortality		5846	ChemIDPlus201	mg/kg
Rat	Mammalian LD50	MOR	Mortality		8000	HSDB 2009	mg/kg
Guinea Pig	Mammalian LD50	MOR	Mortality		2200	ChemIDPlus201	mg/kg

Created By: Naomi Cooper Date: 7/09/2013

Checked By: Kirsten Broadgate Date: 9/09/2013

Name	Fumaric acid
Synonyms	Allmoaleic acid, Butendioic acid, Tumaric acid
CAS Number	110-17-8
Molecular Formula	C4H4O4

Physical Properties	Value	Reference
PhaseState:	Crystalline powder	HSDB 2010
Molecular Weight (g/mol):	116.07	HSDB 2010
Melting Point (°C):	287.00	HSDB 2010
Boiling Point (°C):	522	ChemIDPlus2012
Density / Specific Gravity (g/L at 20oC	1,635.00	HSDB 2010
Vapour Pressure (mm Hg at 25°C):	1.54E-04	HSDB 2010
Solubility (mg/L):	7.00E+03	HSDB 2010
Henry's Law Constant (atm m³/mole):	8.50E-14	HSDB 2010
Organic carbon partition coefficient (Koc):	7.00	HSDB 2010
Log organic carbon partition coefficient (log Koc):	0.87	HSDB 2010
Log octanol - water partition coefficient (log Kow):	0.46	HSDB 2010

Persistance / Bioaccumulation	Value	Reference
Biowin 3 (Ultimate Survey Biodegradation):	3.6719	EPISUITE 2011 v4.1
Biowin 4 (Primary Biodegradation):	4.4514	EPISUITE 2011 v4.1
EPISUITE Ready Biodegradability:	Biodegrades fast	EPISUITE 2011 v4.1
Biowin 7 (Anaerobic Model Prediction):	1.0626	EPISUITE 2011 v4.1
Fugacity_Air: (%)	0.0673	EPISUITE 2011 v4.1
Fugacity_Water: (%)	29	EPISUITE 2011 v4.1
Fugacity_Soil: (%)	70	EPISUITE 2011 v4.1
Fugacity_Sediment: (%)	0.059	EPISUITE 2011 v4.1
Bioconcentration factor (BCF):	3.162	EPISUITE 2011 v4.1
Biotransformation half - life (Days):	0.1841	EPISUITE 2011 v4.1

Project number: 127666004

ORGANIC

Aquatic Ecotoxicological Data

Acute toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc mg/L**	**Reference**
Daphnia magna	Water flea	Invertebrate LC50	MOR	Mortality	2	212	QSAR 2013

Chronic toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc mg/L**	**Reference**
Pseudokirchnerella subcapitata	Green algae	Plant NOEC	MOR	Mortality	3	100	QSAR 2013

Terrestrial Ecotoxicological Data

Common Name	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc**	**Reference**	**Units**
Rat	Mammalian LD50	MOR	Mortality		9300	HSDB 2010	mg/kg

Common Name	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc**	**Reference**	**Units**
Earthworm	1	MOR	Mortality	14	3212	ECOSAR 2012	mg/L

Created By: Naomi Cooper Date: 13/12/2013

Checked By: Carolyn Brumley Date: 13/12/2013

Project number: 127666004

ORGANIC

Name	Triethylenetetramine
Synonyms	Tecza; Teta; Trien
CAS Number	112-24-3
Molecular Formula	C6H18N4

Physical Properties	Value	Reference
PhaseState:	Moderately viscous yellow liquid	HSDB 2002
Molecular Weight (g/mol):	146.24	HSDB 2002
Melting Point (°C):	12.00	HSDB 2002
Boiling Point (°C):	266	HSDB 2002
Density / Specific Gravity (g/L):	0.98	HSDB 2002
Vapour Pressure (mm Hg at 25°C):	1.00E-02	HSDB 2002
Solubility (mg/L):	1.00E+06	EPISUITE 2011 v4.1
Henry's Law Constant (atm m³/mole):	6.74E-19	EPISUITE 2011 v4.1
Organic carbon partition coefficient (Koc):	76.77	EPISUITE 2011 v4.1
Log organic carbon partition coefficient (log Koc):	1.89	EPISUITE 2011 v4.1
Log octanol - water partition coefficient (log Kow):	-2.65	EPISUITE 2011 v4.1

Persistance / Bioaccumulation	Value	Reference
Biowin 3 (Ultimate Survey Biodegradation):	2.9738	EPISUITE 2011 v4.1
Biowin 4 (Primary Biodegradation):	3.8099	EPISUITE 2011 v4.1
EPISUITE Ready Biodegradability:	Biodegrades fast	EPISUITE 2011 v4.1
Biowin 7 (Anaerobic Model Prediction):	1.7012	EPISUITE 2011 v4.1
Fugacity_Air: (%)	0.0000000000125	EPISUITE 2011 v4.1
Fugacity_Water: (%)	20	EPISUITE 2011 v4.1
Fugacity_Soil: (%)	80	EPISUITE 2011 v4.1
Fugacity_Sediment: (%)	0.1	EPISUITE 2011 v4.1
Bioconcentration factor (BCF):	3.162	EPISUITE 2011 v4.1
Biotransformation half - life (Days):	0.1113	EPISUITE 2011 v4.1

Project number: 127666004

ORGANIC

Aquatic Ecotoxicological Data

Acute toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc mg/L**	**Reference**
Poecilia reticulata	Guppy	Fish LC50	MOR	Mortality	4	570	OECD SIDS 1998
Daphnia magna	Water flea	Invertebrate LC50	MOR	Mortality	2	33.9	ECOTOX 2012
Pseudokirchneriella subcapitata	Green algae	Plant EC50	GRO	Growth	4	3.7	ECOTOX 2012

Chronic toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc mg/L**	**Reference**
Daphnia magna	Water flea	Invertebrate NOEC	IMM	Immobilization	21	1	OECD SIDS 1998

Terrestrial Ecotoxicological Data

Common Name	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc**	**Reference**	**Units**
Rat	Mammalian LD50	MOR	Mortality		2500	ChemIDPlus2013	
Mouse	Mammalian LD50	MOR	Mortality		1600	ChemIDPlus2013	
Rabbit	Mammalian LD50	MOR	Mortality		5500	ChemIDPlus2013	

Created By: Naomi Cooper Date: 7/11/2013

Checked By: Carolyn Brumley Date: 8/11/2013

Project number: 127666004

ORGANIC

Name	Butyl diglycol
Synonyms	Butoxy diethylene glycol, Butyl ethyl, Monobutyl ether
CAS Number	112-34-5
Molecular Formula	C8H18O3

Physical Properties	Value	Reference
PhaseState:	Colourless liquid	HSDB 2007
Molecular Weight (g/mol):	162.23	HSDB 2007
Melting Point (°C):	-68.10	HSDB 2007
Boiling Point (°C):	230.4	HSDB 2007
Density / Specific Gravity (20oC):	0.95	HSDB 2007
Vapour Pressure (mm Hg at 25°C):	2.19E-02	HSDB 2007
Solubility (mg/L):	7.19E+04	HSDB 2007
Henry's Law Constant (atm m^3/mole):	7.20E-09	HSDB 2007
Organic carbon partition coefficient (Koc):	48.00	HSDB 2007
Log organic carbon partition coefficient (log Koc):	1.68	HSDB 2007
Log octanol - water partition coefficient (log Kow):	0.56	HSDB 2007

Persistance / Bioaccumulation	Value	Reference
Biowin 3 (Ultimate Survey Biodegradation):	3.2816	EPISUITE 2011 v4.1
Biowin 4 (Primary Biodegradation):	3.9927	EPISUITE 2011 v4.1
EPISUITE Ready Biodegradability:	Biodegrades fast	EPISUITE 2011 v4.1
Biowin 7 (Anaerobic Model Prediction):	0.239	EPISUITE 2011 v4.1
Fugacity_Air: (%)	0.172	EPISUITE 2011 v4.1
Fugacity_Water: (%)	31	EPISUITE 2011 v4.1
Fugacity_Soil: (%)	69	EPISUITE 2011 v4.1
Fugacity_Sediment: (%)	0.0645	EPISUITE 2011 v4.1
Bioconcentration factor (BCF):	3.162	EPISUITE 2011 v4.1
Biotransformation half - life (Days):	0.03627	EPISUITE 2011 v4.1

Project number: 127666004

ORGANIC

Aquatic Ecotoxicological Data

Acute toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc mg/L**	**Reference**
Lepomis macrochirus	Bluegill	Fish LC50	MOR	Mortality	4	1300	ECOTOX 2012
Daphnia magna	Water flea	Invertebrate LC50	MOR	Mortality	1	2850	QSAR 2013

Chronic toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc mg/L**	**Reference**
Scenedesmus subspicatus	Green algae	Plant NOEC	GRO	Biomass	4	100	QSAR 2013

Terrestrial Ecotoxicological Data

Common Name	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc**	**Reference**	**Units**
Rat	Mammalian LD50	MOR	Mortality		4500	HSDB 2007	mg/kg
Mouse	Mammalian LD50	MOR	Mortality		2400	HSDB 2007	mg/kg
Rabbit	Mammalian LD50	MOR	Mortality		2200	HSDB 2007	mg/kg
Guinea pig	Mammalian LD50	MOR	Mortality		2000	HSDB 2007	mg/kg

Common Name	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc**	**Reference**	**Units**
Earthworm	1	MOR	Mortality	14	424	ECOSAR 2012	mg/L

Created By: Naomi Cooper Date: 10/11/2013

Checked By: Carolyn Brumley Date: 11/11/2013

Project number: 127666004

ORGANIC

Name	Tetraethylenepentamine
Synonyms	Tetren; 1,2-ethanediamine, N-(2-aminoethyl)-N'-(2-((2-aminotheyl)amino)ethyl)-
CAS Number	112-57-2
Molecular Formula	C8H23N5

Physical Properties	Value	Reference
PhaseState:	Viscous hygroscopic liquid	HSDB 2003
Molecular Weight (g/mol):	189.31	HSDB 2003
Melting Point (°C):	-30.00	HSDB 2003
Boiling Point (°C):	340.3	HSDB 2003
Density / Specific Gravity (g/L):	1.00	HSDB 2003
Vapour Pressure (mm Hg at 25°C):	8.00E-07	HSDB 2003
Solubility (mg/L):	6.54E+06	HSDB 2003
Henry's Law Constant (atm m³/mole):	3.00E-20	HSDB 2003
Organic carbon partition coefficient (Koc):	1.28	HSDB 2003
Log organic carbon partition coefficient (log Koc):	3.60	HSDB 2003
Log octanol - water partition coefficient (log Kow):	-1.503	HSDB 2003

Persistance / Bioaccumulation	Value	Reference
Biowin 3 (Ultimate Survey Biodegradation):	2.903	EPISUITE 2011 v4.1
Biowin 4 (Primary Biodegradation):	3.791	EPISUITE 2011 v4.1
EPISUITE Ready Biodegradability:	Biodegrades fast	EPISUITE 2011 v4.1
Biowin 7 (Anaerobic Model Prediction):	1.9305	EPISUITE 2011 v4.1
Fugacity_Air: (%)	7.45E-16	EPISUITE 2011 v4.1
Fugacity_Water: (%)	18	EPISUITE 2011 v4.1
Fugacity_Soil: (%)	82	EPISUITE 2011 v4.1
Fugacity_Sediment: (%)	0.155	EPISUITE 2011 v4.1
Bioconcentration factor (BCF):	4.2	EPISUITE 2011 v4.1
Biotransformation half - life (Days):	0.1711	EPISUITE 2011 v4.1

Project number: 127666004

ORGANIC

Aquatic Ecotoxicological Data

Acute toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc mg/L**	**Reference**
Pimephales promelas	Fathead minnow	Fish LC50	MOR	Mortality	4	310	OECD SIDS 2001
Daphnia magna	Water flea	Invertebrate LC50	MOR	Mortality	2	14.6	OECD SIDS 2001
	Green algae	Plant EC50	GRO	Growth	3	2.1	OECD SIDS 2001

Terrestrial Ecotoxicological Data

Common Name	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc**	**Reference**	**Units**
Rat	Mammalian LD50	MOR	Mortality		2100	HSDB 2003	mg/kg

Created By: Naomi Cooper Date: 6/11/2013

Checked By: Carolyn Brumley Date: 8/11/2013

Project number: 127666004

ORGANIC

Name	Disodium ethylene diamine tetra acetate (Surrogate for)
Synonyms	Cheladrate, Disodium EDTA, Sodium versenate
CAS Number	139-33-3
Molecular Formula	C10H14N2Na2O8

Physical Properties	Value	Reference
PhaseState:	Solid - crystals, powder	HSDB 2012
Molecular Weight (g/mol):	336.21	HSDB 2012
Melting Point (°C):	335.19	EPISUITE 2011 v4.1
Boiling Point (°C):	693.42	EPISUITE 2011 v4.1
Density / Specific Gravity (Enter Unit):		
Vapour Pressure (mm Hg at 25°C):	7.57E-17	HSDB 2012
Solubility (mg/L):	1.08E+05	HSDB 2012
Henry's Law Constant (atm m³/mole):	1.18E-23	EPISUITE 2011 v4.1
Organic carbon partition coefficient (Koc):	312.70	EPISUITE 2011 v4.1
Log organic carbon partition coefficient (log Koc):	2.50	EPISUITE 2011 v4.1
Log octanol - water partition coefficient (log Kow):	-11.7	EPISUITE 2011 v4.1

Persistance / Bioaccumulation	Value	Reference
Biowin 3 (Ultimate Survey Biodegradation):	3.5022	EPISUITE 2011 v4.1
Biowin 4 (Primary Biodegradation):	4.3924	EPISUITE 2011 v4.1
EPISUITE Ready Biodegradability:	Biodegrades fast	EPISUITE 2011 v4.1
Biowin 7 (Anaerobic Model Prediction):	-0.4106	EPISUITE 2011 v4.1
Fugacity_Air: (%)	0.00000000355	EPISUITE 2011 v4.1
Fugacity_Water: (%)	19	EPISUITE 2011 v4.1
Fugacity_Soil: (%)	81	EPISUITE 2011 v4.1
Fugacity_Sediment: (%)	0.198	EPISUITE 2011 v4.1
Bioconcentration factor (BCF):	3.162	EPISUITE 2011 v4.1
Biotransformation half - life (Days):	0.0000569	EPISUITE 2011 v4.1

Project number: 127666004

ORGANIC

Aquatic Ecotoxicological Data

Acute toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc mg/L**	**Reference**
Lepomis macrochirus	Blue gill	Fish LC50	MOR	Mortality	4	41	ECHA 2012
Daphnia magna	Water flea	Invertebrate LC50	MOR	Mortality	2	140	ECHA 2012
Desmodesumus subspicatus	Green algae	Plant EC50	GRO	Growth	3	2.77	ECHA 2012

Chronic toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc mg/L**	**Reference**
Daphnia magna	Water flea	Invertebrate NOEC	REP	Reproduction	21	25	ECHA 2012
Daphnia magna	Water flea	Invertebrate LOEC	REP	Reproduction	21	50	ECHA 2012
Desmodesumus subspicatus	Green algae	Plant NOEC	GRO	Growth rate	3	0.39	ECHA 2012
Desmodesumus subspicatus	Green algae	Plant LOEC	GRO	Growth rate	3	0.78	ECHA 2012

Terrestrial Ecotoxicological Data

Common Name	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc**	**Reference**	**Units**
Mouse	Mammalian LD50	MOR	Mortality		400	HSDB 2012	mg/kg
Rat	Mammalian LD50	MOR	Mortality		2000	HSDB 2012	mg/kg

Created By: Naomi Cooper Date: 7/09/2013

Checked By: Kirsten Broadgate Date: 9/09/2013

Project number: 127666004

ORGANIC

Name	Trisodium ethylene diamine tetra acetate (impurity)
Synonyms	Edetate trisodium, Trisodium EDTA, Trisodium versenate
CAS Number	150-38-9
Molecular Formula	C10H13N2O8Na3

Physical Properties	Value	Reference
PhaseState:		
Molecular Weight (g/mol):	358.19	EPISUITE 2011 v4.1
Melting Point (°C):	335.12	EPISUITE 2011 v4.1
Boiling Point (°C):	692.95	EPISUITE 2011 v4.1
Density / Specific Gravity (Enter Unit):		
Vapour Pressure (mm Hg at 25°C):	7.81E-17	EPISUITE 2011 v4.1
Solubility (mg/L):	1.00E+06	EPISUITE 2011 v4.1
Henry's Law Constant (atm m³/mole):	1.18E-23	EPISUITE 2011 v4.1
Organic carbon partition coefficient (Koc):	312.70	EPISUITE 2011 v4.1
Log organic carbon partition coefficient (log Koc):	2.50	EPISUITE 2011 v4.1
Log octanol - water partition coefficient (log Kow):	-13.15	EPISUITE 2011 v4.1

Persistance / Bioaccumulation	Value	Reference
Biowin 3 (Ultimate Survey Biodegradation):	3.5022	EPISUITE 2011 v4.1
Biowin 4 (Primary Biodegradation):	4.3924	EPISUITE 2011 v4.1
EPISUITE Ready Biodegradability:	Biodegrades fast	EPISUITE 2011 v4.1
Biowin 7 (Anaerobic Model Prediction):	-0.4106	EPISUITE 2011 v4.1
Fugacity_Air: (%)	0.00000000345	EPISUITE 2011 v4.1
Fugacity_Water: (%)	19	EPISUITE 2011 v4.1
Fugacity_Soil: (%)	81	EPISUITE 2011 v4.1
Fugacity_Sediment: (%)	0.198	EPISUITE 2011 v4.1
Bioconcentration factor (BCF):	3.162	EPISUITE 2011 v4.1
Biotransformation half - life (Days):	0.00002082	EPISUITE 2011 v4.1

Project number: 127666004

ORGANIC

Terrestrial Ecotoxicological Data

Common Name	Endpoint	Effect	Effect Measure	Test Time (Days)	Conc	Reference	Units
Rat	Mammalian LD50	MOR	Mortality		2150	ChemIDPlus 201	mg/kg
Mouse	Mammalian LD50	MOR	Mortality		2150	ChemIDPlus 201	mg/kg

Created By: Naomi Cooper Date: 9/09/2013

Checked By: Kirsten Broadgate Date: 10/09/2013

Project number: 127666004

ORGANIC

Name	Decyldimethyl amine
Synonyms	N,N-Dimethyldecylamine
CAS Number	1120-24-7
Molecular Formula	C12H27N

Physical Properties	Value	Reference
PhaseState:	Liquid	ECHA 2013
Molecular Weight (g/mol):	185.36	EPISUITE 2011 v4.0
Melting Point (°C):	-33.00	ECHA 2013
Boiling Point (°C):	237	ECHA 2013
Density / Specific Gravity (mg/L):	0.78	ECHA 2013
Vapour Pressure (mm Hg at 25°C):	8.25E-02	ECHA 2013
Solubility (mg/L):	8.22E+01	EPISUITE 2011 v4.0
Henry's Law Constant (atm m³/mole):	4.68E-04	EPISUITE 2011 v4.0
Organic carbon partition coefficient (Koc):	1,699.00	EPISUITE 2011 v4.0
Log organic carbon partition coefficient (log Koc):	3.23	EPISUITE 2011 v4.0
Log octanol - water partition coefficient (log Kow):	4.46	EPISUITE 2011 v4.0

Persistance / Bioaccumulation	Value	Reference
Biowin 3 (Ultimate Survey Biodegradation):	2.8331	EPISUITE 2011 v4.0
Biowin 4 (Primary Biodegradation):	3.5614	EPISUITE 2011 v4.0
EPISUITE Ready Biodegradability:	Biodegrades fast	EPISUITE 2011 v4.0
Biowin 7 (Anaerobic Model Prediction):	-0.5613	EPISUITE 2011 v4.0
Fugacity_Air: (%)	0.623	EPISUITE 2011 v4.0
Fugacity_Water: (%)	19	EPISUITE 2011 v4.0
Fugacity_Soil: (%)	80	EPISUITE 2011 v4.0
Fugacity_Sediment: (%)	1.05	EPISUITE 2011 v4.0
Bioconcentration factor (BCF):	17.16	
Biotransformation half - life (Days):	0.3648	

Project number: 127666004

ORGANIC

Aquatic Ecotoxicological Data

Acute toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc mg/L**	**Reference**
Oncorynchus mykiss	Rainbow trout	Fish LC50	MOR	Mortality	4	0.18	ECHA 2013
Daphnia maga	Water flea	Invertebrate LC50	MOR	Mortality	2	0.0558	ECHA 2013
Scenedesmus subspicatas	Green algae	Plant EC50	MOR	Mortality	3	0.006	ECHA 2013

Chronic toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc mg/L**	**Reference**
Daphnia magna	Water flea	Invertebrate NOEC	REP	Reproduction	21	0.036	ECHA 2013
Scenedesmus subspicatas	Green algae	Plant NOEC	GRO	Growth	3	0.0005	ECHA 2013

Created By: Naomi Cooper Date: 13/11/2013

Checked By: Carolyn Brumley Date: 15/11/2013

Project number: 127666004

ORGANIC

Name	Decyl-dimethyl amine oxide
Synonyms	N,N-dimethyldecylamine N-oxide
CAS Number	2605-79-0
Molecular Formula	C12H27NO

Physical Properties	Value	Reference
PhaseState:	Solid	ECHA 2013
Molecular Weight (g/mol):	201.36	EPISUITE 2011 v4.0
Melting Point (°C):	133.00	ECHA 2013
Boiling Point (°C):	403.41	EPISUITE 2011 v4.0
Density / Specific Gravity (g/L at 23oC	0.72	ECHA 2013
Vapour Pressure (mm Hg at 25°C):	5.63E-07	ECHA 2013
Solubility (mg/L):	3.04E+01	EPISUITE 2011 v4.0
Henry's Law Constant (atm m^3/mole):	3.67E-10	EPISUITE 2011 v4.0
Organic carbon partition coefficient (Koc):	2,408.00	EPISUITE 2011 v4.0
Log organic carbon partition coefficient (log Koc):	3.38	EPISUITE 2011 v4.0
Log octanol - water partition coefficient (log Kow):	3.69	EPISUITE 2011 v4.0

Persistance / Bioaccumulation	Value	Reference
Biowin 3 (Ultimate Survey Biodegradation):	3.0525	EPISUITE 2011 v4.0
Biowin 4 (Primary Biodegradation):	3.8263	EPISUITE 2011 v4.0
EPISUITE Ready Biodegradability:	Biodegrades fast	EPISUITE 2011 v4.0
Biowin 7 (Anaerobic Model Prediction):	0.0758	EPISUITE 2011 v4.0
Fugacity_Air: (%)	0.00074	EPISUITE 2011 v4.0
Fugacity_Water: (%)	16	EPISUITE 2011 v4.0
Fugacity_Soil: (%)	83	EPISUITE 2011 v4.0
Fugacity_Sediment: (%)	1.23	EPISUITE 2011 v4.0
Bioconcentration factor (BCF):	126.5	EPISUITE 2011 v4.0
Biotransformation half - life (Days):	1.17	EPISUITE 2011 v4.0

Project number: 127666004

ORGANIC

Aquatic Ecotoxicological Data

Acute toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc mg/L**	**Reference**
Danio rerio	Zebra fish	Fish LC50	MOR	Mortality	4	2.4	ECHA 2013
Daphnia magna	Water flea	Invertebrate LC50	MOR	Mortality	2	2.64	ECHA 2013
Selenastrum capricornutum	Green algae	Plant EC50	MOR	Mortality	3	0.015	ECHA 2013

Chronic toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc mg/L**	**Reference**
Pimephales promelas	Fathead minnow	Fish NOEC	GRO	Growth	302	0.42	ECHA 2013
Daphnia magna	Water flea	Invertebrate NOEC	REP	Reproduction	21	0.7	ECHA 2013
Selenastrum capricornutum	Green algae	Plant NOEC	GRO	Growth	72	0.003	ECHA 2013
Pimephales promelas	Fathead minnow	Fish LOEC	GRO	Growth	302	0.88	ECHA 2013

Created By: Naomi Cooper Date: 13/11/2013

Checked By: Carolyn Brumley Date: 15/11/2013

Project number: 127666004

ORGANIC

Name	2-methyl-2h-isothiazol-3-one
Synonyms	2-methyl-4-isothizaolin-3-one
CAS Number	2682-20-4
Molecular Formula	C4H5NOS

Physical Properties	Value	Reference
PhaseState:		
Molecular Weight (g/mol):	115.15	ChemIDPlus2012
Melting Point (°C):	47.50	EPISUITE 2011 v4.1
Boiling Point (°C):	237.8	EPISUITE 2011 v4.1
Density / Specific Gravity (Enter Unit):		
Vapour Pressure (mm Hg at 25°C):	3.10E-02	EPISUITE 2011 v4.1
Solubility (mg/L):	5.37E+05	EPISUITE 2011 v4.1
Henry's Law Constant (atm m³/mole):	4.96E-08	EPISUITE 2011 v4.1
Organic carbon partition coefficient (Koc):	12.08	EPISUITE 2011 v4.1
Log organic carbon partition coefficient (log Koc):	1.08	EPISUITE 2011 v4.1
Log octanol - water partition coefficient (log Kow):	-0.83	EPISUITE 2011 v4.1

Persistance / Bioaccumulation	Value	Reference
Biowin 3 (Ultimate Survey Biodegradation):	2.9447	EPISUITE 2011 v4.1
Biowin 4 (Primary Biodegradation):	3.6816	EPISUITE 2011 v4.1
EPISUITE Ready Biodegradability:	Does not biodegrade fast	EPISUITE 2011 v4.1
Biowin 7 (Anaerobic Model Prediction):	0.6095	EPISUITE 2011 v4.1
Fugacity_Air: (%)	0.519	EPISUITE 2011 v4.1
Fugacity_Water: (%)	34	EPISUITE 2011 v4.1
Fugacity_Soil: (%)	65	EPISUITE 2011 v4.1
Fugacity_Sediment: (%)	0.0797	EPISUITE 2011 v4.1
Bioconcentration factor (BCF):	3.162	EPISUITE 2011 v4.1
Biotransformation half - life (Days):	0.02263	EPISUITE 2011 v4.1

Project number: 127666004

ORGANIC

Aquatic Ecotoxicological Data

Acute toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc mg/L**	**Reference**
Oncorhynchus mykiss	Rainbow trout	Fish LC50	MOR	Mortality	4	0.07	ECOTOX 2012

Created By: Naomi Cooper Date: 17/12/2013

Checked By: Kirsten Broadgate Date: 17/12/2013

Project number: 127666004

ORGANIC

Name	Sodium glycolate (impurity)
Synonyms	
CAS Number	2836-32-0
Molecular Formula	C2H303Na

Physical Properties	Value	Reference
PhaseState:		
Molecular Weight (g/mol):	98.03	EPISUITE 2011 v4.1
Melting Point (°C):	174.37	EPISUITE 2011 v4.1
Boiling Point (°C):	435.8	EPISUITE 2011 v4.1
Density / Specific Gravity (Enter Unit):		
Vapour Pressure (mm Hg at 25°C):	4.58E-10	EPISUITE 2011 v4.1
Solubility (mg/L):	1.00E+06	EPISUITE 2011 v4.1
Henry's Law Constant (atm m³/mole):	8.58E-08	EPISUITE 2011 v4.1
Organic carbon partition coefficient (Koc):	1.00	EPISUITE 2011 v4.1
Log organic carbon partition coefficient (log Koc):	0.00	EPISUITE 2011 v4.1
Log octanol - water partition coefficient (log Kow):	-5.19	EPISUITE 2011 v4.1

Persistance / Bioaccumulation	Value	Reference
Biowin 3 (Ultimate Survey Biodegradation):	3.5557	EPISUITE 2011 v4.1
Biowin 4 (Primary Biodegradation):	4.2530	EPISUITE 2011 v4.1
EPISUITE Ready Biodegradability:	Biodegrades fast	EPISUITE 2011 v4.1
Biowin 7 (Anaerobic Model Prediction):	1.1816	EPISUITE 2011 v4.1
Fugacity_Air: (%)	2.36	EPISUITE 2011 v4.1
Fugacity_Water: (%)	35	EPISUITE 2011 v4.1
Fugacity_Soil: (%)	63	EPISUITE 2011 v4.1
Fugacity_Sediment: (%)	0.0616	EPISUITE 2011 v4.1
Bioconcentration factor (BCF):	3.162	EPISUITE 2011 v4.1
Biotransformation half - life (Days):	0.006808	EPISUITE 2011 v4.1

Project number: 127666004

ORGANIC

Aquatic Ecotoxicological Data

Acute toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc mg/L**	**Reference**
	Fish	Fish LC50	MOR	Mortality	4	3.50E+05	ECOSAR 2012
	Daphnid	Invertebrate LC50	MOR	Mortality	2	1.52E+05	ECOSAR 2012
	Green algae	Plant EC50	MOR	Mortality	4	3.51E+04	ECOSAR 2012

Terrestrial Ecotoxicological Data

Common Name	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc**	**Reference**	**Units**
Rat	Mammalian LD50	MOR	Mortality		7110	ChemIDPlus 201	mg/kg
Mouse	Mammalian LD50	MOR	Mortality		6700	ChemIDPlus 201	mg/kg

Common Name	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc**	**Reference**	**Units**
Earthworm	1	Mor	Mortality	14	2750	ECOSAR 2012	mg/L

Created By: Naomi Cooper Date: 7/09/2013

Checked By: Kirsten Broadgate Date: 9/09/2013

Project number: 127666004

ORGANIC

Name	Pentaethylenehexamine
Synonyms	3,6,9,12-Tetraazatetradecane-1,14-diamine
CAS Number	4067-16-7
Molecular Formula	C10H28N6

Physical Properties	Value	Reference
PhaseState:	Liquid	ECHA 2012
Molecular Weight (g/mol):	232.38	ECHA 2012
Melting Point (°C):	-70.00	ECHA 2012
Boiling Point (°C):	426	ECHA 2012
Density / Specific Gravity (g/L at 20oC	1,003.00	ECHA 2012
Vapour Pressure (mm Hg at 25°C):	1.26E-05	ECHA 2012
Solubility (mg/L):	1.00E+06	EPISUITE 2011 v4.1
Henry's Law Constant (atm m³/mole):	8.36E-24	EPISUITE 2011 v4.1
Organic carbon partition coefficient (Koc):	396.40	EPISUITE 2011 v4.1
Log organic carbon partition coefficient (log Koc):	2.60	EPISUITE 2011 v4.1
Log octanol - water partition coefficient (log Kow):	-3.67	ECHA 2012

Persistance / Bioaccumulation	Value	Reference
Biowin 3 (Ultimate Survey Biodegradation):	2.8323	EPISUITE 2011 v4.1
Biowin 4 (Primary Biodegradation):	3.7722	EPISUITE 2011 v4.1
EPISUITE Ready Biodegradability:	Biodegrades fast	EPISUITE 2011 v4.1
Biowin 7 (Anaerobic Model Prediction):	2.1597	EPISUITE 2011 v4.1
Fugacity_Air: (%)	4.59E-20	EPISUITE 2011 v4.1
Fugacity_Water: (%)	17	EPISUITE 2011 v4.1
Fugacity_Soil: (%)	83	EPISUITE 2011 v4.1
Fugacity_Sediment: (%)	0.275	EPISUITE 2011 v4.1
Bioconcentration factor (BCF):	3.162	EPISUITE 2011 v4.1
Biotransformation half - life (Days):	0.2631	EPISUITE 2011 v4.1

Project number: 127666004

ORGANIC

Aquatic Ecotoxicological Data

Acute toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc mg/L**	**Reference**
Poecilia reticulata	Guppy	Fish LC50	MOR	Mortality	4	180	ECHA 2012
Daphnia magna	Water flea	Invertebrate LC50	MOR	Mortality	2	17.5	ECHA 2012
Selenastrum capricornutum	Green algae	Plant EC50	GRO	Growth rate	3	0.7	ECHA 2012

Chronic toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc mg/L**	**Reference**
Selenastrum capricornutum	Green algae	Plant NOEC	GRO	Growth rate	3	0.25	ECHA 2012

Terrestrial Ecotoxicological Data

Common Name	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc**	**Reference**	**Units**
Rat	Mammalian LD50	MOR	Mortality		1600	ChemIDPlus201	mg/kg

Created By: Naomi Cooper Date: 10/11/2013

Checked By: Carolyn Brumley Date: 11/11/2013

Project number: 127666004

ORGANIC

Name	Trisodium nitriloacetate (impurity)
Synonyms	Sodium nitriloacetate, Trisodium NTA
CAS Number	5064-31-3
Molecular Formula	C6H6N1O6Na3

Physical Properties	Value	Reference
PhaseState:		
Molecular Weight (g/mol):	257.09	EPISUITE 2011 v4.1
Melting Point (°C):	199.47	EPISUITE 2011 v4.1
Boiling Point (°C):	487.76	EPISUITE 2011 v4.1
Density / Specific Gravity (Enter Unit):		
Vapour Pressure (mm Hg at 25°C):	8.08E-10	EPISUITE 2011 v4.1
Solubility (mg/L):	1.00E+06	EPISUITE 2011 v4.1
Henry's Law Constant (atm m³/mole):	1.21E-16	EPISUITE 2011 v4.1
Organic carbon partition coefficient (Koc):	26.27	EPISUITE 2011 v4.1
Log organic carbon partition coefficient (log Koc):	1.42	EPISUITE 2011 v4.1
Log octanol - water partition coefficient (log Kow):	-10.08	EPISUITE 2011 v4.1

Persistance / Bioaccumulation	Value	Reference
Biowin 3 (Ultimate Survey Biodegradation):	3.6158	EPISUITE 2011 v4.1
Biowin 4 (Primary Biodegradation):	4.4407	EPISUITE 2011 v4.1
EPISUITE Ready Biodegradability:	Biodegrades fast	EPISUITE 2011 v4.1
Biowin 7 (Anaerobic Model Prediction):	0.3995	EPISUITE 2011 v4.1
Fugacity_Air: (%)	0.0000000838	EPISUITE 2011 v4.1
Fugacity_Water: (%)	24	EPISUITE 2011 v4.1
Fugacity_Soil: (%)	76	EPISUITE 2011 v4.1
Fugacity_Sediment: (%)	0.0653	EPISUITE 2011 v4.1
Bioconcentration factor (BCF):	3.162	EPISUITE 2011 v4.1
Biotransformation half - life (Days):	0.0000837	EPISUITE 2011 v4.1

Project number: 127666004

ORGANIC

Aquatic Ecotoxicological Data

Acute toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc mg/L**	**Reference**
Carassius auratus	Goldfish	Fish LC50	MOR	Mortality	4	257	ECOTOX 2012
Navicula seminulum	Diatom	Plant EC50	MOR	Mortality	4	185	ECOTOX 2012

Chronic toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc mg/L**	**Reference**
Daphnia magna	Water flea	Invertebrate NOEC	MOR	Mortality	21	100	ECOTOX 2012

Terrestrial Ecotoxicological Data

Common Name	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc**	**Reference**	**Units**
Rat	Mammalian LD50	MOR	Mortality		1100	HSDB 2012	mg/kg
Mouse	Mammalian LD50	MOR	Mortality		681	HSDB 2012	mg/kg

Created By: Naomi Cooper Date: 9/09/2013

Checked By: Kirsten Broadgate Date: 10/09/2013

Project number: 127666004

ORGANIC

Name	Polyethylene glycol sorbitan monolaurate
Synonyms	Polyethylene glycol sorbitan laurate, Polysorbate 20
CAS Number	9005-64-5
Molecular Formula	C58-H114-O26 (C48-H94O21)

Physical Properties	Value	Reference
PhaseState:	Liquid	HSDB 2012
Molecular Weight (g/mol):	1288	HSDB 2012
Melting Point (°C):	349.84	EPISUITE
Boiling Point (°C):	1001.79	EPISUITE
Density / Specific Gravity (g/mL at 25	1.10	HSDB 2012
Vapour Pressure (mm Hg at 25°C):	8.65E-33	EPISUITE
Solubility (mg/L):	1.10E+06	EPISUITE
Henry's Law Constant (atm m³/mole):	2.19E-40	EPISUITE
Organic carbon partition coefficient (Koc):	239,700,000.00	EPISUITE
Log organic carbon partition coefficient (log Koc):	8.38	EPISUITE
Log octanol - water partition coefficient (log Kow):	-2.03	EPISUITE 2011 v4.1

Persistance / Bioaccumulation	Value	Reference
Biowin 3 (Ultimate Survey Biodegradation):	1.753	EPISUITE
Biowin 4 (Primary Biodegradation):	3.125	EPISUITE
EPISUITE Ready Biodegradability:	Does not biodegrade fast	EPISUITE
Biowin 7 (Anaerobic Model Prediction):	-2.209	EPISUITE
Fugacity_Air: (%)	0.0000000000301	EPISUITE
Fugacity_Water: (%)	1	EPISUITE
Fugacity_Soil: (%)	42	EPISUITE
Fugacity_Sediment: (%)	57.3	EPISUITE
Bioconcentration factor (BCF):	3.162	EPISUITE
Biotransformation half - life (Days):	0.039	EPISUITE

Project number: 127666004

ORGANIC

Aquatic Ecotoxicological Data

Acute toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc mg/L**	**Reference**
Poecilia reticula	Guppy	Fish LC50	MOR	MORT	1	350	ECOTOX 2012

Terrestrial Ecotoxicological Data

Common Name	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc**	**Reference**	**Units**
Hamster	Mammalian LD50	MOR	MORT		18000 mg/kg	HSDB 2012	
Earthworm	Mammalian LD50	MOR	MORT	14	261000	ECOSAR 2012	

Created By: Naomi Cooper Date: 4/09/2012

Checked By: Kirsten Broadgate Date: 19/09/2012

Project number: 127666004

ORGANIC

Name	5-chloro-2-methyl-2h-isothiazol-3-one
Synonyms	Methylchloroisothiazolinone
CAS Number	26172-55-4
Molecular Formula	C4H4ClNOS

Physical Properties	Value	Reference
PhaseState:		
Molecular Weight (g/mol):	149.6	EPISUITE 2011 v4.1
Melting Point (°C):	50.00	IUCLID 2000
Boiling Point (°C):	106.5	IUCLID 2000
Density / Specific Gravity (g/L at 20oC	1.26	IUCLID 2000
Vapour Pressure (mm Hg at 25°C):	1.56E+01	IUCLID 2000
Solubility (mg/L):	1.49E+05	IUCLID 2000
Henry's Law Constant (atm m³/mole):	3.57E-08	EPISUITE 2011 v4.1
Organic carbon partition coefficient (Koc):	19.38	EPISUITE 2011 v4.1
Log organic carbon partition coefficient (log Koc):	1.29	EPISUITE 2011 v4.1
Log octanol - water partition coefficient (log Kow):	-0.34	EPISUITE 2011 v4.1

Persistance / Bioaccumulation	Value	Reference
Biowin 3 (Ultimate Survey Biodegradation):	2.6954	EPISUITE 2011 v4.1
Biowin 4 (Primary Biodegradation):	3.5313	EPISUITE 2011 v4.1
EPISUITE Ready Biodegradability:	Does not biodegrade fast	EPISUITE 2011 v4.1
Biowin 7 (Anaerobic Model Prediction):	0.6683	EPISUITE 2011 v4.1
Fugacity_Air: (%)	0.251	EPISUITE 2011 v4.1
Fugacity_Water: (%)	32	EPISUITE 2011 v4.1
Fugacity_Soil: (%)	67	EPISUITE 2011 v4.1
Fugacity_Sediment: (%)	0.0918	EPISUITE 2011 v4.1
Bioconcentration factor (BCF):	3.162	EPISUITE 2011 v4.1
Biotransformation half - life (Days):	0.04781	EPISUITE 2011 v4.1

Project number: 127666004

ORGANIC

Aquatic Ecotoxicological Data

Acute toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc mg/L**	**Reference**
Oncorynchus mykiss	Rainbow trout	Fish LC50	MOR	Mortality	4	0.190	ECOTOX 2012
Daphnia magna	Water flea	Invertebrate LC50	MOR	Mortality	2	4.71	IUCLID 2000
Anabaena flos-aquae	Algae	Plant EC50	GRO	Growth	5	0.31	IUCLID 2000

Chronic toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc mg/L**	**Reference**
Oncorynchus mykiss	Rainbow trout	Fish NOEC	GRO	Growth	14	0.05	ECOTOX 2012
Daphnia magna	Water flea	Invertebrate NOEC	REP	Reproduction	21	0.172	IUCLID 2000
Daphnia magna	Water flea	Invertebrate LOEC	REP	Reproduction	21	0.572	IUCLID 2000

Terrestrial Ecotoxicological Data

Common Name	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc**	**Reference**	**Units**
Rat	Mammalian LD50	MOR	Mortality		481	IUCLID 2000	mg/kg

Common Name	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc**	**Reference**	**Units**
Earthworm	1	MOR	Mortality		278	ECOSAR 2012	mg/L

Created By: Naomi Cooper Date: 17/12/2013

Checked By: Kirsten Broadgate Date: 17/12/2013

Project number: 127666004

ORGANIC

Name	Polyethylene glycol monohexyl ether
Synonyms	
CAS Number	31726-34-8
Molecular Formula	C16H34O6

Physical Properties	Value	Reference
PhaseState:		
Molecular Weight (g/mol):	322.45	EPISUITE 2011 v4.1
Melting Point (°C):	133.01	EPISUITE 2011 v4.1
Boiling Point (°C):	391.73	EPISUITE 2011 v4.1
Density / Specific Gravity (Enter Unit):		
Vapour Pressure (mm Hg at 25°C):	2.67E-08	EPISUITE 2011 v4.1
Solubility (mg/L):	1.21E+04	EPISUITE 2011 v4.1
Henry's Law Constant (atm m³/mole):	8.68E-19	EPISUITE 2011 v4.1
Organic carbon partition coefficient (Koc):	10.00	EPISUITE 2011 v4.1
Log organic carbon partition coefficient (log Koc):	1.00	EPISUITE 2011 v4.1
Log octanol - water partition coefficient (log Kow):	0.45	EPISUITE 2011 v4.1

Persistance / Bioaccumulation	Value	Reference
Biowin 3 (Ultimate Survey Biodegradation):	2.9016	EPISUITE 2011 v4.1
Biowin 4 (Primary Biodegradation):	3.7323	EPISUITE 2011 v4.1
EPISUITE Ready Biodegradability:	Biodegrades fast	EPISUITE 2011 v4.1
Biowin 7 (Anaerobic Model Prediction):	-0.3249	EPISUITE 2011 v4.1
Fugacity_Air: (%)	0.0000000000718	EPISUITE 2011 v4.1
Fugacity_Water: (%)	31	EPISUITE 2011 v4.1
Fugacity_Soil: (%)	69	EPISUITE 2011 v4.1
Fugacity_Sediment: (%)	0.0688	EPISUITE 2011 v4.1
Bioconcentration factor (BCF):	3.162	EPISUITE 2011 v4.1
Biotransformation half - life (Days):	0.02036	EPISUITE 2011 v4.1

Project number: 127666004

ORGANIC

Aquatic Ecotoxicological Data

Acute toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc mg/L**	**Reference**
	Fish	Fish LC50	MOR	Mortality		0.168	EPISUITE 2011 v4.1
	Daphnid	Invertebrate LC50	MOR	Mortality		0.168	EPISUITE 2011 v4.1

Common Name	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc**	**Reference**	**Units**
Earthworm	1	MOR	Mortality	14d	812	ECOSAR 2012	mg/L

Created By: Naomi Cooper Date: 7/09/2013

Checked By: Kirsten Broadgate Date: 9/09/2013

Project number: 127666004

ORGANIC

Name	Dicoco dimethyl quarternary ammonium chloride
Synonyms	Dicocodimonium chloride
CAS Number	61789-77-3
Molecular Formula	C26H56ClN

Physical Properties	Value	Reference
PhaseState:		
Molecular Weight (g/mol):	418.2	EPISUITE 2011 v4.1
Melting Point (°C):	250.49	EPISUITE 2011 v4.1
Boiling Point (°C):	581.12	EPISUITE 2011 v4.1
Density / Specific Gravity (Enter Unit):		
Vapour Pressure (mm Hg at 25°C):	8.07E-13	EPISUITE 2011 v4.1
Solubility (mg/L):	4.18E-07	EPISUITE 2011 v4.1
Henry's Law Constant (atm m³/mole):	2.13E-09	EPISUITE 2011 v4.1
Organic carbon partition coefficient (Koc):	5,348,000.00	EPISUITE 2011 v4.1
Log organic carbon partition coefficient (log Koc):	6.73	EPISUITE 2011 v4.1
Log octanol - water partition coefficient (log Kow):	6.62	EPISUITE 2011 v4.1

Persistance / Bioaccumulation	Value	Reference
Biowin 3 (Ultimate Survey Biodegradation):	2.8717	EPISUITE 2011 v4.1
Biowin 4 (Primary Biodegradation):	3.7825	EPISUITE 2011 v4.1
EPISUITE Ready Biodegradability:	Biodegrades fast	EPISUITE 2011 v4.1
Biowin 7 (Anaerobic Model Prediction):	0.0164	EPISUITE 2011 v4.1
Fugacity_Air: (%)	0.144	EPISUITE 2011 v4.1
Fugacity_Water: (%)	4	EPISUITE 2011 v4.1
Fugacity_Soil: (%)	31	EPISUITE 2011 v4.1
Fugacity_Sediment: (%)	65.1	EPISUITE 2011 v4.1
Bioconcentration factor (BCF):	70.79	EPISUITE 2011 v4.1
Biotransformation half - life (Days):	10.16	EPISUITE 2011 v4.1

Project number: 127666004

ORGANIC

Aquatic Ecotoxicological Data

Acute toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc mg/L**	**Reference**
Aedes nigromaculis	Mosquito	Invertebrate LC50	MOR	Mortality	1	0.2	ECOTOX 2012
	Fish	Fish LC50	MOR	Mortality	4	269000	ECOSAR 2012

Common Name	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc**	**Reference**	**Units**
Earthworm	1	MOR	Mortality	14	241	ECOSAR 2012	mg/L

Created By: Naomi Cooper Date: 7/09/2013

Checked By: Kirsten Broadgate Date: 9/09/2013

Project number: 127666004

ORGANIC

Name	Alkyl (C12-C16) dimethylbenzyl ammonium chloride
Synonyms	Alkyl(C12-16)dimethylbenzylammonium chloride, Ammonium, alkyl(C12-C16)dimethylbenzyl-, chlorides, Benzyl-C12-C16-alkyldimethyl ammonium chlorides, C12-16-Alkyldimethylbenzylammonium chloride
CAS Number	68424-85-1
Molecular Formula	C23H42ClN

Physical Properties	Value	Reference
PhaseState:		
Molecular Weight (g/mol):	368.05	EPISUITE 2011 v4.1
Melting Point (°C):	241.02	EPISUITE 2011 v4.1
Boiling Point (°C):	560.84	EPISUITE 2011 v4.1
Density / Specific Gravity (Enter Unit):		
Vapour Pressure (mm Hg at 25°C):	3.53E-12	EPISUITE 2011 v4.1
Solubility (mg/L):	2.20E+00	EPISUITE 2011 v4.1
Henry's Law Constant (atm m³/mole):	1.34E-11	EPISUITE 2011 v4.1
Organic carbon partition coefficient (Koc):	903,000.00	EPISUITE 2011 v4.1
Log organic carbon partition coefficient (log Koc):	5.96	EPISUITE 2011 v4.1
Log octanol - water partition coefficient (log Kow):	3.91	EPISUITE 2011 v4.1

Persistance / Bioaccumulation	Value	Reference
Biowin 3 (Ultimate Survey Biodegradation):	2.7062	EPISUITE 2011 v4.1
Biowin 4 (Primary Biodegradation):	3.5907	EPISUITE 2011 v4.1
EPISUITE Ready Biodegradability:	Does not biodegrade fast	EPISUITE 2011 v4.1
Biowin 7 (Anaerobic Model Prediction):	-0.0865	EPISUITE 2011 v4.1
Fugacity_Air: (%)	0.0401	EPISUITE 2011 v4.1
Fugacity_Water: (%)	3	EPISUITE 2011 v4.1
Fugacity_Soil: (%)	39	EPISUITE 2011 v4.1
Fugacity_Sediment: (%)	58.8	EPISUITE 2011 v4.1
Bioconcentration factor (BCF):	70.79	EPISUITE 2011 v4.1
Biotransformation half - life (Days):	0.5879	EPISUITE 2011 v4.1

Project number: 127666004

ORGANIC

Aquatic Ecotoxicological Data

Acute toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc mg/L**	**Reference**
Oncorhynchus mykiss	Rainbow Trout	Fish LC50	MOR	Mortality	4	0.064	ECOTOX 2012
Chlorella pyrenoidosa	Green algae	Plant EC50	POP	Population	4	0.67	QSAR 2013

Terrestrial Ecotoxicological Data

Common Name	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc**	**Reference**	**Units**
Rat	Mammalian LD50	MOR	Mortality		426	ChemIDPlus201	mg/kg
Mouse	Mammalian LD50	MOR	Mortality		919	ChemIDPlus201	mg/kg

Common Name	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc**	**Reference**	**Units**
Earthworm	1	MOR	Mortality	14	405.5	ECOSAR 2012	mg/L

Created By: Naomi Cooper Date: 8/11/2013

Checked By: Carolyn Brumley Date: 11/11/2013

Project number: 127666004

ORGANIC

Name	Lactic acid, Surrogate for Polylactide resin (9051-89-2) (Surrogate for)
Synonyms	2-Hydroxypropanoic acid, Lactate, Milk acid, Racemic lactic acid
CAS Number	50-21-5
Molecular Formula	C3H6O3

Physical Properties	Value	Reference
PhaseState:	Crytals or syrupy liquid	HSDB 2006
Molecular Weight (g/mol):	90.09	HSDB 2006
Melting Point (°C):	16.80	HSDB 2006
Boiling Point (°C):	122	HSDB 2006
Density / Specific Gravity (g/L at 25oC	1.20	HSDB 2006
Vapour Pressure (mm Hg at 25°C):	8.13E-02	HSDB 2006
Solubility (mg/L):	1.00E+06	EPISUITE 2011 v4.1
Henry's Law Constant (atm m³/mole):	8.10E-08	HSDB 2006
Organic carbon partition coefficient (Koc):	5.70	HSDB 2006
Log organic carbon partition coefficient (log Koc):	0.76	HSDB 2006
Log octanol - water partition coefficient (log Kow):	-0.72	HSDB 2006

Persistance / Bioaccumulation	Value	Reference
Biowin 3 (Ultimate Survey Biodegradation):	3.5247	EPISUITE 2011 v4.1
Biowin 4 (Primary Biodegradation):	4.2328	EPISUITE 2011 v4.1
EPISUITE Ready Biodegradability:	Biodegrades fast	EPISUITE 2011 v4.1
Biowin 7 (Anaerobic Model Prediction):	0.9102	EPISUITE 2011 v4.1
Fugacity_Air: (%)	1.87	EPISUITE 2011 v4.1
Fugacity_Water: (%)	36	EPISUITE 2011 v4.1
Fugacity_Soil: (%)	62	EPISUITE 2011 v4.1
Fugacity_Sediment: (%)	0.0641	EPISUITE 2011 v4.1
Bioconcentration factor (BCF):	3.162	EPISUITE 2011 v4.1
Biotransformation half - life (Days):	0.02417	EPISUITE 2011 v4.1

Project number: 127666004

ORGANIC

Aquatic Ecotoxicological Data

Acute toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc mg/L**	**Reference**
	Fish	Fish LC50	MOR	Mortality		177000	ECOSAR 2012
Meloidogyne arenaria	Peanut root-knot nematode	Invertebrate LC50	MOR	Mortality	1	4504.5	ECOTOX 2012
	Green algae	Plant EC50	GRO	Growth		21338.494	ECOSAR 2012

Terrestrial Ecotoxicological Data

Common Name	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc**	**Reference**	**Units**
Rat	Mammalian LD50	MOR	Mortality		3730	HSDB 2006	mg/kg
Mouse	Mammalian LD50	MOR	Mortality		4875	HSDB 2006	mg/kg
Guinea Pig	Mammalian LD50	MOR	Mortality		1810	HSDB 2006	mg/kg

Common Name	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc**	**Reference**	**Units**
Earthworm	1	MOR	Mortality	14d	2947.999	ECOSAR 2012	mg/L

Created By: Naomi Cooper Date: 7/09/2013

Checked By: Kirsten Broadgate Date: 9/09/2013

Name	Decanoic acid, Surrogate for Octadecanoic acid, calcium salt (1592-23-0) (Surrogate for)
Synonyms	
CAS Number	57-11-4
Molecular Formula	C18H36O2

Physical Properties	Value	Reference
PhaseState:	Solid	HSDB 2008
Molecular Weight (g/mol):	284.48	HSDB 2008
Melting Point (°C):	69.30	HSDB 2008
Boiling Point (°C):	350	HSDB 2008
Density / Specific Gravity (no units):	0.60	HSDB 2008
Vapour Pressure (mm Hg at 25°C):	4.28E-08	HSDB 2008
Solubility (mg/L):	5.97E-01	
Henry's Law Constant (atm m³/mole):	4.76E-07	HSDB 2008
Organic carbon partition coefficient (Koc):	710,000.00	HSDB 2008
Log organic carbon partition coefficient (log Koc):	5.85	HSDB 2008
Log octanol - water partition coefficient (log Kow):	8.23	HSDB 2008

Persistance / Bioaccumulation	Value	Reference
Biowin 3 (Ultimate Survey Biodegradation):	3.2334	EPISUITE 2011 v4.0
Biowin 4 (Primary Biodegradation):	4.0191	EPISUITE 2011 v4.0
EPISUITE Ready Biodegradability:	Biodegrades fast	EPISUITE 2011 v4.0
Biowin 7 (Anaerobic Model Prediction):	1.0414	EPISUITE 2011 v4.0
Fugacity_Air: (%)	0.878	EPISUITE 2011 v4.0
Fugacity_Water: (%)	23	EPISUITE 2011 v4.0
Fugacity_Soil: (%)	75	EPISUITE 2011 v4.0
Fugacity_Sediment: (%)	0.867	EPISUITE 2011 v4.0
Bioconcentration factor (BCF):	10	EPISUITE 2011 v4.0
Biotransformation half - life (Days):	20.39	EPISUITE 2011 v4.0

Project number: 127666004

ORGANIC

Aquatic Ecotoxicological Data

Acute toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc mg/L**	**Reference**
Oncorhynchus kisutch	Silver salmon	Fish LC50	MOR	Mortality	4	12	ECOTOX 2012

Terrestrial Ecotoxicological Data

Common Name	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc**	**Reference**	**Units**
Rat	Mammalian LD50	MOR	Mortality		4600	HSDB 2008	mg/kg

Common Name	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc**	**Reference**	**Units**
Earthworm	1	MOR	Mortality		1196	ECOSAR 2012	mg/L

Created By: Naomi Cooper Date: 13/11/2013

Checked By: Carolyn Brumley Date: 15/11/2013

Project number: 127666004

ORGANIC

Name	1,1 DCE (Surrogate for Vinylidene Chloride/Methacrylate Copolymer 25038-72-6)
Synonyms	
CAS Number	75-35-4
Molecular Formula	C2H2Cl2

Physical Properties	Value	Reference
PhaseState:	Liquid	HSDB 2011
Molecular Weight (g/mol):	96.94	HSDB 2011
Melting Point (°C):	-122.50	HSDB 2011
Boiling Point (°C):	31.7	HSDB 2011
Density / Specific Gravity (Enter Unit):	1.21	HSDB 2011
Vapour Pressure (mm Hg at 25°C):	6.00E+02	HSDB 2011
Solubility (mg/L):	2.42E+03	HSDB 2011
Henry's Law Constant (atm m^3/mole):	2.61E-02	HSDB 2011
Organic carbon partition coefficient (Koc):	64.00	HSDB 2011
Log organic carbon partition coefficient (log Koc):	1.81	HSDB 2011
Log octanol - water partition coefficient (log Kow):	2.13	HSDB 2011

Persistance / Bioaccumulation	Value	Reference
Biowin 3 (Ultimate Survey Biodegradation):	2.6386	EPISUITE 2011 v4.1
Biowin 4 (Primary Biodegradation):	3.5067	EPISUITE 2011 v4.1
EPISUITE Ready Biodegradability:	Does not biodegrade fast	EPISUITE 2011 v4.1
Biowin 7 (Anaerobic Model Prediction):	0.6597	EPISUITE 2011 v4.1
Fugacity_Air: (%)	20.8	EPISUITE 2011 v4.1
Fugacity_Water: (%)	75	EPISUITE 2011 v4.1
Fugacity_Soil: (%)	4	EPISUITE 2011 v4.1
Fugacity_Sediment: (%)	0.257	EPISUITE 2011 v4.1
Bioconcentration factor (BCF):	11.81	EPISUITE 2011 v4.1
Biotransformation half - life (Days):	0.614	EPISUITE 2011 v4.1

Project number: 127666004

ORGANIC

Aquatic Ecotoxicological Data

Acute toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc mg/L**	**Reference**
Daphnia magna	Water flea	Invertebrate LC50	MOR	Mortality	1	11.6	ECOTOX 2012
Pimephales promelas	Fathead minnow	Fish LC50	MOR	Mortality	7	29	ECOTOX 2012
Chlamydomonas reinhardtii	Green algae	Plant EC50	POP	Biomass	3	9.12	ECOTOX 2012

Chronic toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc mg/L**	**Reference**
Pimephales promelas	Fathead minnow	Fish MATC	GRO	Growth	30	2.8	ECOTOX 2012
	Green algae	Plant NOEC	POP	Biomass	4	56	ECOTOX 2012

Terrestrial Ecotoxicological Data

Common Name	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc**	**Reference**	**Units**
Mouse	Mammalian LD50	MOR	Mortality		194	HSDB 2010	mg/kg

Common Name	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc**	**Reference**	**Units**
Earthworm	1	MOR	Mortality	14	121	ECOSAR 2012	mg/L

Created By: Naomi Cooper Date: 17/12/2013

Checked By: Kirsten Broadgate Date: 17/12/2013

Project number: 127666004

ORGANIC

Name	Gluconic acid, surrogate for Sodium Gluconate (527-07-1) (Surrogate for)
Synonyms	Dextronic acid, Glycogenic acid, Maltonic acid
CAS Number	526-95-4
Molecular Formula	C6H12O7

Physical Properties	Value	Reference
PhaseState:	Solid - crystals	HSDB 2003
Molecular Weight (g/mol):	196.16	HSDB 2003
Melting Point (°C):	131.00	HSDB 2003
Boiling Point (°C):		
Density / Specific Gravity (g/L at 25oC	1.24	HSDB 2003
Vapour Pressure (mm Hg at 25°C):	8.17E+10	EPISUITE 2011 v4.1
Solubility (mg/L):	3.16E+05	EPISUITE 2011 v4.1
Henry's Law Constant (atm m³/mole):	4.74E-13	EPISUITE 2011 v4.1
Organic carbon partition coefficient (Koc):	10.00	EPISUITE 2011 v4.1
Log organic carbon partition coefficient (log Koc):	1.00	EPISUITE 2011 v4.1
Log octanol - water partition coefficient (log Kow):	-1.87	EPISUITE 2011 v4.1

Persistance / Bioaccumulation	Value	Reference
Biowin 3 (Ultimate Survey Biodegradation):	3.9301	EPISUITE 2011 v4.1
Biowin 4 (Primary Biodegradation):	4.5975	EPISUITE 2011 v4.1
EPISUITE Ready Biodegradability:	Biodegrades fast	
Biowin 7 (Anaerobic Model Prediction):	1.0493	
Fugacity_Air: (%)	0.00257	EPISUITE 2011 v4.1
Fugacity_Water: (%)	24	EPISUITE 2011 v4.1
Fugacity_Soil: (%)	76	EPISUITE 2011 v4.1
Fugacity_Sediment: (%)	0.0362	EPISUITE 2011 v4.1
Bioconcentration factor (BCF):	3.162	EPISUITE 2011 v4.1
Biotransformation half - life (Days):	0.0005227	EPISUITE 2011 v4.1

Project number: 127666004

ORGANIC

Common Name	Endpoint	Effect	Effect Measure	Test Time (Days)	Conc	Reference	Units
Earthworm	1	MOR	Mortality	14	8584.013	ECOSAR 2012	mg/L

Created By: Naomi Cooper Date: 7/09/2013

Checked By: Kirsten Broadgate Date: 9/09/2013

Project number: 127666004

ORGANIC

Name	2-Acrylamido-2-methylpropanesulfonic acid, sodium salt, surrogate for Acrylamide, 2-acrylamido-2-methylpropanesulfonic acid, sodium salt polymer (38193-60-1)
Synonyms	
CAS Number	5165-97-9
Molecular Formula	C7H12NNaO4S

Physical Properties	Value	Reference
PhaseState:	Solid	USEPA 2009
Molecular Weight (g/mol):	229.23	USEPA 2009
Melting Point (°C):	260.35	USEPA 2009
Boiling Point (°C):		
Density / Specific Gravity (Enter Unit):		
Vapour Pressure (mm Hg at 25°C):	1.72E-13	USEPA 2009
Solubility (mg/L):	1.00E+06	USEPA 2009
Henry's Law Constant (atm m³/mole):	5.20E-20	EPISUITE 2011 v4.1
Organic carbon partition coefficient (Koc):	10.00	EPISUITE 2011 v4.1
Log organic carbon partition coefficient (log Koc):	1.00	EPISUITE 2011 v4.1
Log octanol - water partition coefficient (log Kow):	-4.34	USEPA 2009

Persistance / Bioaccumulation	Value	Reference
Biowin 3 (Ultimate Survey Biodegradation):	2.6674	EPISUITE 2011 v4.1
Biowin 4 (Primary Biodegradation):	3.7779	EPISUITE 2011 v4.1
EPISUITE Ready Biodegradability:	Does not biodegrade fast	
Biowin 7 (Anaerobic Model Prediction):	-0.4197	EPISUITE 2011 v4.1
Fugacity_Air: (%)	0.00151	EPISUITE 2011 v4.1
Fugacity_Water: (%)	35	EPISUITE 2011 v4.1
Fugacity_Soil: (%)	65	EPISUITE 2011 v4.1
Fugacity_Sediment: (%)	0.0836	EPISUITE 2011 v4.1
Bioconcentration factor (BCF):	3.162	
Biotransformation half - life (Days):	0.001495	

Project number: 127666004

ORGANIC

Aquatic Ecotoxicological Data

Acute toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc mg/L**	**Reference**
Lepomis macrochirus	Bluegill	Fish LC50	Mortality	Mortality	4	>1000	USEPA 2009
Daphnia magna	Cladoceran	Invertebrate EC50	Mortality	Mortality	2	>1000	USEPA 2009
Pseudokirchneriella subcapitata	Green Algae	Plant EC50	GRO	Growth	4	>2000	USEPA 2009

Chronic toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc mg/L**	**Reference**
Selenastrum capricornutum	Green Algae	Plant NOEC	GRO	Growth	4	2000	QSAR 2013

Common Name	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc**	**Reference**	**Units**
Sprague-Dawley Rats	2	Mortality	Mortality	14	>16000	USEPA 2009	

Created By: Naomi Cooper Date: 2/07/2013

Checked By: Kirsten Broadgate Date: 2/07/2013

Project number: 127666004

ORGANIC

Name	Hydroxypropyl methylcellulose, surrogate for Hydroxypropyl cellulose (9004-64-2)
Synonyms	2-Hydroxypropyl cellusloe methyl ether; Hypromellose
CAS Number	9004-65-3
Molecular Formula	C20H38O12

Physical Properties	Value	Reference
PhaseState:		
Molecular Weight (g/mol):	470.52	EPISUITE 2011 v4.0
Melting Point (°C):	288.23	EPISUITE 2011 v4.0
Boiling Point (°C):	661.91	EPISUITE 2011 v4.0
Density / Specific Gravity (Enter Unit):		
Vapour Pressure (mm Hg at 25°C):	7.89E-20	EPISUITE 2011 v4.0
Solubility (mg/L):	1.00E+06	EPISUITE 2011 v4.0
Henry's Law Constant (atm m³/mole):	1.83E-24	EPISUITE 2011 v4.0
Organic carbon partition coefficient (Koc):	35.65	EPISUITE 2011 v4.0
Log organic carbon partition coefficient (log Koc):	1.55	EPISUITE 2011 v4.0
Log octanol - water partition coefficient (log Kow):	-5.3	EPISUITE 2011 v4.0

Persistance / Bioaccumulation	Value	Reference
Biowin 3 (Ultimate Survey Biodegradation):	3.2358	EPISUITE 2011 v4.0
Biowin 4 (Primary Biodegradation):	4.0263	EPISUITE 2011 v4.0
EPISUITE Ready Biodegradability:	Biodegrades fast	EPISUITE 2011 v4.0
Biowin 7 (Anaerobic Model Prediction):	0.7306	EPISUITE 2011 v4.0
Fugacity_Air: (%)	0.00000101	EPISUITE 2011 v4.0
Fugacity_Water: (%)	24	EPISUITE 2011 v4.0
Fugacity_Soil: (%)	76	EPISUITE 2011 v4.0
Fugacity_Sediment: (%)	0.0778	EPISUITE 2011 v4.0
Bioconcentration factor (BCF):	3.162	EPISUITE 2011 v4.0
Biotransformation half - life (Days):	0.0000555	EPISUITE 2011 v4.0

Project number: 127666004

ORGANIC

Common Name	Endpoint	Effect	Effect Measure	Test Time (Days)	Conc	Reference	Units
Earthworm	1	MOR	Mortality	14	4675.2	ECOSAR 2012	mg/L

Created By: Naomi Cooper Date: 13/11/2013

Checked By: Carolyn Brumley Date: 15/11/2013

APPENDIX G

Fluid Analytical Results

cash . sale .

CHAIN OF CUSTODY

ALS Laboratory: please tick →

☐ **Sydney**: 277 Woodpark Rd, Smithfield NSW 2176 Ph: 02 8784 8555 E:samples.sydney@alsenviro.com
☐ **Newcastle**: 5 Rosegum Rd, Warabrook NSW 2304 Ph:02 4968 9433 E:samples.newcastle@alsenviro.com
☐ **Brisbane**: 32 Shand St, Stafford QLD 4053 Ph:07 3243 7222 E:samples.brisbane@alsenviro.com
☐ **Townsville**: 14-15 Desma Ct, Bohle QLD 4818 Ph:07 4796 0600 E: townsville.environmental@alsenviro.com
☐ **Melbourne**: 2-4 Westall Rd, Springvale VIC 3171 Ph:03 8549 9600 E: samples.melbourne@alsenviro.com
☐ **Adelaide**: 2-1 Burma Rd, Pooraka SA 5095 Ph: 08 8359 0890 E:adelaide@alsenviro.com
☐ **Perth**: 10 Hod Way, Malaga WA 6090 Ph: 08 9209 7655 E: samples.perth@alsenviro.com
☐ **Launceston**: 27 Wellington St, Launceston TAS 7250 Ph: 03 6331 2158 E: launceston@alsenviro.com

CLIENT: Schlumberger	**TURNAROUND REQUIREMENTS :** (Standard TAT may be longer for some tests e.g., Ultra Trace Organics) ☒ Non Standard or urgent TAT (List due date): ASAP	**FOR LABORATORY USE ONLY (Circle)**	
OFFICE:		Custody Seal Intact?	Yes / No / N/A
PROJECT:	**ALS QUOTE NO.:**	Free ice / frozen ice bricks present upon receipt?	Yes / No / N/A
ORDER NUMBER:	**COC SEQUENCE NUMBER (Circle)** COC: 1 2 3 4 5 6 7	Random Sample Temperature on Receipt: 13.3 °C	
PROJECT MANAGER: Sean McCallum	**CONTACT PH:** 0418 532 890 OF: 1 2 3 4 5 6 7	Other comment:	

SAMPLER:	**SAMPLER MOBILE:**	**RELINQUISHED BY:**	**RECEIVED BY:**
COC emailed to ALS? (	**EDD FORMAT (or default):**	*Damian Jones*	Greg Vogel
Email Reports to (will default to PM if no other addresses are listed): smccallum2@slb.com		DATE/TIME:	DATE/TIME: 14/8/13 9:30
Email Invoice to (will default to PM if no other addresses are listed): smccallum2@slb.com		**RELINQUISHED BY:** DATE/TIME:	**RECEIVED BY:** DATE/TIME:

COMMENTS/SPECIAL HANDLING/STORAGE OR DISPOSAL:

ALS USE ONLY	SAMPLE DETAILS MATRIX: Solid(S) Water(W)			CONTAINER INFORMATION		ANALYSIS REQUIRED including SUITES (NB. Suite Codes must be listed to attract suite price) Where **Metals** are required, specify **Total** (unfiltered bottle required) or **Dissolved** (field filtered bottle required).								Additional Information
LAB ID	SAMPLE ID	DATE / TIME	MATRIX	TYPE & PRESERVATIVE *(refer to codes below)*	TOTAL BOTTLES	BTEX	PAH							Comments on likely contaminant levels, dilutions, or samples requiring specific QC analysis etc.
1	ThermaFRAC Additives	12-Aug-13	Water	40 mL Glass vial with sulphuric acid preservative	2	X	X							Ensure detection limits as per email to SLB Requirements. (< 1 ug/L on all analytes)
2	ThermaFRAC Polymer	12-Aug-13	Water	40 mL Glass vial with sulphuric acid preservative	2	X	X							
3	Slickwater	12-Aug-13	Water	40 mL Glass vial with sulphuric acid preservative	2	X	X							
				TOTAL	6									

Environmental Division
Brisbane
Work Order
EB1319648

Telephone : +61-7-3243 7222

Water Container Codes: P = Unpreserved Plastic; N = Nitric Preserved Plastic; ORC = Nitric Preserved ORC; SH = Sodium Hydroxide/Cd Preserved; S = Sodium Hydroxide Preserved Plastic; AG = Amber Glass Unpreserved; AP - Airfreight Unpreserved Plastic
V = VOA Vial HCl Preserved; VB = VOA Vial Sodium Bisulphate Preserved; VS = VOA Vial Sulfuric Preserved; AV = Airfreight Unpreserved Vial SG = Sulfuric Preserved Amber Glass; H = HCl preserved Plastic; HS = HCl preserved Speciation bottle; SP = Sulfuric Preserved Plastic; F = Formaldehyde Preserved Glass;
Z = Zinc Acetate Preserved Bottle; E = EDTA Preserved Bottles; ST = Sterile Bottle; ASS = Plastic Bag for Acid Sulphate Soils; B = Unpreserved Bag.

Environmental Division

CERTIFICATE OF ANALYSIS

Work Order	: **EB1319648**	Page	: 1 of 5
Client	: **SCHLUMBERGER WATER SERVICES AUSTRALIA PTY LTD**	Laboratory	: Environmental Division Brisbane
Contact	: MR SEAN McCALLUM	Contact	: Customer Services
Address	: 34 - 38 CARMICHAEL STREET CHINCHILLA QLD, AUSTRALIA 4413	Address	: 2 Byth Street Stafford QLD Australia 4053
E-mail	: cash.sale@alsenviro.com	E-mail	: Brisbane.Enviro.Services@alsglobal.com
Telephone	: +61 07 4669 1364	Telephone	: +61 7 3243 7222
Facsimile	: ----	Facsimile	: +61 7 3243 7218
Project	: ThermaFRAC Slickwater	QC Level	: NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Order number	: ----		
C-O-C number	: ----	Date Samples Received	: 14-AUG-2013
Sampler	:	Issue Date	: 26-AUG-2013
Site	: ----		
		No. of samples received	: 3
Quote number	: ----	No. of samples analysed	: 3

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results
- Surrogate Control Limits

NATA Accredited Laboratory 825

Accredited for compliance with ISO/IEC 17025.

Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Phalak Inthaksone	Laboratory Manager - Organics	Sydney Organics
Phalak Inthaksone	Laboratory Manager - Organics	Sydney Organics

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting

- **EP132: Insufficient sample has been provided for standard analysis. Where applicable LOR values have been adjusted accordingly.**

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	ThermaFRAC Additives	ThermaFRAC Polymer	Slickwater	----	----
				Client sampling date / time	12-AUG-2013 15:00	12-AUG-2013 15:00	12-AUG-2013 15:00	----	----
Compound	CAS Number	LOR	Unit		EB1319648-001	EB1319648-002	EB1319648-003	----	----
EP125A: Monocyclic Aromatic Hydrocarbons									
Benzene	71-43-2	0.05	µg/L		<0.05	<0.05	<0.05	----	----
Toluene	108-88-3	0.5	µg/L		**3.7**	<0.5	<0.5	----	----
Ethylbenzene	100-41-4	0.05	µg/L		**0.07**	<0.05	<0.05	----	----
meta- & para-Xylene	108-38-3 106-42-3	0.05	µg/L		<0.05	<0.05	<0.05	----	----
Styrene	100-42-5	0.05	µg/L		**0.25**	<0.05	<0.05	----	----
ortho-Xylene	95-47-6	0.05	µg/L		<0.05	<0.05	<0.05	----	----
1.3.5-Trimethylbenzene	108-67-8	0.05	µg/L		<0.05	<0.05	<0.05	----	----
1.2.4-Trimethylbenzene	95-63-6	0.05	µg/L		<0.05	<0.05	<0.05	----	----
Sum of Xylenes	1330-20-7	0.05	µg/L		<0.05	<0.05	<0.05	----	----
EP132B: Polynuclear Aromatic Hydrocarbons									
3-Methylcholanthrene	56-49-5	0.1	µg/L		<0.1	<0.1	<0.2	----	----
2-Methylnaphthalene	91-57-6	0.1	µg/L		<0.1	<0.1	<0.2	----	----
7.12-Dimethylbenz(a)anthracene	57-97-6	0.1	µg/L		<0.1	<0.1	<0.2	----	----
Acenaphthene	83-32-9	0.1	µg/L		<0.1	<0.1	<0.2	----	----
Acenaphthylene	208-96-8	0.1	µg/L		<0.1	<0.1	<0.2	----	----
Anthracene	120-12-7	0.1	µg/L		<0.1	<0.1	<0.2	----	----
Benz(a)anthracene	56-55-3	0.1	µg/L		<0.1	<0.1	<0.2	----	----
Benzo(a)pyrene	50-32-8	0.05	µg/L		<0.07	<0.07	<0.08	----	----
Benzo(b)fluoranthene	205-99-2	0.1	µg/L		<0.1	<0.1	<0.2	----	----
Benzo(e)pyrene	192-97-2	0.1	µg/L		<0.1	<0.1	<0.2	----	----
Benzo(g.h.i)perylene	191-24-2	0.1	µg/L		<0.1	**0.2**	<0.2	----	----
Benzo(k)fluoranthene	207-08-9	0.1	µg/L		<0.1	<0.1	<0.2	----	----
Chrysene	218-01-9	0.1	µg/L		<0.1	<0.1	<0.2	----	----
Coronene	191-07-1	0.1	µg/L		<0.1	<0.1	<0.2	----	----
Dibenz(a.h)anthracene	53-70-3	0.1	µg/L		<0.1	<0.1	<0.2	----	----
Fluoranthene	206-44-0	0.1	µg/L		<0.1	<0.1	<0.2	----	----
Fluorene	86-73-7	0.1	µg/L		<0.1	<0.1	<0.2	----	----
Indeno(1.2.3.cd)pyrene	193-39-5	0.1	µg/L		<0.1	<0.1	<0.2	----	----
N-2-Fluorenyl Acetamide	53-96-3	0.1	µg/L		<0.1	<0.1	<0.2	----	----
Naphthalene	91-20-3	0.1	µg/L		<0.1	**0.7**	<0.2	----	----
Perylene	198-55-0	0.1	µg/L		<0.1	<0.1	<0.2	----	----
Phenanthrene	85-01-8	0.1	µg/L		<0.1	**0.3**	<0.2	----	----
Pyrene	129-00-0	0.1	µg/L		<0.1	<0.1	<0.2	----	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	ThermaFRAC Additives	ThermaFRAC Polymer	Slickwater	----	----
				Client sampling date / time	12-AUG-2013 15:00	12-AUG-2013 15:00	12-AUG-2013 15:00	----	----
Compound	CAS Number	LOR	Unit		EB1319648-001	EB1319648-002	EB1319648-003	----	----
EP132B: Polynuclear Aromatic Hydrocarbons - Continued									
^ **Sum of PAHs**	----	0.05	µg/L		<0.1	**1.2**	<0.2	----	----
^ **Benzo(a)pyrene TEQ (zero)**	----	0.05	µg/L		<0.1	<0.1	<0.2	----	----
EP125S: VOC Surrogates									
1.2-Dichloroethane-D4	17060-07-0	0.1	%		**113**	**91.4**	**113**	----	----
Toluene-D8	2037-26-5	0.1	%		**105**	**86.5**	**102**	----	----
4-Bromofluorobenzene	460-00-4	0.1	%		**97.8**	**79.9**	**104**	----	----
EP132T: Base/Neutral Extractable Surrogates									
2-Fluorobiphenyl	321-60-8	0.1	%		**68.4**	**84.4**	**87.4**	----	----
Anthracene-d10	1719-06-8	0.1	%		**75.3**	**89.7**	**81.7**	----	----
4-Terphenyl-d14	1718-51-0	0.1	%		**70.2**	**91.1**	**80.9**	----	----

Surrogate Control Limits

Sub-Matrix: **WATER**

Compound	CAS Number	Recovery Limits (%) Low	Recovery Limits (%) High
EP125S: VOC Surrogates			
1.2-Dichloroethane-D4	17060-07-0	73	129
Toluene-D8	2037-26-5	65	127
4-Bromofluorobenzene	460-00-4	68	124
EP132T: Base/Neutral Extractable Surrogates			
2-Fluorobiphenyl	321-60-8	43	135
Anthracene-d10	1719-06-8	48	138
4-Terphenyl-d14	1718-51-0	48	144

Environmental Division

CERTIFICATE OF ANALYSIS

Work Order	: **EB1317643**	Page	: 1 of 5
Client	: **SCHLUMBERGER WATER SERVICES AUSTRALIA PTY LTD**	Laboratory	: Environmental Division Brisbane
Contact	: ASHLEY WATLING (COC/SRN)	Contact	: Customer Services
Address	: 34 - 38 CARMICHAEL STREET CHINCHILLA QLD, AUSTRALIA 4413	Address	: 2 Byth Street Stafford QLD Australia 4053
E-mail	: awatling@slb.com	E-mail	: Brisbane.Enviro.Services@alsglobal.com
Telephone	: +61 07 4669 1364	Telephone	: +61 7 3243 7222
Facsimile	: ----	Facsimile	: +61 7 3243 7218
Project	: ----	QC Level	: NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Order number	: ----		
C-O-C number	: ----	Date Samples Received	: 24-JUL-2013
Sampler		Issue Date	: 01-AUG-2013
Site			
		No. of samples received	: 2
Quote number	: ----	No. of samples analysed	: 2

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results
- Surrogate Control Limits

NATA Accredited Laboratory 825

Accredited for compliance with ISO/IEC 17025.

Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Matt Frost	Senior Organic Chemist	Brisbane Organics
Pabi Subba	Senior Organic Chemist	Sydney Organics

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

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Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting

- **EP125: Sample YF140 HTD has been heated to reduce viscosity of the gel. As such volatile analytes may have been lost through evaporation.**
- **EP125;Particular samples required dilution due to matrix interferences. LOR values have been adjusted accordingly.**
- **PAH: Sample 'YF140 HTD' required dilution prior to extraction due to matrix interferences. LOR values have been adjusted accordingly.**
- **PAH: Samples 'YF120 W/L071 and YF140 HTD' show poor surrogate recovery for Anthracene-d10 due to matrix interference.**

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	YF120 W/L071	YF140 HTD	----	----	----
			Client sampling date / time	17-JUL-2013 15:00	17-JUL-2013 15:00	----	----	----
Compound	CAS Number	LOR	Unit	EB1317643-001	EB1317643-002	----	----	----
EP075(SIM)B: Polynuclear Aromatic Hydrocarbons								
Naphthalene	91-20-3	1.0	µg/L	<1.0	<5.0	----	----	----
Acenaphthylene	208-96-8	1.0	µg/L	<1.0	<5.0	----	----	----
Acenaphthene	83-32-9	1.0	µg/L	<1.0	<5.0	----	----	----
Fluorene	86-73-7	1.0	µg/L	<1.0	<5.0	----	----	----
Phenanthrene	85-01-8	1.0	µg/L	<1.0	<5.0	----	----	----
Anthracene	120-12-7	1.0	µg/L	<1.0	<5.0	----	----	----
Fluoranthene	206-44-0	1.0	µg/L	<1.0	<5.0	----	----	----
Pyrene	129-00-0	1.0	µg/L	<1.0	<5.0	----	----	----
Benz(a)anthracene	56-55-3	1.0	µg/L	<1.0	<5.0	----	----	----
Chrysene	218-01-9	1.0	µg/L	<1.0	<5.0	----	----	----
Benzo(b)fluoranthene	205-99-2	1.0	µg/L	<1.0	<5.0	----	----	----
Benzo(k)fluoranthene	207-08-9	1.0	µg/L	<1.0	<5.0	----	----	----
Benzo(a)pyrene	50-32-8	0.5	µg/L	<0.5	<5.0	----	----	----
Indeno(1.2.3.cd)pyrene	193-39-5	1.0	µg/L	<1.0	<5.0	----	----	----
Dibenz(a.h)anthracene	53-70-3	1.0	µg/L	<1.0	<5.0	----	----	----
Benzo(g.h.i)perylene	191-24-2	1.0	µg/L	<1.0	<5.0	----	----	----
^ Sum of polycyclic aromatic hydrocarbons	----	0.5	µg/L	<0.5	<2.5	----	----	----
^ Benzo(a)pyrene TEQ (zero)	----	0.5	µg/L	<0.5	<5.0	----	----	----
EP125A: Monocyclic Aromatic Hydrocarbons								
Benzene	71-43-2	0.05	µg/L	----	<0.12	----	----	----
Toluene	108-88-3	0.5	µg/L	----	<0.5	----	----	----
Ethylbenzene	100-41-4	0.05	µg/L	----	<0.12	----	----	----
meta- & para-Xylene	108-38-3 106-42-3	0.05	µg/L	----	<0.25	----	----	----
Styrene	100-42-5	0.05	µg/L	----	<0.15	----	----	----
ortho-Xylene	95-47-6	0.05	µg/L	----	<0.12	----	----	----
1.3.5-Trimethylbenzene	108-67-8	0.05	µg/L	----	<0.15	----	----	----
1.2.4-Trimethylbenzene	95-63-6	0.05	µg/L	----	<0.15	----	----	----
Sum of Xylenes	1330-20-7	0.05	µg/L	----	<0.25	----	----	----
EP075(SIM)S: Phenolic Compound Surrogates								
Phenol-d6	13127-88-3	0.1	%	**17.9**	**19.2**	----	----	----
2-Chlorophenol-D4	93951-73-6	0.1	%	**46.1**	**52.6**	----	----	----
2.4.6-Tribromophenol	118-79-6	0.1	%	**72.1**	**79.7**	----	----	----
EP075(SIM)T: PAH Surrogates								

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	YF120 W/L071	YF140 HTD	----	----	----
			Client sampling date / time	17-JUL-2013 15:00	17-JUL-2013 15:00	----	----	----
Compound	CAS Number	LOR	Unit	EB1317643-001	EB1317643-002	----	----	----
EP075(SIM)T: PAH Surrogates - Continued								
2-Fluorobiphenyl	321-60-8	0.1	%	**48.7**	**62.5**	----	----	----
Anthracene-d10	1719-06-8	0.1	%	**26.0**	**22.0**	----	----	----
4-Terphenyl-d14	1718-51-0	0.1	%	**50.5**	**63.8**	----	----	----
EP125S: VOC Surrogates								
1.2-Dichloroethane-D4	17060-07-0	0.1	%	----	**99.7**	----	----	----
Toluene-D8	2037-26-5	0.1	%	----	**104**	----	----	----
4-Bromofluorobenzene	460-00-4	0.1	%	----	**85.5**	----	----	----

Surrogate Control Limits

Sub-Matrix: **WATER**

Compound	CAS Number	Recovery Limits (%) Low	High
EP075(SIM)S: Phenolic Compound Surrogates			
Phenol-d6	13127-88-3	10.0	71.9
2-Chlorophenol-D4	93951-73-6	26.8	130.2
2.4.6-Tribromophenol	118-79-6	19.3	180.8
EP075(SIM)T: PAH Surrogates			
2-Fluorobiphenyl	321-60-8	13.9	146.1
Anthracene-d10	1719-06-8	34.6	137.4
4-Terphenyl-d14	1718-51-0	36.2	154.2
EP125S: VOC Surrogates			
1.2-Dichloroethane-D4	17060-07-0	73	129
Toluene-D8	2037-26-5	65	127
4-Bromofluorobenzene	460-00-4	68	124

CASH SALE

CHAIN OF CUSTODY

ALS Laboratory: please tick →

☐ Sydney: 277 Woodpark Rd, Smithfield NSW 2176 Ph: 02 8784 8555 E:samples.sydney@alsenviro.com
☐ Newcastle: 5 Rosegum Rd, Warabrook NSW 2304 Ph: 02 4968 9433 E:samples.newcastle@alsenviro.com
☐ Brisbane: 32 Shand St, Stafford QLD 4053 Ph: 07 3243 7222 E:samples.brisbane@alsenviro.com
☐ Townsville: 14-15 Desma Ct, Bohle QLD 4818 Ph: 07 4796 0600 E:townsville.environmental@alsenviro.com
☐ Melbourne: 2-4 Westall Rd, Springvale VIC 3171 Ph: 03 8549 9600 E:samples.melbourne@alsenviro.com
☐ Adelaide: 2-1 Burma Rd, Pooraka SA 5095 Ph: 08 8359 0890 E:adelaide@alsenviro.com
☐ Perth: 10 Hod Way, Malaga WA 6090 Ph: 08 9209 7655 E:samples.perth@alsenviro.com
☐ Launceston: 27 Wellington St, Launceston TAS 7250 Ph: 03 6331 2158 E:launceston@alsenviro.com

CLIENT: Schlumberger

OFFICE: Chinchilla

PROJECT:

ORDER NUMBER:

PROJECT MANAGER: Sean McCullan

CONTACT PH: 0418 532 890

SAMPLER: Damian Jones

SAMPLER MOBILE:

COC emailed to ALS? (YES / NO) — NO circled

EDD FORMAT (or default):

Email Reports to (will default to PM if no other addresses are listed): awatling@slb.com

Email Invoice to (will default to PM if no other addresses are listed): awatling@slb.com

TURNAROUND REQUIREMENTS : (Standard TAT may be longer for some tests e.g. Ultra Trace Organics)

☒ Standard TAT (List due date):

☐ Non Standard or urgent TAT (List due date):

ALS QUOTE NO.:

COC SEQUENCE NUMBER (Circle)

COC: 1 2 3 4 5 6 7

OF: 1 2 3 4 5 6 7

FOR LABORATORY USE ONLY (Circle)

Custody Seal Intact? Yes No N/A

Free ice / frozen ice bricks present upon receipt? Yes No N/A

Random Sample Temperature on Receipt: °C

Other comment:

RELINQUISHED BY:	RECEIVED BY:	RELINQUISHED BY:	RECEIVED BY:
Ashley	[signature]		
DATE/TIME: 17/7/13	DATE/TIME: 24/07/13 09:40	DATE/TIME:	DATE/TIME:

COMMENTS/SPECIAL HANDLING/STORAGE OR DISPOSAL:

ALS USE ONLY	SAMPLE DETAILS MATRIX: Solid(S) Water(W)			CONTAINER INFORMATION		ANALYSIS REQUIRED including SUITES (NB. Suite Codes must be listed to attract suite price) Where Metals are required, specify Total (unfiltered bottle required) or Dissolved (field filtered bottle required).								Additional Information
LAB ID	SAMPLE ID	DATE / TIME	MATRIX	TYPE & PRESERVATIVE (refer to codes below)	TOTAL BOTTLES	PAH	BTEX - low level MDT contact Sean McCallum before analysis							Comments on likely contaminant levels, dilutions, or samples requiring specific QC analysis etc.
	~~YF120~~	~~17-7-13~~		~~AG~~	~~2~~									
	~~1400481~~	~~17-7-13~~			~~2~~									
1	YF120 w/L071	17-7-13	W	AG	2	X								
2	YF140 HTD	17-7-13	W	AG	2	X	X							
				TOTAL	4									

Environmental Division
Brisbane
Work Order
EB1317643
Telephone : + 61-7-3243 7222

Water Container Codes: P = Unpreserved Plastic; N = Nitric Preserved Plastic; ORC = Nitric Preserved ORC; SH = Sodium Hydroxide/Cd Preserved; S = Sodium Hydroxide Preserved Plastic; AG = Amber Glass Unpreserved; AP - Airfreight Unpreserved Plastic
V = VOA Vial HCl Preserved; VB = VOA Vial Sodium Bisulphate Preserved; VS = VOA Vial Sulfuric Preserved; AV = Airfreight Unpreserved Vial SG = Sulfuric Preserved Amber Glass, H = HCl preserved Plastic; HS = HCl preserved Speciation bottle; SP = Sulfuric Preserved Plastic; F = Formaldehyde Preserved Glass;
Z = Zinc Acetate Preserved Bottle; E = EDTA Preserved Bottles; ST = Sterile Bottle; ASS = Plastic Bag for Acid Sulphate Soils; B = Unpreserved Bag.

golder.com

Statutory Declaration

Resource activities other than mining

Declaration of compliance for written documents

A statutory declaration is a written statement of facts that is sworn or declared under the Oaths Act 1867. *This statutory declaration has been prepared to declare the authority holders compliance with the provisions of the* Environmental Protection Act 1994 *(EP Act) or an environmental authority condition that stipulates the requirement to submit a certified written document to the administering authority.*

Oaths Act 1867

QUEENSLAND
TO WIT

Re: Written documents relating to an environmental authority for a resource activity other than mining under the *Environmental Protection Act 1994*.

Written document: Stimulation Risk Assessment – Santos Southwest Queensland, dated June 2020

(Insert type of document, e.g. contingency plan for emergency environmental incidents)

Subject matter: Compliance with Well Construction, Maintenance, Stimulation Schedule conditions as per Table 1 within the written document.

(Insert subject matter, e.g. compliance with environmental authority number PEN1001222222)

Authority holder: Santos Ltd

I, _____

of, _____

(Insert suburb and city of the person making this declaration)

ABN 46 640 294 485

in the State of Victoria do solemnly and sincerely declare that:

1. I am a suitably qualified person as defined in the environmental authority; having professional qualifications, training, skills and experience relevant to the subject matter and can give authoritative assessment, advice and analysis relative to the subject matter using the relevant protocols, standards, methods or literature. A copy of my curriculum vitae is Annexure A to this declaration[1];
2. Relevant material, including current published guidelines (where available) have been considered in the written document
3. I have not knowingly included false, misleading or incomplete information in the *Stimulation Risk Assessment Report – Santos Southwest Queensland*, dated June 2020
4. I have not knowingly failed to reveal any relevant information or document to the Department of Environment and Science
5. The Stimulation Risk Assessment Report – Santos Southwest Queensland, dated June 2020, addresses relevant matters under K6 of Schedule K of the Environmental Authority as per Table 1 within the written document and is factually correct; and
6. The opinions expressed in it are honestly and reasonably held.

And I make this solemn declaration conscientiously believing the same to be true, and by virtue of the provisions of the *Oaths Act 1867*.

Taken and declared before me, at _____

(Insert name of town or city and suburb)

this _____ day of _____ in the year _____

(Insert day, e.g. 18th) (Insert month) (Insert year)

_____ _____ _____ _____

(Person making this declaration) ut whichever is not applicable)

~~Justice of the Peace~~ / ~~Commissioner for Declarations~~ / Solicitor / ~~Barrister~~

_____

(Print name and registration number, if applicable)

[1] The signatory does need to initial each page of the annexure, but it does need to be marked with the following: "This is the [*insert name of document]* or a copy of the [insert name of document] marked with the letter "A" referred to in the Statutory Declaration [insert sworn/taken/affirmed/solemnly declared] before me at [insert day] of [insert month], [insert year].

Approved By

Signature

Date

Director
Energy Regulation and Implementation Unit
Environmental Protection Act 1994
Department of Environment and Heritage Protection

Enquiries:
Energy Regulation and Implementation Unit
(Level 7, 400 George Street)
Department of Environment and Heritage Protection
Regular or registered post:
GPO Box 2454, Brisbane QLD 4001
Courier or hand delivery:
Level 3, 400 George Street, Brisbane QLD 4000
Telephone: (07) 3330 5619
Facsimile: (07) 3330 5634

Annexure A. This is the curriculum vitae marked with the letter "A" referred to in the Statutory Declaration which was declared before me on 13th of July, 2020.

Appendix C – Revised Ecological Assessment Report – PL 1058

Ecological Assessment

Santos
Petroleum Lease 1058 (Bearcat)

Level 1
30 Little Cribb Street
MILTON QLD 4064

Issue Date: 1 September 2021
mail@e2mconsulting.com.au
www.e2mconsulting.com.au

Document management

Rev.	Issue Date	Description	Author (s)	Approved	Signature
A	16/12/2019	Issued for review	J. van Osta	B. Dreis	
0	28/04/2020	Issued for use	J. van Osta	B. Dreis	
1	24/11/2020	Issued for use	J. van Osta	B. Dreis	
2	11/03/2021	Issued for use	J. van Osta J. Gamack	B. Dreis	
3	1/09/2021	Issued for use	J. van Osta	B. Dreis	

Document Reference: QEJ19010_PL1058_EcoAssessment_Rev3

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Definitions

Term	Definition
Disturbance footprint	The area that is proposed to be impacted by the project.
The project	Bearcat (PL1058) petroleum activities.
Regional Ecosystem	A vegetation community in a bioregion that is consistently associated with a particular combination of geology, landform and soil. Regional Ecosystems are described in the Regional Ecosystem Description Database, produced by the Queensland Herbarium.
Regulated vegetation	Vegetation that is mapped within the Regulated Vegetation Management Map produced by DNRME.
The PL	Petroleum Lease (PL) 1058 (Bearcat).
Suitable habitat	A species preferred environment required to sustain a viable population. Suitable habitat may include breeding, foraging and shelter resources for fauna or preferred environmental conditions of flora.
Threatened species	Extinct (EX), extinct in the wild (XW), critically endangered (CE), endangered (E), vulnerable (V) or conservation dependent (CD) under the *Environment Protection and Biodiversity Conservation Act 1999* or extinct in the wild (PE), Endangered, Vulnerable or Near Threatened (EVNT) under the *Nature Conservation Act 1992*.

Abbreviations

Abbreviation	Description
DAWE	Department of Agriculture, Water and the Environment (formerly Department of the Environment and Energy (DEE))
DES	Department of Environment and Science
DNRME	Department of Natural Resources, Mines and Energy
E2M	E2M Pty Ltd
EO Act	*Environmental Offsets Act 2014*
EO Regulation	*Environmental Offsets Regulation 2014*
EP Act	*Environmental Protection Act 1994*
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
MNES	Matters of National Environmental Significance
MSES	Matters of State Environmental Significance
NC Act	*Nature Conservation Act 1992*
RE	Regional Ecosystem
SEA	Strategic Environmental Area, defined under the EO Regulation
SRI	Significant Residual Impact

1 Introduction

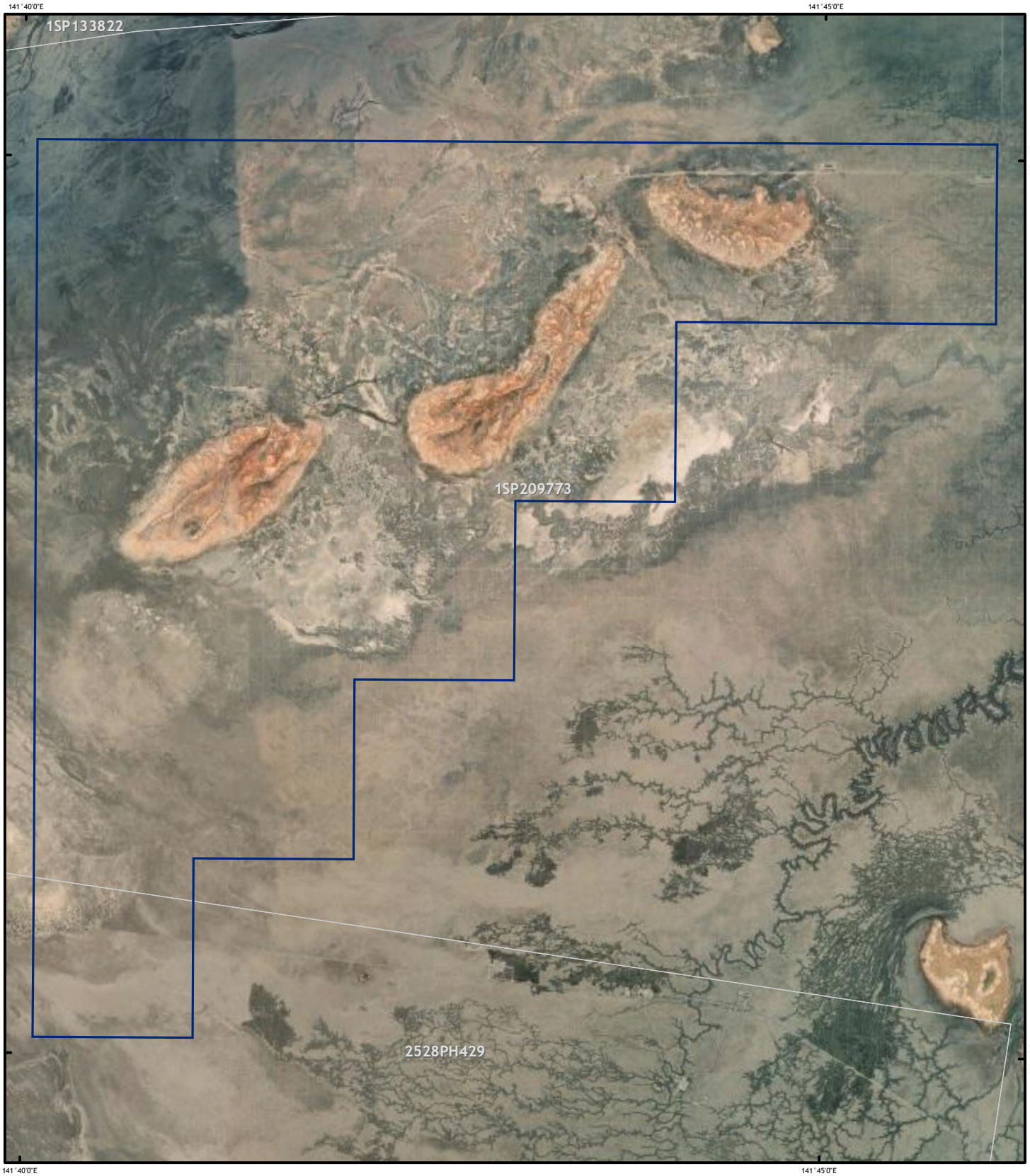
1.1 Project background and scope

Santos is proposing new petroleum activities within Petroleum Lease (PL) 1058 (Bearcat), herein referred to as 'the PL', and has engaged E2M to undertake an ecological assessment for the PL. The scope of this assessment is to:

- Conduct a review of Commonwealth and State Government environmental mapping, databases and legislative considerations
- Undertake a field assessment to ground-truth vegetation communities and habitat for species listed as Matters of National Environmental Significance (MNES) and/or Matters of State Environmental Significance (MSES) within the PL
- Provide a preliminary assessment of potential impacts of the proposed development on identified MNES and MSES
- Detail management strategies to avoid, minimise or mitigate potential impacts to MNES and MSES within the PL; and
- Undertake preliminary significant residual impact (SRI) assessments to determine potential offset requirements for identified MNES and MSES.

1.2 Site description

The PL is located within the Cooper Creek floodplain, approximately 40 km south of the Ballera gas plant. The PL is approximately 4,851 ha and is contained within Lot 1 on SP209773 and Lot 2528 on PH429. Land within the PL is predominately used for cattle grazing. The PL and surrounding environs are depicted in Figure 1.



Legend

- Road
- Petroleum Lease
- Cadastre

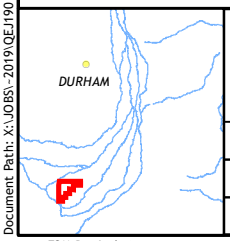
N

Scale 1:55,000 (A4)

0 1 2 3

Kilometres

Coordinate System: GDA 1994 MGA Zone 54
Projection: Transverse Mercator



Notes:
Aerial Imagery: © ESRI 2019
Cadastre: © DNRME 2019
Petroleum Lease: © DNRME 2019
MSES: © DNRME 2017

Rev	Description	Drawn	Approved	Date
2	Issued for Use	DL	JVO	26/02/2021
1	Issued for Use	DL	JVO	19/02/2021

FIGURE 1: SITE LOCATION - PL 1058

Ecological Assessment Report
Santos

Map Number	Job Number	Rev
1 of 1	QEJ19010	2

Document Path: X:\JOBS\-2019\QEJ19010\GIS\QEJ19010_EAR_SiteLocation.mxd

2 Methods

2.1 Desktop assessment

A desktop assessment was undertaken to review Commonwealth and State Government environmental mapping and databases to identify potential MNES and MSES within the PL. The following legislation, associated triggers and databases were reviewed:

- Department of Agriculture, Water and the Environment (DAWE) Protected Matters Report, for a search radius of 100 km from the approximate centre of the PL (-27.78389, 141.70621)
- Department of Environment and Science (DES) MSES mapping for the PL
- Department of Natural Resources, Mines and Energy (DNRME) Regulated Vegetation Management Map, Vegetation Management Supporting Map (Regional Ecosystem mapping) and Essential Habitat Map for the PL
- DES Protected Plants Flora Survey Trigger mapping for the PL
- DES WildNet Database, for a 100 km buffer around the boundaries of the PL
- DES Map of Environmentally Sensitive Areas for the PL
- Queensland Globe environmental mapping layers for the PL
- Atlas of Living Australia species records; and
- The latest available aerial photography.

2.2 Field assessment

A field assessment of the PL was conducted by two E2M ecologists (Brad Dreis and John van Osta) from 1 to 4 April 2019 and from 24 to 29 August 2019. Brad Dreis and John van Osta are suitably qualified persons for the purposes of undertaking ecological field surveys. The field assessment was undertaken in conjunction with field assessments of PL 1047 (Okotoko), PL 1055 (Bantam) PL 1060 (Jarrar) and Potential Commercial Area 251 (Greater Okotoko).

The following data were collected during the survey:

- Delineation of the ground-truthed extents of RE polygons, with a particular focus on delineating homogenous polygons of wetland REs. Ground-truthed Regional Ecosystems (GTREs) were delineated in accordance with Neldner *et al* (2019).
- Assessment of potential habitat for MNES and MSES fauna
- Targeted searches for grey grasswren (*Amytornis barbatus*) within areas of suitable habitat; and
- Opportunistic observations of fauna encountered throughout the PL.

Trimble TDC100 Global Positioning System (GPS) devices were used to delineate the extent of vegetation communities within the PL and record species and habitat data. Captured data was validated, mapped and assessed using a geographical information system, whereby the development footprint and observed features and extents were overlaid on the relevant regulatory mapping (GDA94/MGA zone 54).

2.3 Regional Ecosystem verification

To verify the extent of the vegetation communities in the field, a combination of Secondary, Tertiary and Quaternary type surveys using the CORVEG Methodology (outlined within *Methodology for Survey and Mapping of Regional Ecosystems and Vegetation Communities in Queensland* (Neldner *et al.* 2019)) were used. Secondary surveys were conducted to collect detailed floristic and structural information, while Tertiary surveys were conducted in REs that had not been flooded and a detailed floristic composition could not be recorded. Quaternary surveys were conducted as a rapid assessment method to characterise the vegetation community.

Where possible, vegetation communities were verified to single homogenous RE polygons in accordance with the Regional Ecosystem Description Database (REDD) (Queensland Herbarium 2019a). However, in areas where multiple REs occurred on a fine scale over extensive areas, such as the floodplain matrix, heterogenous RE polygons were assigned, which included an estimate of the proportion of each RE within each polygon (Neldner *et al.* 2019).

Ground-truthed vegetation communities are used to determine:

- The presence of EPBC Act listed Threatened Ecological Communities (TEC), none of which occur within the PL; and
- Habitat for threatened species.

2.4 Likelihood of occurrence assessment

Threatened flora and fauna species identified in the desktop review were assessed for their likelihood of occurrence within the PL. This assessment considered the species distribution, habitat requirements and historical records in proximity to the PL as well as observations and evidence of occurrence, habitat suitability, threats and on-site conditions identified during the field survey.

The likelihood of occurrence of threatened, migratory and marine species were based on the following criteria:

- **Likely to occur**: suitable habitat to support the species is present and the species has previously been recorded within 100 km of the PL (the desktop search extent)
- **Possible occurrence**: The PL is within the species known distribution and suitable habitat to support the species is present; however
  - the species has not previously been recorded within the desktop search extent; and/or
  - suitable habitat is degraded or of limited extent, thereby reducing the likelihood of the species occurrence.
- **Unlikely to occur**: the PL does not comprise suitable habitat for the species, or is outside of the species known distribution.

2.5 Assumptions and limitations

Ecological surveys have a range of inherent limitations associated with seasonal timing of the survey, variable climate conditions and species behaviour. As such, the survey conducted only represents a "snapshot" in time and may not provide a true indication of presence or absence of flora and fauna species within the PL. In light of the identified limitations, precautionary principles were applied to assume presence where necessary for impact assessment purposes.

Preliminary impact assessments were based on design information that includes the disturbance assumptions identified within Section 5.1. The actual impact arising from the proposed works may differ to the preliminary assessment. The self-assessment has only considered impacts resulting from the proposed works and has not considered cumulative impacts.

3 Results

3.1 Desktop assessment

3.1.1 Commonwealth matters

A Protected Matters Report, generated by the DAWE, was generated to identify MNES that are predicted to occur within the PL (the search results have been included in Appendix A). Matters identified as potentially occurring within 100 km of the PL include:

- One wetland of International Importance (Coongie lakes)
- Nine threatened fauna species
- Two threatened flora species
- Nine migratory (marine, terrestrial, wetland) species; and
- 14 marine species.

A likelihood of occurrence assessment has been conducted for MNES flora and fauna species (Appendix C).

3.1.2 State matters

3.1.2.1 Vegetation Management Act 1999

The PL was mapped as entirely containing Category B (remnant) regulated vegetation. All Regional Ecosystems (REs) mapped within the PL by DNRME have a 'least concern' vegetation management class and 'no concern at present' biodiversity status (Queensland Herbarium 2019a).

3.1.2.2 Nature Conservation Act 1992

The Queensland Government WildNet database was searched within a 100 km buffer of the PL boundaries to identify the confirmed recorded presence of threatened flora and fauna species. The extract listed four bird, three mammal and four plant species (Appendix A). To determine potential presence within the PL, a likelihood of occurrence assessment has been conducted for these species (Appendix C).

3.1.2.2.1 NC Act Protected Plants

The *Nature Conservation Wildlife Regulation 2006* (NC Regulation) lists flora and fauna species considered to be extinct in the wild, Endangered, Vulnerable or Near Threatened (EVNT) or least concern in Queensland. Clearing of protected plants (i.e. EVNT species) is regulated by the NC Regulation. Furthermore, the State Government has produced a mapping layer which triggers a flora survey requirement if disturbance is proposed within a mapped high risk area. The PL does not contain mapped high risk areas.

3.1.3 Environmental Offsets Act 2014

The EO Act outlines the framework for environmental offsets within Queensland and how they should be provided. As defined within Section 7 of the EO Act, an environmental offset is an *activity undertaken to counterbalance a significant residual impact of a prescribed activity on a prescribed environmental matter*, such as matters of Commonwealth, State or local significance.

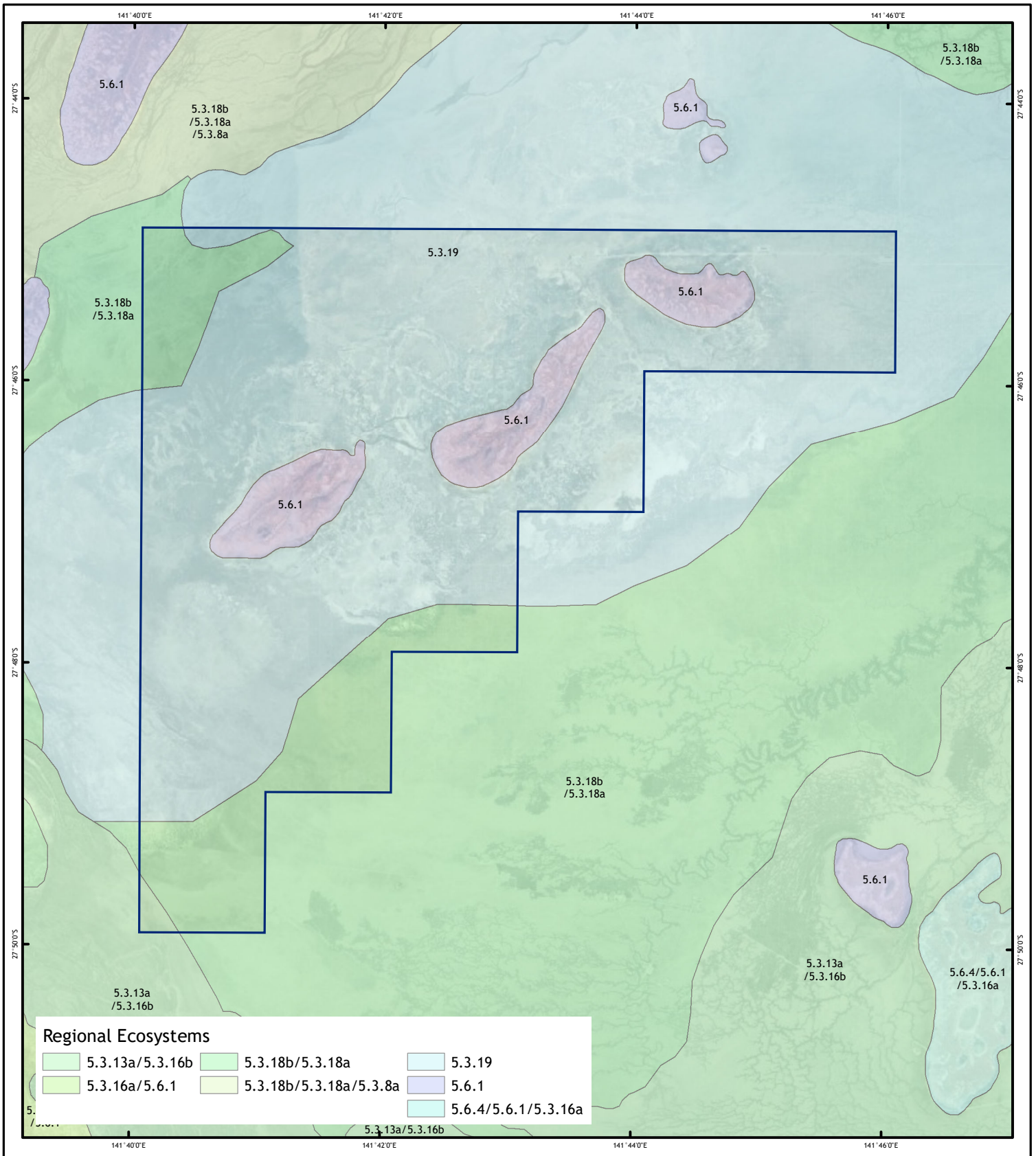
Environmental offsets are not an assessment trigger, but are imposed as a condition for a proposed activity. If a SRI on the prescribed environmental matter remains after the application of impact avoidance, minimisation and mitigation measures, an environmental offset may be required. MSES identified within the PL in the desktop assessment include:

- Threatened species listed under the NC Act
- Special least concern species listed under the NC Act
- Regulated vegetation – intersecting a watercourse
- Regulated vegetation – within 100 m of a Vegetation Management Wetland
- High Ecological Significance wetlands
- Connectivity areas; and
- Channel Country Strategic Environmental Area (SEA).

3.1.4 Environmental Protection Act 1994

No Category A, B or C ESAs are mapped to occur within the PL on the Map of Environmentally Sensitive Areas produced by the DES. Other matters mapped as occurring within the PL that are relevant to the PL include:

- Referable wetlands
- Dominant wetlands (51-100%); and
- Subdominant wetlands (0-50%).



Legend

Petroleum Lease

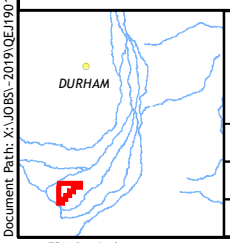
N

Scale 1:68,000 (A4)

0 1 2 3

Kilometres

Coordinate System: GDA 1994 MGA Zone 54
Projection: Transverse Mercator



Notes:
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Regional Ecosystems: © DNRME 2019

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2	Issued for Use	DL	JVO	26/02/2021
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FIGURE 2: DNRME MAPPED REGIONAL ECOSYSTEMS - PL 1058

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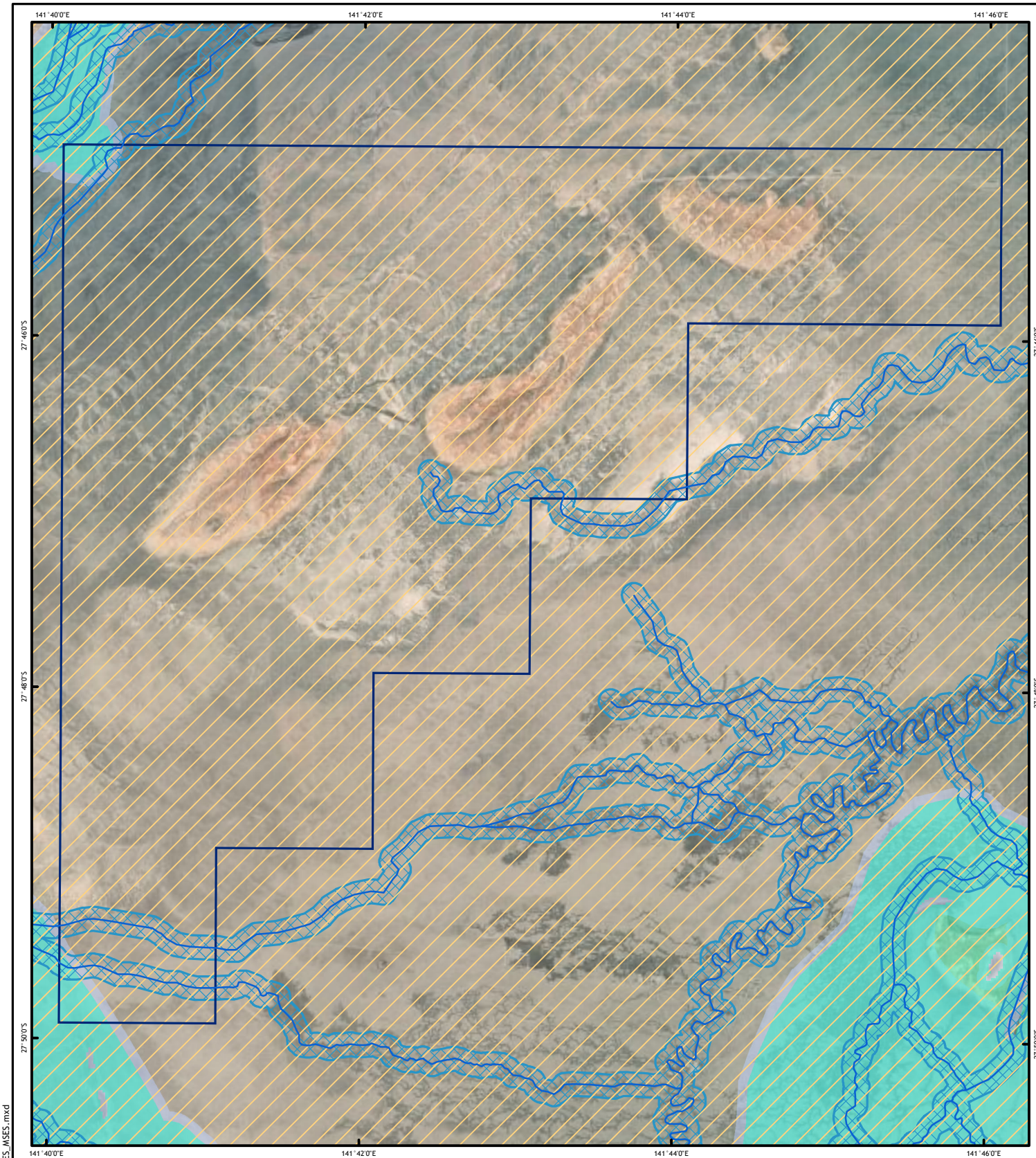
1 of 1	QEJ19010	2

Document Path: X:\JOBS\-2019\QEJ19010\GIS\QEJ19010_EAR_RegEco.mxd



Legend

- MSES - Watercourse
- MSES Regulated Vegetation – Intersecting a Watercourse
- MSES High Ecological Significance Wetlands
- MSES Regulated Vegetation – within 100m of a Vegetation Management Wetland
- Channel Country Stategic Environmental Area

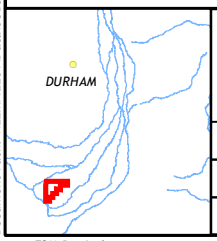
N

Scale 1:55,000 (A4)

0 1 2 3

Kilometres

Coordinate System: GDA 1994 MGA Zone 54
Projection: Transverse Mercator



Notes:
Aerial Imagery: © ESRI 2019
Petroleum Lease: © DNRME 2019
MSES Watercourses: © DES 2020
MSES Wetlands: © DES 2020
SEA: © DILGP 2019

Rev	Description	Drawn	Approved	Date
2	Issued for Use	DL	JVO	26/02/2021
1	Issued for Use	DL	JVO	19/02/2021

FIGURE 3: QUEENSLAND GOVERNMENT MAPPED MSES - PL 1058

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Map Number	Job Number	Rev
1 of 1	QEJ19010	2

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4 Field assessment results

4.1 Matters of National Environmental Significance

Five MNES have been identified as likely to occur within the PL. These MNES comprise one species listed as endangered under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), grey grasswren (Section 4.1.1), and a further four species listed as migratory under the EPBC Act (Section 4.1.2). In addition, five bird species listed as marine were identified as known or likely to occur (Section 4.1.3). Marine species, while not a MNES are protected under the EPBC Act through their relationship with the Commonwealth marine environment. Habitat associations for MNES species likely to occur within the PL are summarised in Table 1.

Table 1 MNES species likely to occur within the PL

Species	EPBC Act status	Regional Ecosystem (RE) associations	Area within the PL (ha)
Fork-tailed swift (*Apus pacificus*)	Marine and migratory	All REs	4,851.1
Glossy ibis (*Plegadis falcinellus*)	Marine and migratory	REs associated with riverine and palustrine wetlands, including: 5.3.13a and 5.3.18a	818.3
Grey grasswren (*Amytornis barbatus*)	Endangered	REs containing lignum (*Duma florulenta*) and swamp canegrass (*Eragrostis australasica*) thickets, which solely comprises 5.3.13a within the PL	224.3
Gull-billed tern (*Gelochelidon nilotica*)	Marine and migratory	REs associated with riverine and palustrine wetlands, including: 5.3.13a and 5.3.18a	818.3
Sharp-tailed sandpiper (*Calidris acuminata*)	Marine and migratory	REs associated with riverine and palustrine wetlands, including: 5.3.13a and 5.3.18a	818.3

4.1.1 Threatened species

While no EPBC Act listed threatened species were identified within the PL during the field assessment, the likelihood of occurrence assessment (Appendix C) identified that the PL is likely to provide habitat for one threatened species listed under the NC Act, namely grey grasswren. The Cooper Creek floodplain is known to support grey grasswren; however, the subspecies status of this population is uncertain (Black *et al.* 2011; DEE 2019). The Cooper Creek population may comprise either the Bulloo subspecies (*Amytornis barbatus barbatus*), listed as endangered under the EPBC Act; or the Diamantina subspecies (*Amytornis barbatus diamantina*), not listed under the EPBC Act. In light of this uncertainty, for the purposes of this report, the grey grasswren population has been assumed to comprise the endangered Bulloo subspecies. Habitat for grey grasswren within the PL is mapped within Figure 5.

A further seven threatened species listed under the EPBC Act are considered to have the possibility of occurrence within the PL; however, these species are not considered likely, primarily due to the absence of previous records within 100 km of the PL or the marginal quality of potential habitat for each species within the PL (Appendix C).

Fauna habitat mapping is based on GTRE mapping (Figure 4), which includes mixed RE polygons. Where a species habitat is associated with any of the REs that comprise a mixed polygon, the entire polygon was mapped as habitat. As such, the mapped fauna habitat depicted (Figure 5) may include areas of RE that are not habitat for the species.

4.1.2 Migratory species

While no migratory species were recorded within the PL during the field assessment, the likelihood of occurrence assessment identified that the PL is likely to provide habitat for four migratory species, including:

- fork-tailed swift – marine and migratory
- sharp-tailed sandpiper – marine and migratory
- glossy ibis – marine and migratory; and
- gull-billed tern – marine and migratory.

A project is required to seek approval under the EPBC Act for actions that are likely to have 'significant impact' on listed migratory species. 'Important habitat' for migratory species is a key factor for determining whether an action will result in a significant impact. Important habitat is defined in the significance criteria (DoE 2013) as:

- habitat utilised by a migratory species occasionally or periodically within a region that supports an ecologically significant proportion of the population of the species, and/or
- habitat that is of critical importance to the species at particular life-cycle stages, and/or
- habitat utilised by a migratory species which is at the limit of the species range, and/or
- habitat within an area where the species is declining.

The PL does not comprise important habitat for any migratory species listed under the EPBC Act and is therefore not likely to have a significant impact on listed migratory species.

4.1.3 Marine species

Three marine bird species, listed under the EPBC Act were identified within the PL during the field assessment. In addition, the likelihood of occurrence assessment identified that the PL is likely to provide habitat for a further six marine bird species.

A project is required to seek approval under the EPBC Act for actions that are likely to have 'significant impact' on the Commonwealth marine environment, which includes resulting in a '*substantial adverse effect on a population of a marine species or cetacean including its life cycle (for example, breeding, feeding, migration behaviour, life expectancy) and spatial distribution*'.

Impact to listed marine species resulting from the proposed disturbance is likely to be minimal. As such, the project will not have a significant impact on listed marine species.

4.2 State matters

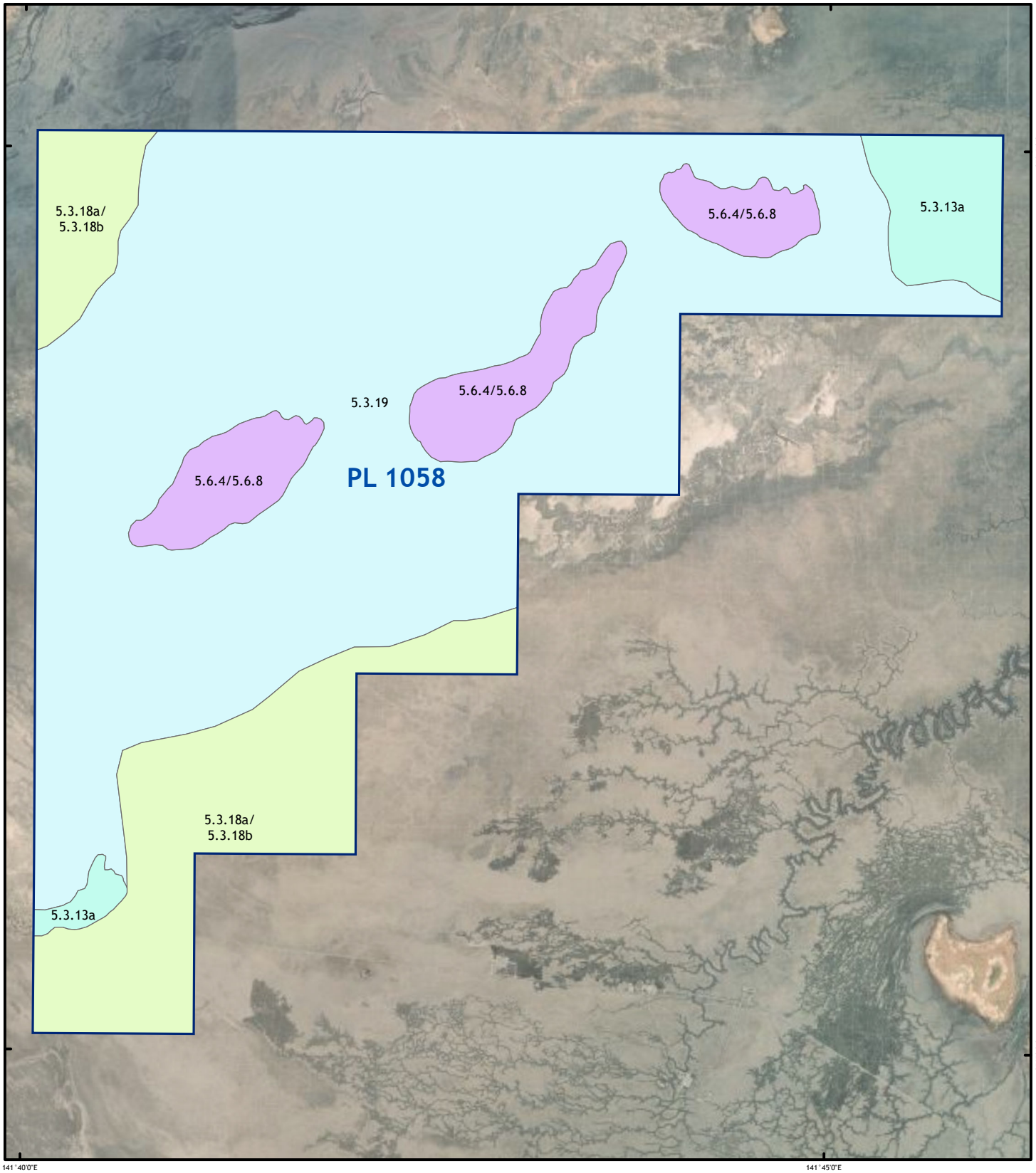
4.2.1 Ground-truthed Regional Ecosystems

GTREs within the PL entirely comprise Category B regulated vegetation under the *Vegetation Management Act 1999* and have a 'least concern' vegetation management class and 'no concern at present' biodiversity status (Queensland Herbarium 2019a). The distribution of all GTREs within the PL is described in Table 2 and is depicted in Figure 4.

Table 2 E2M Ground-truthed Regional Ecosystems (GTREs)

RE Code	Short Description	VM Class/BD Status	Structural category	Area within the PL (ha)[1]
5.3.13a	*Duma florulenta* open shrubland in depressions on flood plains, interdune flats, clay pans and clay plains	Least concern / No concern at present	Very sparse	224.3
5.3.18a	*Chenopodium auricomum* open shrubland on braided channel complex of major alluvial plains.	Least concern / No concern at present	Sparse	594
5.3.18b	Variable sparse to open-herbland on braided channel complex of major alluvial plains.	Least concern / No concern at present	Sparse	254.6
5.3.19	Variable sparse to open herbland on frequently flooded alluvial plains	Least concern / No concern at present	Sparse	3,379
5.6.4	*Atalaya hemiglauca* +/- *Acacia aneura* +/- *Acacia* spp. +/- *Corymbia terminalis* low open woodland on reticulate sand dunes	Least concern / No concern at present	Sparse	359.3
5.6.8	*Zygochloa paradoxa* and/or *Crotalaria eremaea* +/- *Triodia basedowii* open tussock grassland and herbland on mobile crests and slopes of sand dunes	Least concern / No concern at present	Grassland	39.9

[1] GTRE mapping for the PL includes polygons with multiple REs (heterogenous polygons). Area calculations used the approximate proportion of REs within each heterogenous polygon.



Legend

Petroleum Lease

Ground-truthed Regional Ecosystem

5.3.13a | 5.3.18a/5.3.18b | 5.3.19 | 5.6.4/5.6.8

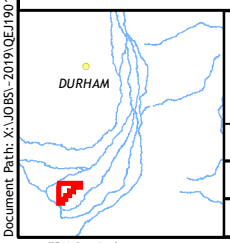
N

Scale 1:55,000 (A4)

0 1 2 3

Kilometres

Coordinate System: GDA 1994 MGA Zone 54
Projection: Transverse Mercator



Notes:
Aerial Imagery: © ESRI 2019
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2	Issued for Use	DL	JVO	26/02/2021
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FIGURE 4: GROUND-TRUTHED REGIONAL ECOSYSTEMS - PL 1058

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1 of 1	QEJ19010	2

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4.2.2 Threatened and special least concern species

While no NC Act listed threatened species were identified within the PL during the field assessment, the likelihood of occurrence assessment (Appendix C) identified that the PL is likely to provide habitat for one threatened species listed under the NC Act. Namely, grey grasswren, listed as endangered/near threatened under the NC Act.

As discussed within Section 4.1.1, the subspecies status of grey grasswren within the Cooper Creek floodplain is uncertain (Black *et al*. 2011; DEE 2019). The Cooper Creek population may comprise either the Bulloo subspecies (*Amytornis barbatus barbatus*), listed as endangered under the NC Act; or the Diamantina subspecies (*Amytornis barbatus diamantina*), listed as near threatened under the NC Act. In light of this uncertainty, for the purposes of this report, the grey grasswren population has been assumed to comprise the Bulloo subspecies, listed as endangered under the EPBC Act and NC Act.

Habitat for grey grasswren within the PL is mapped within Figure 5. As identified in Section 4.1.1, fauna habitat mapping is based on GTRE mapping (Figure 4), which includes mixed RE polygons. As such, where a species habitat is associated with any of the REs that comprise a mixed polygon, the entire polygon was mapped as habitat. Consequently, the mapped fauna habitat depicted (Figure 5) may include areas of RE that are not habitat for the species. Associated extent of habitat within the mixed polygon is dependent on the percentage of REs identified as suitable habitat within the polygon.

A further five species listed under the NC Act as special least concern are considered likely to occur (Appendix C), including:

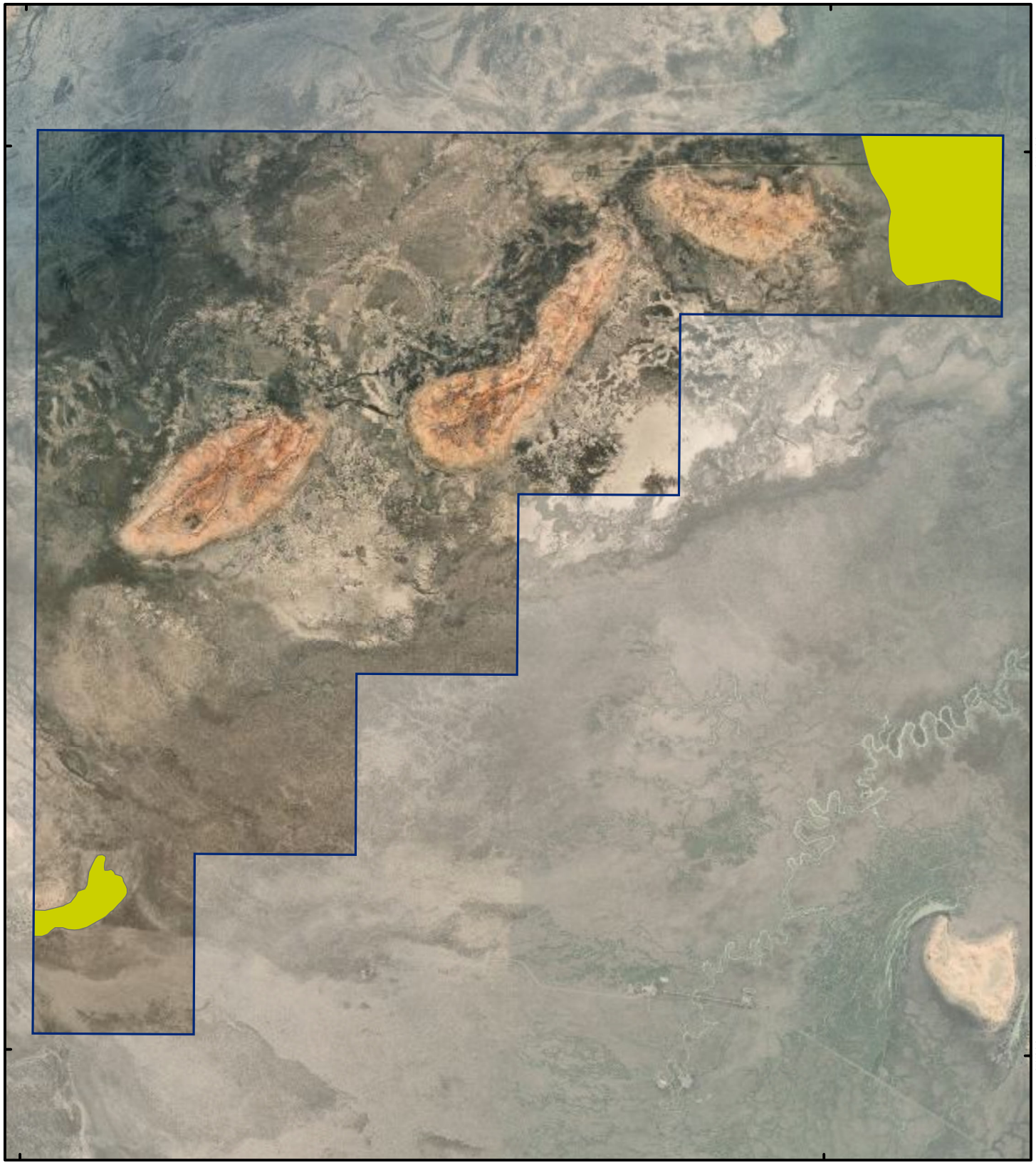
- fork-tailed swift
- sharp-tailed sandpiper
- glossy ibis
- gull-billed tern; and
- short-beaked echidna.

Of these special least concern species, only short-beaked echidna is listed as a MSES under the EO Regulation. Habitat associations for MSES and other special least concern species likely to occur within the PL are summarised in Table 3.

A further 10 species listed under the NC Act as threatened or special least concern are considered to have the possibility of occurrence within the PL; however, the likelihood of these species occurring has been reduced primarily due to the absence of previous records within 100 km of the PL or the marginal quality of potential habitat for each species within the PL (Appendix C).

Table 3 Threatened and special least concern species likely to occur within the PL

Species	NC Act status	RE associations	Area within the PL (ha)
Fork-tailed swift (*Apus pacificus*)	Special least concern	All REs	4,851.1
Glossy ibis (*Plegadis falcinellus*)	Special least concern	REs associated with riverine and palustrine wetlands, including: 5.3.13a and 5.3.18a	818.3
Grey grasswren (*Amytornis barbatus*)	Endangered or near threatened	REs containing lignum (*Duma florulenta*) and swamp canegrass (*Eragrostis australasica*) thickets, which solely comprises 5.3.13a within the PL	224.3
Gull-billed tern (*Gelochelidon nilotica*)	Special least concern	REs associated with riverine and palustrine wetlands, including: 5.3.13a and 5.3.18a	818.3
Sharp-tailed sandpiper (*Calidris acuminata*)	Special least concern	REs associated with riverine and palustrine wetlands, including: 5.3.13a and 5.3.18a	818.3
Short-beaked echidna (*Tachyglossus aculeatus*)	Special least concern	All REs	4,851.1



Legend

- Petroleum Lease
- **Threatened Species Habitat**
  - Grey Grasswren

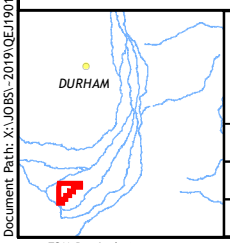
N

Scale 1:55,000 (A4)

0 1 2 3

Kilometres

Coordinate System: GDA 1994 MGA Zone 54
Projection: Transverse Mercator



Notes:
Aerial Imagery: © ESRI 2019
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MSES: © DNRME 2017

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2	Issued for Use	DL	JVO	19/02/2021
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FIGURE 5: THREATENED SPECIES HABITAT - PL 1058

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4.2.3 Wetlands

The majority of the PL is located on alluvial soils within the Cooper Creek floodplain. Vegetation communities within these alluvial soils may be seasonally inundated, with the frequency of inundation playing a large role in the distribution of REs present (Queensland Herbarium 2019a). Wetland values identified within the PL include REs listed within the REDD (Queensland Herbarium 2019a), to contain:

- palustrine wetland; and
- floodplain (other than floodplain wetlands).

The August 2019 survey was undertaken following a major flooding event. Areas flooded typically corresponded to REs listed as containing palustrine wetland in the REDD (Queensland Herbarium 2019a), while areas not flooded occurred on higher ground, or outside of the floodplain (Photograph 1).

Photograph 1 RE 5.3.18a that was recently flooded and listed as a wetland RE (left) and RE 5.3.19, that had not been recently flooded and is not listed as a wetland RE (right)

4.2.4 Waterways

The field assessment and analysis of high-resolution satellite imagery identified that all watercourse channels and drainage features within the PL are minor, with a size that is reflective of a stream order 1 (Photograph 2).

The *vegetation management watercourse and drainage feature map* identifies 7.0 km of stream order 8 watercourses and drainage features within the PL. The location of defining banks for Vegetation Management Watercourses was estimated by buffering the centreline of Vegetation Management Watercourses by 25 m on each side i.e. this assumes a typical watercourse channel width of 50 m. Assessment of the MSES regulated vegetation – intersecting a watercourse is discussed in Section 5.3.2.

No watercourse was considered to comprise the MSES 'waterway providing for fish passage'. The EO Regulation states that '*waterway providing for passage of fish is a matter of State environmental significance only if the construction, installation or modification of waterway barrier works carried out under an authority will limit the passage of fish along the waterway*'. As the proposed development will not limit fish passage within the Cooper Creek floodplain, this MSES does not apply.

Note: ground-truthing of watercourse and drainage feature centrelines and high-banks was not conducted, due to the high density of braided channels making ground-truthing unfeasible.

Photograph 2 Typical drainage feature within the PL (left) and view of braided channel complex within the PL (right)

4.2.5 Corridors and connectivity

The PL entirely contains remnant RE, with unimpeded habitat connectivity to adjacent contiguous habitats, particularly the Cooper Creek floodplain surrounding the PL. The entire the PL is located within the Channel Country SEA and partially contains a state-wide terrestrial biodiversity corridor. The PL contains environmental attributes characteristic of the Channel Country SEA, as identified within the *Regional Planning Interests (RPI) Regulation 2014*, including:

- natural, unrestricted flows in and along stream channels and the channel network in the area
- overflow from stream channels and the channel network onto the flood plains of the area, or the other way
- natural flow paths of water across flood plains connecting waterholes, lakes and wetlands in the area
- the natural water quality in the stream channels and aquifers and on flood plains in the area; and
- the beneficial flooding of land that supports flood plain grazing and ecological processes in the area.

The MSES 'connectivity areas' includes all remnant vegetation that is required for ecosystem functioning. As the entire PL contains remnant RE and is connected to extensive areas of adjacent remnant vegetation, the entire PL is considered to comprise the MSES connectivity areas.

4.2.6 Introduced/non-native flora

No introduced/non-native flora species listed as Weeds of National Environmental Significance (WONS) or under the Queensland *Biosecurity Act 2014*, were recorded within the PL.

4.2.7 Fauna habitat

Incidental fauna observations recorded during the field survey are provided within Appendix B. Fauna species observed predominantly comprised bird species recorded opportunistically. In addition to habitat for threatened fauna discussed in the 'threatened species' section above, the PL contained a diversity of fauna habitat features for least concern (NC Act) fauna, including:

- extensive alluvial soils forming deep cracks, which provide habitat for cryptic reptiles and small mammals
- decorticating bark, which provide potential habitat for microchiropteran bats and arboreal reptiles
- dense leaf litter for cryptic reptiles and small mammals; and
- bird nests.

4.2.8 Matters of State Environmental Significance

Seven MSES have been identified as known or likely to occur within the PL (Table 4). These MSES are associated with habitat for threatened and special least concern species, regulated vegetation, connectivity areas and the Channel Country SEA.

Table 4 MSES summary

MSES	Report section	Area within the PL (ha)
Regulated vegetation: • within 100 m of a Vegetation Management Wetland • intersecting a watercourse	Section 4.2.3 Section 4.2.4	54.7 7.0 km of DNRME mapped vegetation management watercourses and drainage features. A maximum estimated area of regulated vegetation - intersecting a watercourse was 174.2 ha (refer to Section 4.2.4)
Connectivity areas	Section 4.2.5	4,851.1
Wetlands and watercourses - High Ecological Significance wetlands	Section 4.2.3	35.9
Designated precinct in the Channel Country SEA	Section 4.2.5	4,851.1
Protected wildlife habitat for: grey grasswren, listed as endangered Short-beaked echidna, listed as special least concern. A further four special least concern bird species are considered likely to occur within the PL; however, only short-beaked echidna is listed as a MSES under the EO Regulation	Section 4.2.2	 224.3 4,851.1
Protected areas	N/a	0
Highly protected zones of State marine parks	N/a	0
Fish habitat areas	N/a	0
Waterway providing for fish passage	Section 4.2.4	0
Marine plants	N/a	0
Legally secured offset areas	N/a	0

5 Impacts and mitigation

5.1 Potential impacts

The proposed works are for the construction of ten petroleum well leases and associated infrastructure including borrow pits, pipeline right of ways and access tracks. The location and extent of disturbance footprints are under investigation and are preliminary in nature. The preliminary disturbance footprints for each of the ten wells and associated infrastructure are identified within Table 5.

The preliminary disturbance footprint comprises a total area of 116 ha, which includes 39 ha to be rehabilitated post-construction and 77 ha to be rehabilitated at the end of the asset's life. Preliminary disturbance footprints are conservative and, for the purposes of impact assessment, a large proportion of the proposed disturbance footprint has been located within 'high constraint' areas, where appropriate (refer to Section 5.2 and 5.3). As such, the assessment of impacts within this report takes a precautionary approach and simulates a conservative disturbance scenario.

Potential impacts arising from the proposed works include:

- removal of native vegetation
- removal of fauna habitat for native species, including potentially suitable habitat for threatened species
- potential injury and death of native fauna associated with vegetation removal and operational activities
- modification of overland flow/hydrology
- sedimentation and erosion, particularly during flood events; and
- introduction and spread of pest species.

Table 5 Proposed disturbance footprint assumptions per well

Infrastructure type	Surface disturbance (ha)	Area rehabilitated post-construction (ha)	Area for final rehabilitation at end of life (ha)
Well pad	1.65	0	1.65
Flowline	4.8 (16 m flowline disturbance width)	3.9	0.9
Access track	3.9 (13 m unsealed access track width)	0	3.9
Borrow pits	1.25	0	1.25
Total per well	**11.6**	**3.9**	**7.7**

5.2 Significant residual impact assessment

5.2.1 Matters of National Environmental Significance

The field assessment identified that the PL contains habitat for grey grasswren. In light of the uncertainty regarding the subspecies status of the Cooper Creek population (refer to Section 4.1.1), it has been assumed to comprise the EPBC Act listed endangered bulloo subspecies. The Australian Government has produced the *Matters of National Environmental Significance: Significant Impact Guidelines 1.1* (2013) (MNES Referral Guidelines) to assist in determining if residual impacts associated with a proposed development requires referral. An assessment against the MNES Referral Guidelines is provided in Appendix D. In summary it was determined that the PL is likely to provide habitat for the grey grasswren. The proposed works are considered unlikely to result in a significant impact to the species as:

- The proposed works will require the clearing of approximately 11.6 ha of grey grasswren habitat, which represents 5.2% of the grey grasswren habitat identified within the PL. Given suitable habitat for the species is widely available within the PL and the surrounding Cooper Creek floodplain, the proposed works are unlikely to impact the local population of the species.
- Lignum, which is the key habitat feature for the species, rapidly re-establishes within disturbed areas following flood events (Dawson *et al*. 2017; Higgisson, Briggs & Dyer 2018). Approximately 3.9 ha of the disturbance footprint is proposed for rehabilitation, which includes pipeline right of ways, sump pits and a proportion of the lease areas. These areas are expected to re-establish to suitable habitat for grey grasswren.
- Management measures have been identified to mitigate impacts on the species habitat (Section 5.3.3).

In addition, habitat for four migratory bird species was identified within the PL. Significant impact for these species is unlikely as the PL is not considered to meet the definition of 'important habitat' for these species (Section 4.1.2).

5.2.2 Matters of State Environmental Significance

Assessments against the *Queensland Environmental Offsets Policy Significant Residual Impact Guideline* (SRI Guideline) (DES 2014) were conducted to determine if offsets are likely to be required for impacts to MSES (Appendix E). SRI assessments determined that SRI to all MSES known or likely to occur within with PL is unlikely. In summary it was determined that the proposed works will require the clearing of up to approximately:

- 11.6 ha of grey grasswren habitat, which represents 5.2% of the species habitat identified within the PL. A SRI to the species is unlikely for the reasons identified within Section 5.2.1.
- 116 ha of echidna habitat, which represents 2.4% of the species habitat identified within the PL. A SRI to the species is unlikely as:
  - The proposed clearing comprises a negligible proportion of the species habitat, which is widely available within and surrounding the PL.
  - Management measures have been identified to mitigate impacts on the species habitat (Section 5.3).
  - The proposed clearing will not increase fragmentation of the species habitat.
- 1.3 ha of MSES regulated vegetation – within 100 m of a Vegetation Management Wetland, which represents 2.4% of this MSES identified within the PL. This disturbance area is based on an assumed maximum disturbance of this MSES. The proposed disturbance is less than the residual impact criteria

for both linear and non-linear infrastructure (refer to Section 5.3.2). As such, a SRI to this MSES is unlikely.

- 0.9 ha of High Ecological Significance wetland, which represents 2.5% of this MSES identified within the PL. This disturbance area is based on an assumed maximum disturbance of this MSES. A significant residual impact to this MSES is unlikely as:
  - During detailed design stages, infrastructure will be micro-sited to minimise impacts to HES wetlands.
  - Construction and rehabilitation works will be timed to occur outside of flood periods, which will minimise impacts on wetland values.
  - Approximately 0.3 ha of disturbed area will be immediately rehabilitated post-disturbance, which includes pipeline Right of Ways and a portion of disturbance for well leases and sump pits. Rehabilitation is expected to rapidly reinstate a vegetation community consistent with the pre-disturbance vegetation.
  - Vegetation communities within the disturbance footprint contain no to very limited woody vegetation, which minimises impact to soil stability.
  - The proposed works are unlikely to affect the hydrological processes or water quality of the wetland.
- 116 ha of a 'designated precinct' within the Channel Country Strategic Environmental Area, which represents 2.4% of this MSES identified within the PL. The proposed works are unlikely to have a SRI on any environmental attribute of the Channel Country SEA. Environmental attributes associated with the Channel Country SEA are largely associated with water quality, hydrologic and geomorphic processes and beneficial flooding, which are unlikely to be significantly affected by the proposed works. Furthermore, the proposed works will not impact the suitability of land in the area to be used for grazing, which is the primary land use for the PL.
- 116 ha of a connectivity area, which represents 2.4% of this MSES identified within the PL. While the Landscape Fragmentation and Connectivity Tool (DES 2018) could not be used as the location of disturbance has not been confirmed, the scale of the disturbance in relation to the extensive areas of remnant regional ecosystem in the surrounding region result in an unlikely SRI on Connectivity.

In addition, areas of regulated vegetation – intersecting a watercourse may require clearing. The project will avoid the placement of non-linear infrastructure within the defined distance of the defining bank of regulated vegetation intersecting a watercourse (refer to Section 5.3.2), where practicable. Where disturbance occurs within the defined distance of a Vegetation Management Watercourses and Drainage Features and within 5 m of the defining bank, it will comply with SRI clearing limits. As such, a SRI to this MSES is unlikely.

5.3 Mitigation measures

The EPBC Act Environmental Offsets Policy (DSEWPC 2012) and Queensland Environmental Offsets Policy (DES 2019) require proponents to take all reasonable avoidance and mitigation measures to remove or reduce potential impact to MNES and MSES. The following section identifies measures to avoid, minimise and mitigate potential ecological impacts associated with the proposed petroleum infrastructure. Application of these measures is likely to avoid significant residual impact to MNES and MSES.

5.3.1 Impact avoidance

A risk-based approach has been used to identify environmentally constrained areas within the PL (Figure 6). Where possible, avoidance of disturbance to environmentally constrained areas is preferred. The level of environmental constraint has been determined using the following framework.

High constraint

The proposed petroleum activities within high constraint areas have substantial potential to result in a SRI. High constraint areas require targeted impact avoidance, minimisation and mitigation measures to be implemented to avoid a SRI, which are in addition to the typical ecological management measures employed. Targeted management measures to avoid a SRI are identified within Sections 5.3.2 and 5.3.3. High constraint areas within the PL have been identified as areas that:

- Are located within Queensland Government mapped MSES regulated vegetation – within 100 m of a Vegetation Management Wetland; and
- Provide habitat for threatened species listed under the EPBC Act and/or NC Act. Of relevance to the PL, this includes grey grasswren, which inhabit REs dominated by lignum (*Duma florulenta*) and swamp canegrass (*Eragrostis australasica*).

Areas that meet these criteria are shown in Figure 6. High constraint areas also provide habitat for non-threatened MNES and special least concern fauna species, including the sharp-tailed sandpiper, glossy ibis and gull-billed tern.

Moderate constraint

The proposed petroleum activities are unlikely to result in an SRI within moderate constraint areas provided general ecological management measures, typical for the petroleum activities, are employed. Moderate constraint areas within the PL have been identified as areas containing Queensland Government mapped regulated vegetation – within 100 m of a Vegetation Management Wetland (Section 4.2.3), which have not already been included in the 'high constraint' areas; or, provide habitat for a threatened MNES/MSES species, which have not already been included in the 'high constraint' areas.

Low constraint

The proposed petroleum activities within low constraint areas have limited potential to result in a SRI. Of relevance to the PL, these areas include all other REs that provide habitat for MNES/MSES species, including fork-tailed swift and short-beaked echidna.

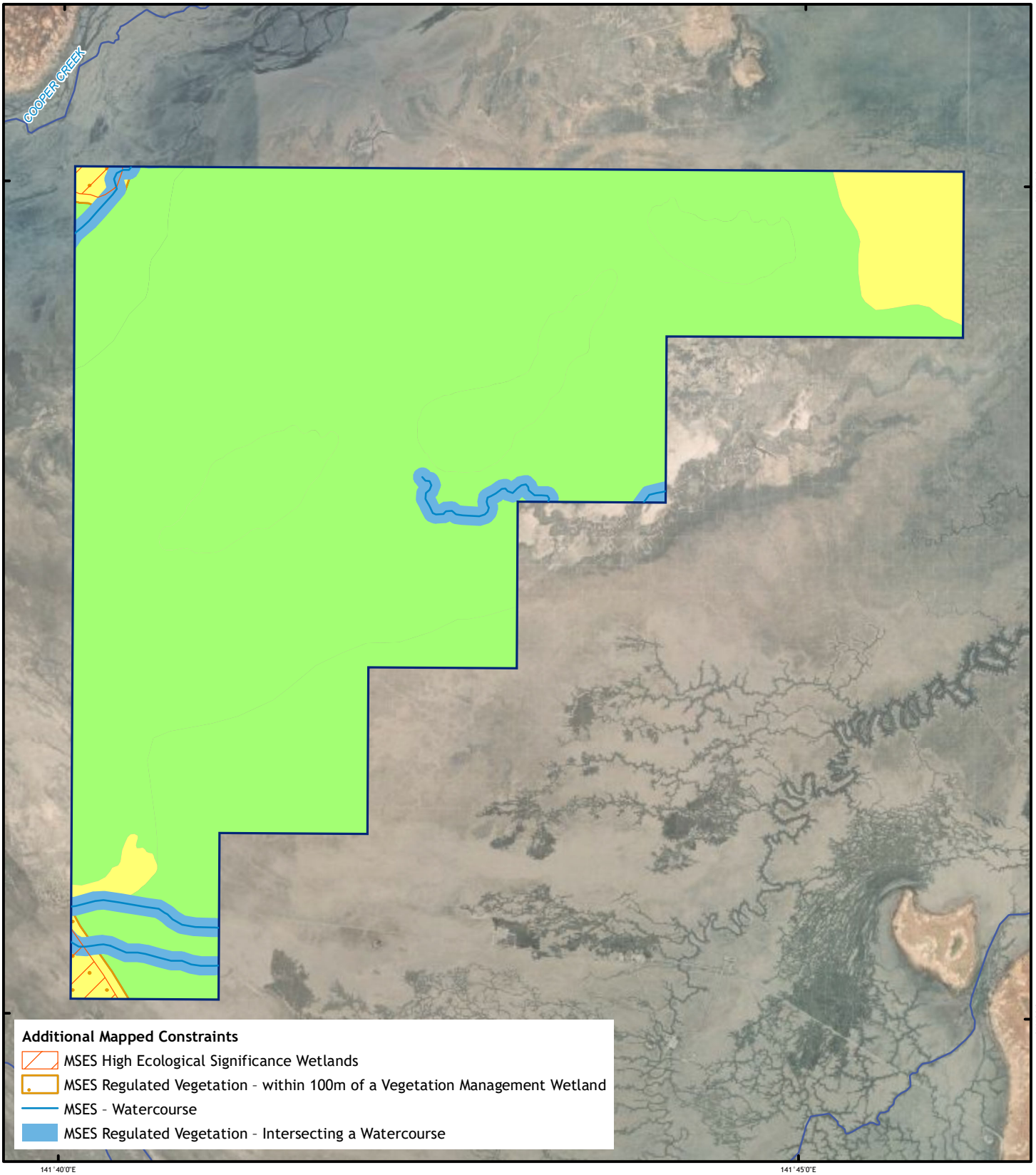
Additional mapped constraints

The high, moderate and low constraint areas discussed above are based on ecological values ground-truthed within the PL. In addition to ground-truthed values, the PL is mapped to contain environmental constraints that represent legislative 'triggers'. Should works be proposed in these mapped legislative trigger areas, additional assessment may be required to demonstrate the mapped environmental values

are not present and/or inform an assessment by the relevant regulatory agency. The mapped additional legislative considerations within the PL include:

- MSES High Ecological Significance wetlands; and
- MSES regulated vegetation - intersecting a watercourse, which due to the nature of braided river channels throughout the Cooper Creek floodplain are likely to be inaccurate in their location.

In addition, the PL is entirely mapped within the Channel Country SEA. A SRI to a SEA may arise where a resource activity impacts a feature, quality, characteristic or other attribute of the area or the land use suitability (i.e. for grazing). Any future resource activity within the SEA will require a regional interest development approval (RIDA) issued under section 53 of the RPI Act. The RIDA application would assess the impacts of the proposed resource activity on the environmental attributes associated with the Channel Country SEA and consider suitable measures to avoid, minimise or mitigate impacts to the SEA such that a SRI does not occur.



Legend

- Road
- Major Watercourse
- Petroleum Lease

Constraint Areas

- High
- Moderate
- Low

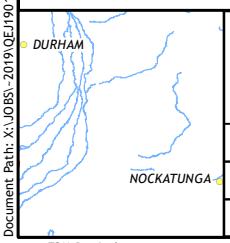
N

Scale 1:59,800 (A4)

0 1 2

Kilometres

Coordinate System: GDA 1994 MGA Zone 54
Projection: Transverse Mercator



Notes:
Aerial Imagery: © ESRI 2019
Petroleum Leases: © DNRME 2019
MSES Regulated Vegetation: DNRME 2017
MSES High Ecological Significance: © DNRME 2017
Watercourse: © Geoscience Australia 2018
MSES Regulated Vegetation wetlands: © DNRME 2019

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2	Issued for Use	DL	JVO	26/02/2021
1	Issued for Use	DL	JVO	19/02/2021

FIGURE 6: ENVIRONMENTAL CONSTRAINTS - PL 1058

Ecological Assessment Report
Santos

Map Number	Job Number	Rev
1 of 1	QEJ19010	2

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5.3.2 Impact minimisation

Significant Residual Impact Guideline Clearing Limits – Regulated Vegetation

The **SRI Guideline** (DEHP 2014) provides criteria for identifying when an impact to a MSES may be deemed to be significant. The SRI guideline contains tests and criteria that provide a trigger for when Environmental Offsets may be required.

The SRI Guideline provides test criteria for two MSES occurring within the PL, namely:

- Regulated vegetation:
  - within 100 m of a Vegetation Management Wetland; and
  - intersecting a watercourse.

Section 2.1 of the SRI Guideline states that for an SRI to occur for these MSES, proposed disturbance must exceed clearing area and width limits (refer to Table 6), and clearing must occur within a specific distance of the 'defining bank' of the wetland or watercourse.

For the purposes of this SRI assessment, the following rules and assumptions have been applied:

For clearing in the portion of a regional ecosystem that lies within a mapped wetland:

1. Vegetation Management Wetlands are as per the Regulated Vegetation Management Map to the extent the regional ecosystem contains remnant vegetation.
2. The 'defining bank' of a VMA wetland is as per the map (i.e. the defining bank is the mapped polygon edge of the wetland).

For clearing in a regional ecosystem that is within the defined distance of a watercourse:

1. Vegetation Management Watercourses are as per the Vegetation Management Watercourse and Drainage Feature Map (as per Section 20AA of the VMA) to the extent the regional RE contains remnant vegetation.
2. Defined distance from the defining banks of Vegetation Management Watercourses is as per the Queensland Environmental Offsets Policy V1.9 (DES 2020) using stream order as per the Vegetation Management Watercourse and Drainage Feature Map.
3. The location of defining banks for Vegetation Management Watercourses was estimated by buffering the centreline of Vegetation Management Watercourses by 25 m on each side (i.e. this assumes a typical watercourse channel width of 50 m).

The maximum area of regulated vegetation - intersecting a watercourse was estimated by buffering the Vegetation Management Watercourse and Drainage Feature Map by the defined distance as per the Queensland Environmental Offsets Policy V1.9 (DES 2020), using stream order as per the Vegetation Management Watercourse and Drainage Feature Map.

Other MNES and MSES do not have prescribed clearing area test criteria within the SRI Guideline (DEHP 2014) or the Commonwealth MNES Significant Impact Guidelines (DotE 2013).

Table 6 Significant Residual Impact test criteria and impact minimisation measures

MSES	Infrastructure type	SRI test criteria (DEHP 2014)	Impact minimisation for the project
Regulated vegetation - within 100 m of a Vegetation Management Wetland	Linear	20 m wide in a sparse or very sparse RE; or 25 m wide in a grassland RE. Clearing must also occur within the wetland or within 50 m of the defining bank to trigger a SRI (as described in Section 5.3.2).	Linear infrastructure will be located outside Vegetation Management Wetlands, and greater than 50 m from the defining bank, where practicable. Where disturbance occurs in Vegetation Management Wetlands and within 50 m of the defining bank, it will comply with SRI clearing limits.
	Non-linear	2 ha within a sparse or very sparse RE; or 5 ha within in a grassland RE. Clearing must also occur within the wetland or within 50 m of the defining bank to trigger a SRI (as described in Section 5.3.2).	Non-linear infrastructure will be located outside Vegetation Management Wetlands, and greater than 50 m from the defining bank, where practicable. Where disturbance occurs in Vegetation Management Wetlands and within 50 m of the defining bank, it will comply with SRI clearing limits.
Regulated vegetation - intersecting a watercourse	Linear	20 m wide in a sparse or very sparse RE; or 25 m wide in a grassland RE. Clearing must also occur within the defined distance or within 5 m of the defining bank to trigger a SRI (as described in Section 5.3.2).	Linear infrastructure will be located outside the defined distance from the defining banks of Vegetation Management Watercourses and Drainage Features, where practicable. Where disturbance occurs within the defined distance of Vegetation Management Watercourses and Drainage Features and within 5 m of the defining bank, it will comply with SRI clearing limits.
	Non-linear	2 ha within a sparse or very sparse RE; or 5 ha within a grassland RE. Clearing must also occur within the defined distance or within 5 m of the defining bank to trigger a SRI (as described in Section 5.3.2).	Non-linear infrastructure will be located outside the defined distance from the defining banks of Vegetation Management Watercourses and Drainage Features, where practicable. Where disturbance occurs within the defined distance of Vegetation Management Watercourses and Drainage Features and within 5 m of the defining bank, it will comply with SRI clearing limits.

Siting and co-location of linear infrastructure

Co-location of linear infrastructure including access tracks and flowlines, potentially reduces the total disturbance footprint and reduces habitat fragmentation. When assessing route optimisation Santos may consider combining access track and flowlines into a single disturbance footprint and/or co-locating linear infrastructure within existing disturbed areas, where possible. The sparse nature of vegetation may also enable areas of woody vegetation to be avoided by linear infrastructure.

5.3.3 Impact mitigation

Management measures to further mitigate ecological impacts and avoid SRI resulting from the proposed development are identified within Table 7.

Table 7 Impact mitigation measures

Impact mitigation measures
During construction
Vegetation to be retained adjacent to proposed disturbance areas will be suitably demarcated where required (e.g. using marker pegs, flagging tape).
Clearing of vegetation is to be undertaken by a suitably qualified contractor.
Disturbance activities will be excluded from areas of retained vegetation.
Erosion and sediment control measures implemented where appropriate.
Hygiene protocols implemented as appropriate to minimise the introduction, spread and persistence of weeds, pest plants, animals and pathogens.
Measures implemented to reduce risks to fauna from entrapment and injury in pipes and excavations, including: • Use of a qualified fauna spotter/catcher where required. • Pipes capped to prevent fauna entrapment during construction or after abandonment. • Facilities (e.g. borrow pits, well cellars) are designed and constructed as far as practicable to minimise impacts to fauna. • Borrow pits are not established in locations which pose an unacceptable hazard to livestock. • Sumps, mud pits and other pits holding fluid are fenced as appropriate to minimise fauna (medium to large) and livestock access. • Minimising the period trenches remain open to as short as reasonably practicable. • Regular inspections of open excavations / trenches and prior to backfilling. • Provision of escape ramps and refuge material for fauna that do enter trenches. • Hollow logs (located on ground) within disturbance areas retained and shifted to adjacent undisturbed areas.

Impact mitigation measures

Post construction

Flowline Right of Ways will be reinstated as soon as practicable following gathering line / pipeline installation. The rehabilitation works are expected to mitigate the majority of impacts resulting from disturbance for flowline construction. Rehabilitation aims to reshape and stabilise disturbed areas to provide appropriate site conditions to facilitate natural revegetation processes, and will include the following activities (where appropriate):

- ripping of areas of compacted soil (except on sensitive soils / environments).
- respreading of stockpiled topsoil, vegetation and seed stock (where available) to facilitate natural revegetation; and
- restoration of natural landform contours.

Final rehabilitation of disturbed areas would be undertaken to achieve the final rehabilitation criteria conditions specified in the relevant Environmental Authority.

Threatened species specific mitigation measures

- Where threatened species nests are identified to be present, disturbance should be avoided.
- If disturbance cannot be avoided, clearing of the nest and a surrounding area should be postponed until after the relevant breeding season and/or incubation period.
- Clearing must not occur while the nest is active, with adults, eggs or nestlings.

Grey grasswren:

- Field and desktop based assessments will be undertaken to preferentially place infrastructure/disturbance outside of areas that are likely to represent grey grasswren habitat (where practicable).
- Disturbance of areas that are likely to represent grey grasswren habitat will be preferentially timed to occur outside of the breeding season for the species where practical (breeding behaviour is poorly known but is thought to occur from late July to August (DEE 2019)).
- Typical characteristics of grey grasswren nests are semi-domed nests that are lined with soft grass, plant down, rootlet and sometimes a few feathers (DEE 2019). The species typically nests in lignum and less commonly swamp canegrass (DotE 2014; DEE 2019).
- The DEE (2019) identifies the likely incubation period of eggs to be about 13 to 15 days and a nestling period to be about 12 to 14 days.

Wetland specific mitigation measures

Time construction and rehabilitation activities to occur outside of flood periods.

Where possible, areas to be rehabilitated should be immediately rehabilitated post-disturbance. Rehabilitation areas may include pipeline Right of Ways and a portion of disturbance for well leases and sump pits.

Rehabilitation activities will reinstate natural landform contours to ensure natural surface water flows are not impacted.

Topsoil stockpiles separated from subsoil and maintained to preserve the seedbank (where practicable).

Compaction of topsoil stockpiles avoided.

The topsoil contains an existing seed bank, which will accelerate rehabilitation following a flood event after landform reinstatement.

A topsoil stripping depth of up to 200 mm is generally appropriate to retain the seed bank.

Soils should be replaced in order of excavation wherever practicable to restore subsurface soil horizons.

Impact mitigation measures
No drilling is proposed in waterway channels. Activities to be located away from watercourses and wetlands (GES/HES) wherever practicable. Where activities are to be undertaken in or near HES/GES wetlands, appropriate review, assessment and mitigation measures are implemented to ensure surface water flows are maintained.
Access tracks, infrastructure and seismic lines located, prepared and constructed to maintain pre-existing surface water flows. Culverts and floodways installed where required.
Fuel, oil and chemical storage and handling undertaken in accordance with Australian standards and guidelines (i.e. in bunded areas) and in small volumes wherever practicable. Spill response equipment and materials kept on site and in operational vehicles (where appropriate). In the event of expected flooding, non-essential items/facilities such as chemicals, fuel and oil storages and waste receptacles removed from areas at risk of inundation (where appropriate / safe to do so).
Where possible, restrict the width of linear infrastructure corridors (access tracks and pipeline Right of Ways) to the minimum width practicable at waterway channel crossings. Preferentially select dry crossing sites for linear infrastructure with minimal earthworks requirements. Pre-existing areas of disturbance used to place infrastructure or seismic lines wherever practicable.

5.4 Cumulative impacts

For the purposes of undertaking a cumulative impact assessment, disturbances within the PL have been defined according to:

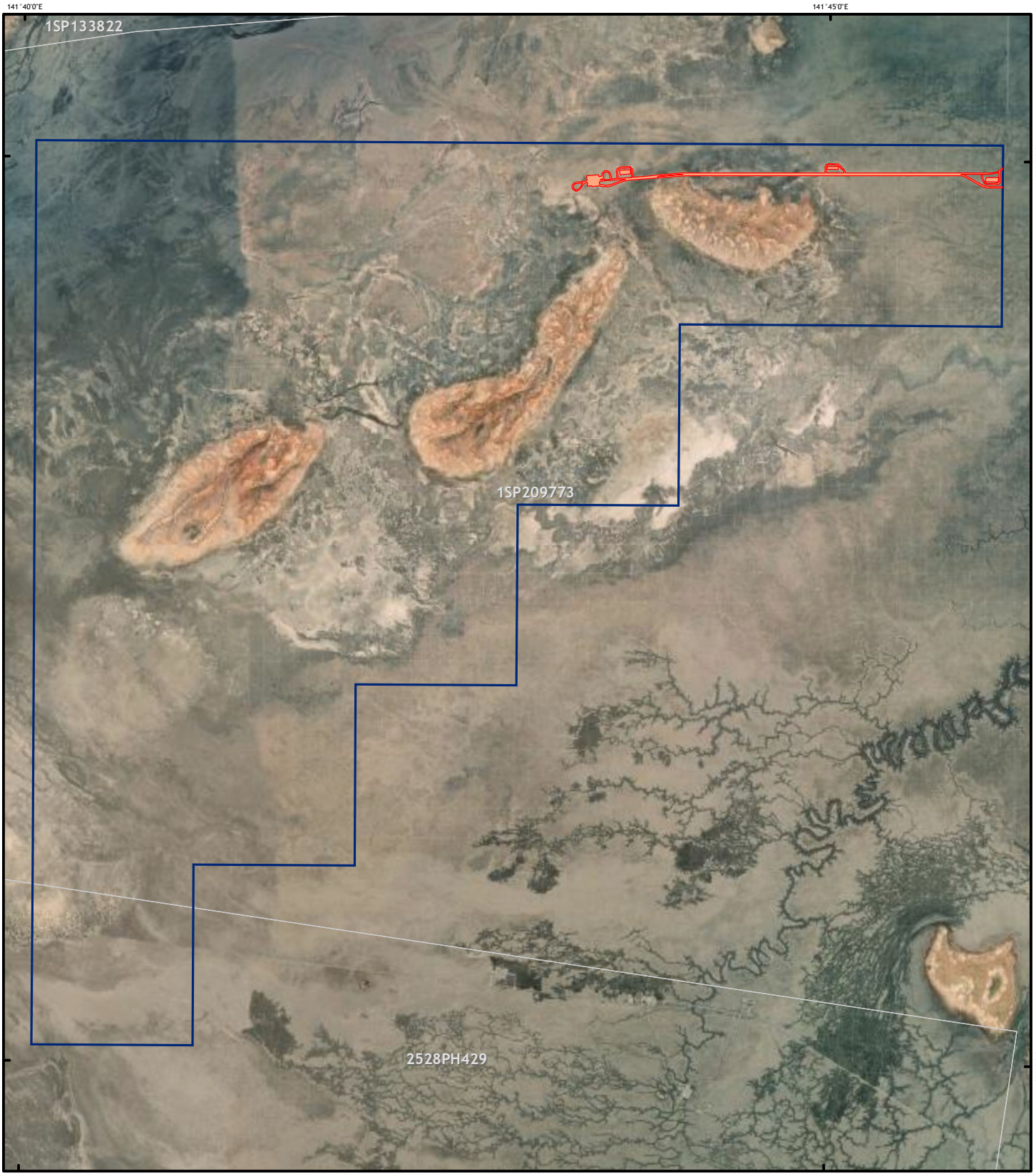
1. **Existing disturbance**: comprises a total area of 16.4 ha, which includes existing well leases, access tracks, flowlines, borrow pits and other disturbance footprints for supporting infrastructure[2].
2. **Proposed disturbance**: comprises a total area of 116 ha. Approximately 39 ha of this area is proposed to be rehabilitated immediately post-construction and 77 ha to be rehabilitated at the end of the asset's life.

The existing disturbance and proposed disturbance areas for each MNES and MSES identified within the PL are summarised within Table 8 and depicted within Figure 7.

[2] Existing disturbance footprints are based on data supplied by Santos on 28 November 2019. Where supplied disturbance feature data comprised point, or line information, a disturbance polygon was created by assuming a 16m wide corridor for pipelines, 6m wide corridor for access tracks and 1.65 ha disturbance area for well leases.

Table 8 MNES and MSES cumulative impact disturbance area

MNES/MSES	Existing disturbance (ha)	Proposed disturbance (ha)
MNES		
Grey grasswren habitat, listed as endangered	4.9	11.6
MSES		
Regulated vegetation:		
• Intersecting a watercourse	0	N/A
• Within 100 m of a Vegetation Management Wetland	0	1.3
Connectivity areas	16.4	116
Wetlands and watercourses - High Ecological Significance wetlands	0	0.9
Designated precinct in the Channel Country SEA	16.4	116
Protected wildlife habitat for:		
• Grey grasswren, listed as endangered	4.9	11.6
• Short-beaked echidna, listed as special least concern. A further four special least concern bird species are considered likely to occur within the PL; however, only short-beaked echidna is listed as a MSES under the EO Regulation.	16.4	116
Protected areas	0	0
Highly protected zones of State marine parks	0	0
Fish habitat areas	0	0
Waterway providing for fish passage	0	0
Marine plants	0	0
Legally secured offset areas	0	0



Legend

- Petroleum Lease
- Cadastre
- Existing Disturbance

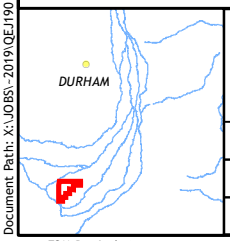
N

Scale 1:55,000 (A4)

0 1 2 3

Kilometres

Coordinate System: GDA 1994 MGA Zone 54
Projection: Transverse Mercator



Notes:
Aerial Imagery: © ESRI 2019
Cadastre: © DNRME 2019
Petroleum Lease: © DNRME 2019
MSES: © DNRME 2017

Rev	Description	Drawn	Approved	Date
2	Issued for Use	DL	JVO	26/02/2021
1	Issued for Use	DL	JVO	19/02/2021

FIGURE 7: CUMULATIVE IMPACT - PL 1058

Ecological Assessment Report
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Map Number	Job Number	Rev
1 of 1	QEJ19010	2

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6 Legislative compliance

6.1 Summary

6.2 Commonwealth legislation

6.2.1 Environment Protection and Biodiversity Conservation Act 1999

Preliminary assessments against the Australian Government MNES Referral Guidelines (DotE 2013) were conducted to assist in determining if residual impacts associated with a proposed development requires referral. In summary, it was determined that the proposed works are unlikely to result in a significant impact to MNES. Based on the findings of the preliminary assessment against the MNES Referral Guidelines, the proposed development is unlikely to require a referral to the DAWE. Significant Impact assessments are summarised within Section 5.2.1 and provided in detail in Appendix D.

6.3 State legislation

6.3.1 Environmental Offsets Act 2014

Assessments against the *Queensland Environmental Offsets Policy Significant Residual Impact Guideline* (DES 2014) were conducted to determine if offsets are likely to be required for impact to MSES. In summary, SRI assessments determined that SRI to all MSES known or likely to occur within with the PL is unlikely. As such, environmental offsets under the EO Act are unlikely to be required for the project. SRI assessments are summarised within Section 5.2.2 and provided in detail in Appendix E.

6.3.2 Environmental Protection Act 1994

No Category A, B or C ESAs were identified within the PL during the desktop and field assessments. Ground-truthing of watercourses as defined under the EP Act was not conducted (Section 4.2.4).

6.3.2.1 NC Act Protected Plants

The PL does not contain mapped 'high risk' areas, and as such the provisions of the *Flora Survey Guidelines - Protected Plants* do not apply. However, any threatened plant occurring 'in the wild' cannot be knowingly cleared or impacted without a clearing permit. If a protected plant is identified within the disturbance footprint and requires removal, a clearing permit will be needed.

7 Conclusion

Santos is proposing new petroleum activities within PL 1058 (Bearcat). Desktop and field assessments were conducted to identify environmental values that are known, or are likely, to occur within the PL.

MNES identified within the PL include:

- One species, grey grasswren, listed as endangered under the EPBC Act; and
- Four species listed as migratory under the EPBC Act.

MSES identified within the PL include:

- One species, grey grasswren, listed as endangered under the NC Act
- One species, echidna, listed as special least concern under the NC Act
- Regulated vegetation – within 100 m of a Vegetation Management Wetland
- Regulated vegetation – intersecting a watercourse
- High Ecological Significance wetlands
- Channel Country SEA; and
- Connectivity areas.

No Category A, B or C ESAs under the EP Act occur within the PL. Referable wetlands (High Ecological Significance Wetlands) under the EP Act were identified within the PL.

Commonwealth and Queensland Government legislative frameworks require proponents to take all reasonable avoidance and mitigation measures to remove or reduce potential impact to MNES and MSES (DSEWPC 2012; DES 2019). The mitigation hierarchy of avoid, minimise, mitigate and offset is to be applied in the design process for the proposed petroleum infrastructure. After the application of avoidance, minimisation and mitigation measures it was determined that the proposed development is unlikely to have a significant residual impact on MNES and MSES occurring within the PL.

8 References

Atlas of Living Australia. (2020) Atlas of Living Australia Occurrence Records, https://www.ala.org.au/

Beruldsen, G. (2003) *Australian Birds Their Nests and Eggs*. G. Beruldsen, Kenmore Hills.

Black, A., Carpenter, G., Pedler, R., Pedler, L. & Langdon, P. (2011) Habitats of the Grey Grasswren Amytornis barbatus diamantina and a review of the species' distribution. *Corella*, **36**, 29–37.

Curtis, L.K. & Dennis, A.J. (2012) *Queensland's Threatened Animals* (eds K.R. McDonald, P.M. Kyne, & S.J.S. Debus). CSIRO Publishing, Collingwood.

Dawson, K.S., Warton, D.I., Kingsford, R.T., Berney, P., Keith, D.A. & Catford, J.A. (2017) Plant traits of propagule banks and standing vegetation reveal flooding alleviates impacts of agriculture on wetland restoration. *Journal of Applied Ecology*, **54**, 1907–1918.

Department of Agriculture, Water and the Environment. (2020) Species Profile and Threats Database, http://www.environment.gov.au/cgi-bin/sprat/public/sprat.pl

Department of Environment and Heritage Protection. (2014) *Queensland Environmental Offsets Policy Significant Residual Impact Guideline*. State of Queensland, Brisbane.

Department of Environment and Science. (2019) *Queensland Environmental Offsets Policy v.1.7*. State of Queensland, Brisbane.

Department of Sustainability, Environment, Water, Population and Communities. (2012) *EPBC Act Environmental Offsets Policy*. Australian Government.

Department of the Environment. (2013) *Significant Impact Guidelines 1.1 - Matters of National Environmental Significance*. Commonwealth of Australia.

Department of the Environment. (2014) *Conservation Advice Amytornis Barbatus Barbatus Grey Grasswren (Bulloo)*. Commonwealth of Australia, Canberra.

Department of the Environment and the Government of South Australia Department of Environment, Water and Natural Resources. (2016) *National Recovery Plan for the Plains-Wanderer (Pedionomus Torquatus)*. Commonwealth of Australia, Canberra.

Department of the Environment, Water, Heritage and the Arts. (2008a) *Approved Conservation Advice for Frankenia Plicata*. Commonwealth of Australia, Canberra.

Department of the Environment, Water, Heritage and the Arts. (2008b) *Approved Conservation Advice for Sclerolaena Walkeri*. Commonwealth of Australia, Canberra.

Department of the Environment, Water, Heritage and the Arts. (2008c) *Approved Conservation Advice for Notomys Fuscus (Dusky Hopping-Mouse)*. Commonwealth of Australia, Canberra.

Garnett, S., Szabo, J. & Dutson, G. (2011) *The Action Plan for Australian Birds*. CSIRO Publishing, Melbourne.

Higgins, P.J. (1999) *Handbook of Australian, New Zealand and Antarctic Birds* (eds J.N. Davies & K.Y. Dabbagh). Oxford University Press, Melbourne.

Higgins, P.J. & Davies, S.J.J.F. (1996) *Handbook of Australian, New Zealand and Antarctic Birds*. Oxford University Press, Melbourne.

Higgins, P.J., Peter, J.M. & Steele, W.K. (eds). (2001) *Handbook of Australian, New Zealand and Antarctic Birds*. Oxford University Press, Melbourne.

Higgisson, W., Briggs, S. & Dyer, F. (2018) Seed germination of tangled lignum (Duma florulenta) and nitre goosefoot (Chenopodium nitrariaceum) under experimental hydrological regimes. *Marine and Freshwater Research*, **69**, 1268–1278.

Neldner, V.J., Wilson, B.A., Dillewaard, H.A., Ryan, T.S., Butler, D.W., McDonald, W.J.F., Addicott, E.P. & Appelman, C.N. (2019) *Methodology for Survey and Mapping of Regional Ecosystems and Vegetation Communities in Queensland v.5.0*. Queensland Herbarium, Science and Technology Division, Department of Environment and Science, Brisbane.

Pizzey, G. & Knight, F. (2007) *The Field Guide to the Birds of Australia*. Harper Collins Publishers, Sydney.

Queensland Herbarium. (2019a) *Regional Ecosystem Description Database v.11*. Department of Environment and Science, Brisbane.

Queensland Herbarium. (2019b) *Census of the Queensland Flora 2019*. Department of Environment and Science, Brisbane.

Threatened Species Scientific Committee. (2016a) *Conservation Advice Pezoporus Occidentalis Night Parrot*. Department of the Environment, Canberra.

Threatened Species Scientific Committee. (2016b) *Conservation Advice Macrotis Lagotis Greater Bilby*. Department of the Environment, Canberra.

Threatened Species Scientific Committee. (2016c) *Conservation Advice Petrogale Xanthopus Celeris Yellow-Footed Rock-Wallaby (Central-Western Queensland)*. Department of the Environment, Canberra.

Van Dyck, S. & Strahan, R. (eds). (2008) *The Mammals of Australia*, 3rd ed. New Holland Publishers, Sydney.

Appendix A Database search results

WildNet Records supplied by the Department of Environment and Science (2019)

Kingdom	Family	Scientific name	Common name	NC Act	EPBC Act	Record Date	Locality	Latitude	Longitude
Animalia	Cacatuidae	Lophochroa leadbeateri	Major Mitchell's cockatoo	V	<Null>	1/09/1919	Nappa Merrie HS area	-27.59833	141.1025
Animalia	Laridae	Gelochelidon nilotica	gull-billed tern	SL	<Null>	12/06/1976	LAKE PURE; 80 MLS NORTH OF NAPPA MERRIE	-27.02349	141.17623
Animalia	Laridae	Gelochelidon nilotica	gull-billed tern	SL	<Null>	1/06/1976	LAKE PURE-COOPER CREEK-KARMONA MIDDLE	-27.20682	141.66789
Animalia	Scolopacidae	Calidris acuminata	sharp-tailed sandpiper	SL	<Null>	25/08/1994	Coothero Waterhole- Nockatunga Station	-27.72628	142.71652
Animalia	Tachyglossidae	Tachyglossus aculeatus	short-beaked echidna	SL	<Null>	3/09/2011	QSN3 Wallumbilla - Ballera	-27.14302	142.50749
Animalia	Threskiornithidae	Plegadis falcinellus	glossy ibis	SL	<Null>	1/06/1976	COOPER CREEK - NAPPA MERRIE - MIDDLE	-27.58182	141.2929
Animalia	Threskiornithidae	Plegadis falcinellus	glossy ibis	SL	<Null>	28/10/2012	Wilson River Campground, Noccundra Waterhole, Noccundra, SWQ.	-27.8214	142.58994
Plantae	Asteraceae	Rhodanthe rufescens	<Null>	NT	<Null>	11/08/1987	Noccundra about 130km WNW of Thargomindah.	-27.80681	142.59289

Queensland Government

Department of Environment and Science

Environmental Reports

Matters of State Environmental Significance

For the selected area of interest
pl: 1058

Environmental Reports - General Information

The Environmental Reports portal provides for the assessment of selected matters of interest relevant to a user specified location, or area of interest (AOI). All area and derivative figures are relevant to the extent of matters of interest contained within the AOI unless otherwise stated. Please note, if a user selects an AOI via the "central coordinates" option, the resulting assessment area encompasses an area extending for a 2km radius from the point of interest.

All area and area derived figures included in this report have been calculated via reprojecting relevant spatial features to Albers equal-area conic projection (central meridian = 146, datum Geocentric Datum of Australia 1994). As a result, area figures may differ slightly if calculated for the same features using a different co-ordinate system.

Figures in tables may be affected by rounding.

The matters of interest reported on in this document are based upon available state mapped datasets. Where the report indicates that a matter of interest is not present within the AOI (e.g. where area related calculations are equal to zero, or no values are listed), this may be due either to the fact that state mapping has not been undertaken for the AOI, that state mapping is incomplete for the AOI, or that no values have been identified within the site.

The information presented in this report should be considered as a guide only and field survey may be required to validate values on the ground.

Please direct queries about these reports to: Planning.Support@des.qld.gov.au

Disclaimer

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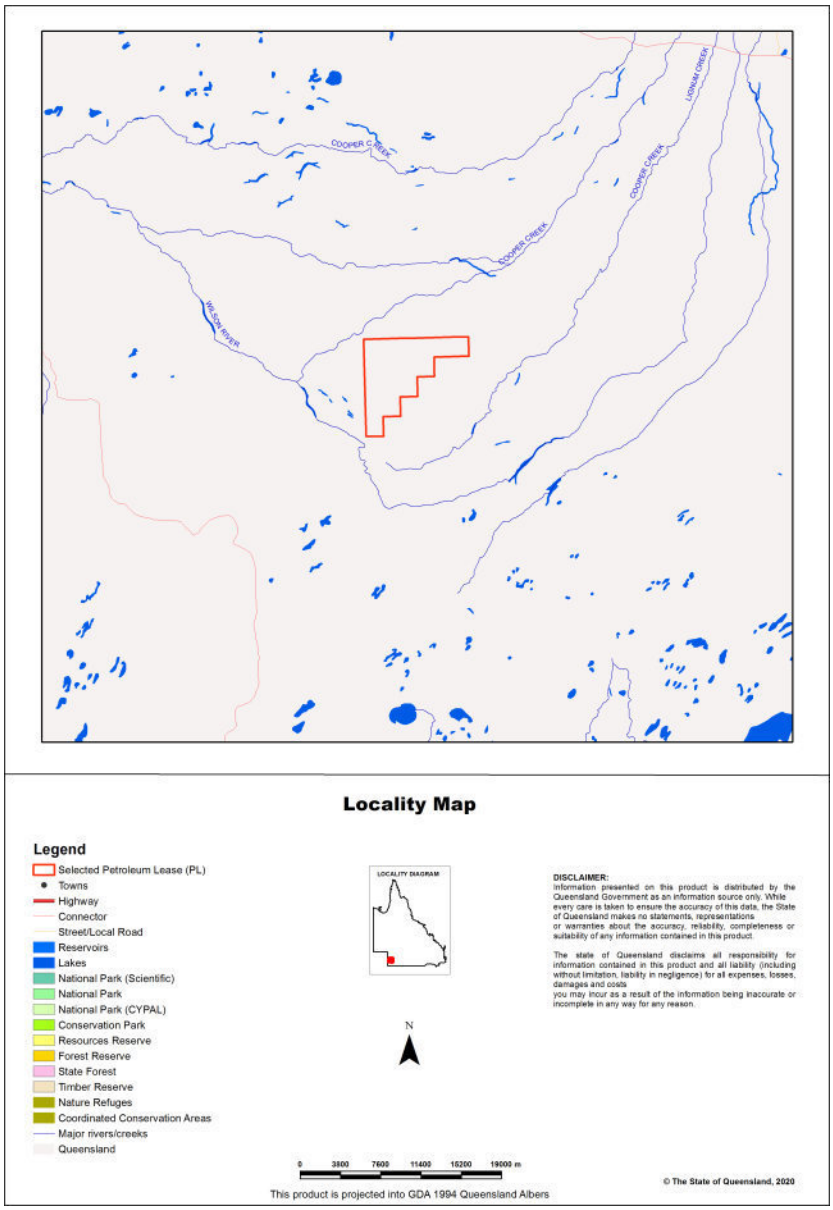
Assessment Area Details

The following table provides an overview of the area of interest (AOI) with respect to selected topographic and environmental values.

Table 1: Summary table, details for AOI pl: 1058

Size (ha)	4,854.4
Local Government(s)	Bulloo Shire
Bioregion(s)	Channel Country
Subregion(s)	Cooper - Diamantina Plains
Catchment(s)	Cooper Creek



Matters of State Environmental Significance (MSES)

MSES Categories

Queensland's State Planning Policy (SPP) includes a biodiversity State interest that states:

'The sustainable, long-term conservation of biodiversity is supported. Significant impacts on matters of national or state environmental significance are avoided, or where this cannot be reasonably achieved; impacts are minimised and residual impacts offset.'

The MSES mapping product is a guide to assist planning and development assessment decision-making. Its primary purpose is to support implementation of the SPP biodiversity policy. While it supports the SPP, the mapping does not replace the regulatory mapping or environmental values specifically called up under other laws or regulations. Similarly, the SPP biodiversity policy does not override or replace specific requirements of other Acts or regulations.

The SPP defines matters of state environmental significance as:

- Protected areas (including all classes of protected area except coordinated conservation areas) under the *Nature Conservation Act 1992* ;

- Marine parks and land within a 'marine national park', 'conservation park', 'scientific research', 'preservation' or 'buffer' zone under the *Marine Parks Act 2004* ;

- Areas within declared fish habitat areas that are management A areas or management B areas under the Fisheries Regulation 2008;

- Threatened wildlife under the *Nature Conservation Act 1992* and special least concern animals under the Nature Conservation (Wildlife) Regulation 2006;

- Regulated vegetation under the *Vegetation Management Act 1999* that is:

    • Category B areas on the regulated vegetation management map, that are 'endangered' or 'of concern' regional ecosystems;

    • Category C areas on the regulated vegetation management map that are 'endangered' or 'of concern' regional ecosystems;

    • Category R areas on the regulated vegetation management map;

    • Regional ecosystems that intersect with watercourses identified on the vegetation management watercourse and drainage feature map;

    • Regional ecosystems that intersect with wetlands identified on the vegetation management wetlands map;

- Strategic Environmental Areas under the *Regional Planning Interests Act 2014* ;

- Wetlands in a wetland protection area of wetlands of high ecological significance shown on the Map of Queensland Wetland Environmental Values under the Environment Protection Regulation 2019;

- Wetlands and watercourses in high ecological value waters defined in the Environmental Protection (Water) Policy 2009, schedule 2;

- Legally secured offset areas.

MSES Values Present

The MSES values that are present in the area of interest are summarised in the table below:

Table 2: Summary of MSES present within the AOI

1a Protected Areas- estates	0.0 ha	0.0 %
1b Protected Areas- nature refuges	0.0 ha	0.0 %
2 State Marine Parks- highly protected zones	0.0 ha	0.0 %
3 Fish habitat areas (A and B areas)	0.0 ha	0.0 %
4 Strategic Environmental Areas (SEA)	4854.4 ha	100.0%
5 High Ecological Significance wetlands on the map of Referable Wetlands	35.83 ha	0.7%
6a High Ecological Value (HEV) wetlands	0.0 ha	0.0 %
6b High Ecological Value (HEV) waterways **	0.0 km	Not applicable
7a Threatened (endangered or vulnerable) wildlife	0.0 ha	0.0 %
7b Special least concern animals	0.0 ha	0.0 %
7c i Koala habitat area - core (SEQ)	0.0 ha	0.0 %
7c ii Koala habitat area - locally refined (SEQ)	0.0 ha	0.0 %
8a Regulated Vegetation - Endangered/Of concern in Category B (remnant)	0.0 ha	0.0 %
8b Regulated Vegetation - Endangered/Of concern in Category C (regrowth)	0.0 ha	0.0 %
8c Regulated Vegetation - Category R (GBR riverine regrowth)	0.0 ha	0.0 %
8d Regulated Vegetation - Essential habitat	0.0 ha	0.0 %
8e Regulated Vegetation - intersecting a watercourse **	7.0 km	Not applicable
8f Regulated Vegetation - within 100m of a Vegetation Management Wetland	54.7 ha	1.1%
9a Legally secured offset areas- offset register areas	0.0 ha	0.0 %
9b Legally secured offset areas- vegetation offsets through a Property Map of Assessable Vegetation	0.0 ha	0.0 %

Additional Information with Respect to MSES Values Present

MSES - State Conservation Areas

1a. Protected Areas - estates

(no results)

1b. Protected Areas - nature refuges

(no results)

2. State Marine Parks - highly protected zones

(no results)

3. Fish habitat areas (A and B areas)

(no results)

Refer to **Map 1 - MSES - State Conservation Areas** for an overview of the relevant MSES.

MSES - Wetlands and Waterways

4. Strategic Environmental Areas (SEA)

Regional planning interest type	Region	Status
Strategic Environmental Area - Designated Precinct	Channel Country	Current - June 2014

5. High Ecological Significance wetlands on the Map of Queensland Wetland Environmental Values

Natural wetlands that are 'High Ecological Significance' (HES) on the Map of Queensland Wetland Environmental Values are present.

6a. Wetlands in High Ecological Value (HEV) waters

(no results)

6b. Waterways in High Ecological Value (HEV) waters

(no results)

Refer to **Map 2 - MSES - Wetlands and Waterways** for an overview of the relevant MSES.

MSES - Species

7a. Threatened (endangered or vulnerable) wildlife

Not applicable

7b. Special least concern animals

Not applicable

7c i. Koala habitat area - core (SEQ)

Not applicable

7c ii. Koala habitat area - locally refined (SEQ)

Not applicable

Threatened (endangered or vulnerable) wildlife habitat suitability models

Species	Common name	NCA status	Presence
Boronia keysii		V	None
Calyptorhynchus lathami	Glossy black cockatoo	V	None
Casuarius casuarius johnsonii	Sthn population cassowary	E	None
Crinia tinnula	Wallum froglet	V	None
Denisonia maculata	Ornamental snake	V	None
Litoria freycineti	Wallum rocketfrog	V	None
Litoria olongburensis	Wallum sedgefrog	V	None
Melaleuca irbyana		E	None
Petaurus gracilis	Mahogany Glider	E	None
Petrogale persephone	Proserpine rock-wallaby	E	None
Phascolarctos cinereus	Koala - outside SEQ*	V	None
Pezoporus wallicus wallicus	Eastern ground parrot	V	None
Taudactylus pleione	Kroombit tinkerfrog	E	None
Xeromys myoides	Water Mouse	V	None

**For koala model, this includes areas outside SEQ. Check 7c SEQ koala habitat for presence/absence.*

Threatened (endangered or vulnerable) wildlife species records

(no results)

Special least concern animal species records

(no results)

**Nature Conservation Act 1992 (NCA) Status- Endangered (E), Vulnerable (V) or Special Least Concern Animal (SL). Environment Protection and Biodiversity Conservation Act 1999 (EPBC) status: Critically Endangered (CE) Endangered (E), Vulnerable (V)*

Migratory status (M) - China and Australia Migratory Bird Agreement (C), Japan and Australia Migratory Bird Agreement (J), Republic of Korea and Australia Migratory Bird Agreement (R), Bonn Migratory Convention (B), Eastern Flyway (E)

To request a species list for an area, or search for a species profile, access Wildlife Online at:

https://www.qld.gov.au/environment/plants-animals/species-list/

Refer to **Map 3a - MSES - Species - Threatened (endangered or vulnerable) wildlife and special least concern animals** and **Map 3b - MSES - Species - Koala habitat area (SEQ)** for an overview of the relevant MSES.

MSES - Regulated Vegetation

For further information relating to regional ecosystems in general, go to:
https://www.qld.gov.au/environment/plants-animals/plants/ecosystems/
For a more detailed description of a particular regional ecosystem, access the regional ecosystem search page at:
https://environment.ehp.qld.gov.au/regional-ecosystems/

8a. Regulated Vegetation - Endangered/Of concern in Category B (remnant)

Not applicable

8b. Regulated Vegetation - Endangered/Of concern in Category C (regrowth)

Not applicable

8c. Regulated Vegetation - Category R (GBR riverine regrowth)

Not applicable

8d. Regulated Vegetation - Essential habitat

Not applicable

8e. Regulated Vegetation - intersecting a watercourse**

A vegetation management watercourse is mapped as present

8f. Regulated Vegetation - within 100m of a Vegetation Management wetland

Regulated vegetation map category	Map number	RVM rule
B	7242	2

Refer to **Map 4 - MSES - Regulated Vegetation** for an overview of the relevant MSES.

MSES - Offsets

9a. Legally secured offset areas - offset register areas

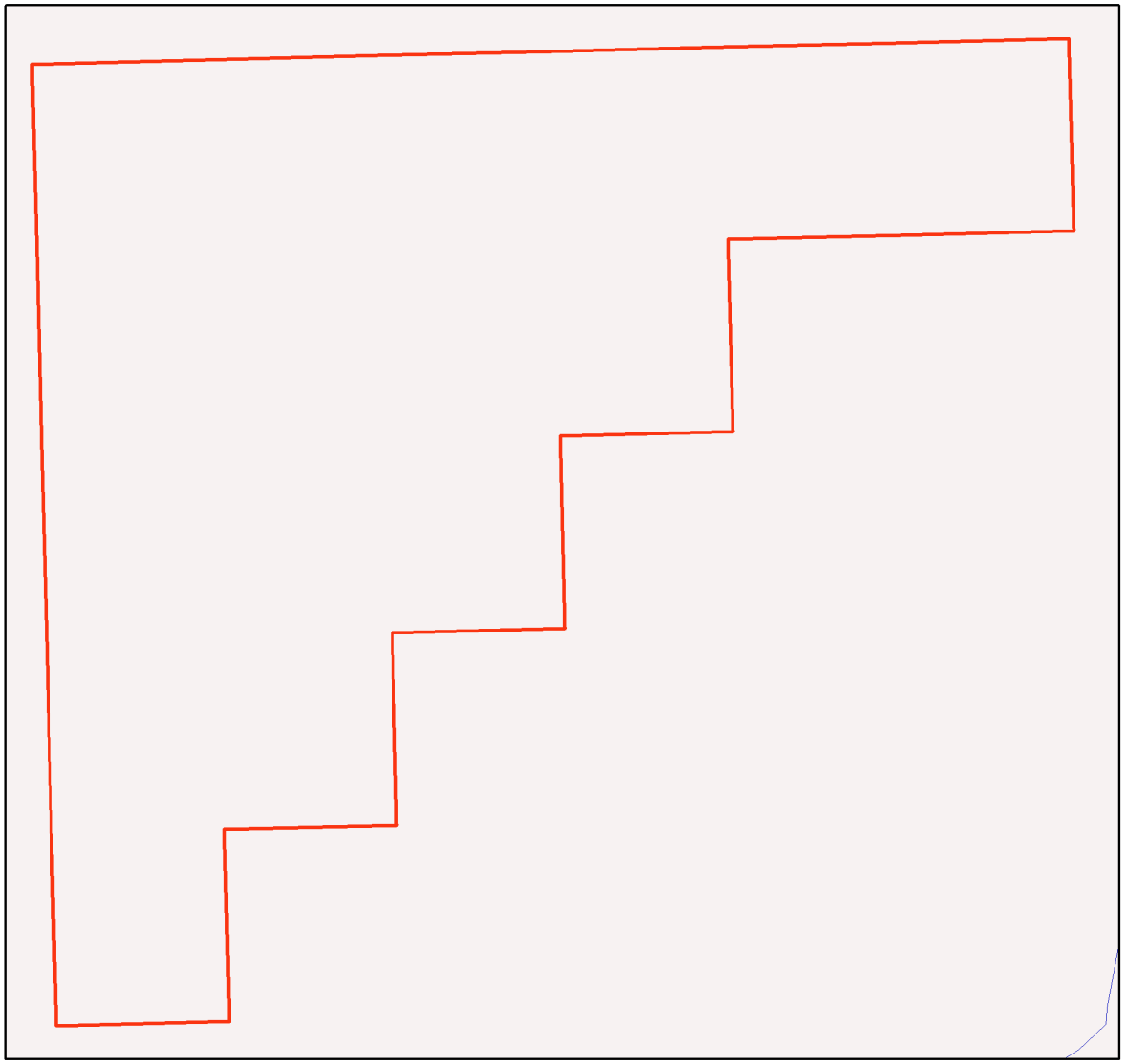
(no results)

9b. Legally secured offset areas - vegetation offsets through a Property Map of Assessable Vegetation

(no results)

Refer to **Map 5 - MSES - Offset Areas** for an overview of the relevant MSES.

Map 1 - MSES - State Conservation Areas

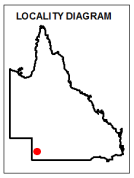


MSES - State Conservation Areas

Area of Interest

- Selected Petroleum Lease (PL)
- Towns
- Freeways/Highways
- Secondary roads
- Major rivers/creeks
- Protected area (estates)
- Declared fish habitat area (A and B areas)
- Marine park (highly protected)

LOCALITY DIAGRAM



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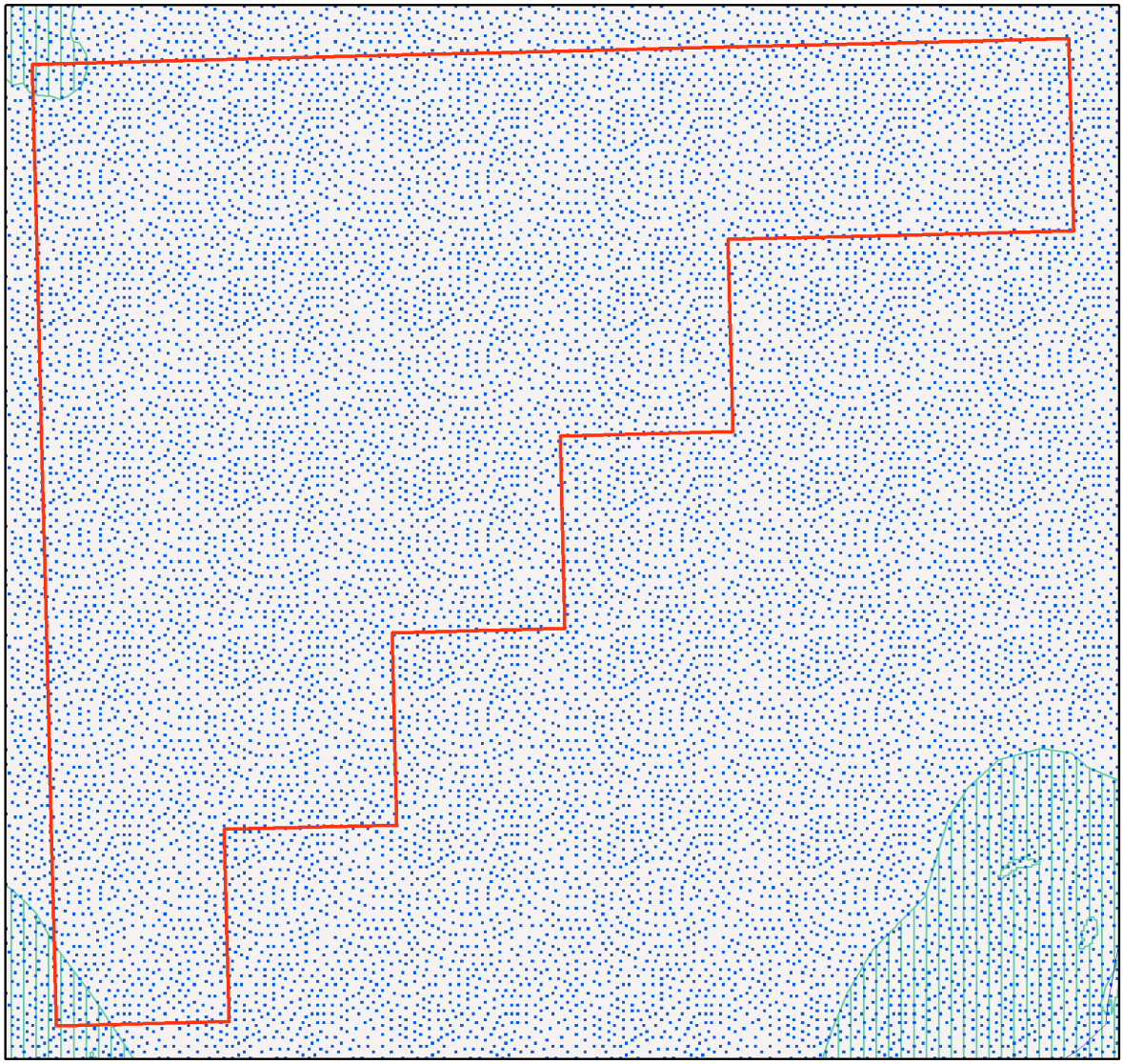
0 575 1150 1725 2300 2875 m

This product is projected into GDA 1994 Queensland Albers

Map 2 - MSES - Wetlands and Waterways

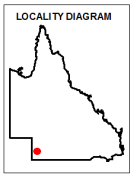


MSES - Wetlands and Waterways

Area of Interest

- Selected Petroleum Lease (PL)
- Towns
- Freeways/Highways
- Secondary roads
- Major rivers/creeks
- Declared high ecological value waters (watercourse)
- Strategic environmental area (designated precinct)
- Declared high ecological value waters (wetland)
- High ecological significance wetlands

LOCALITY DIAGRAM



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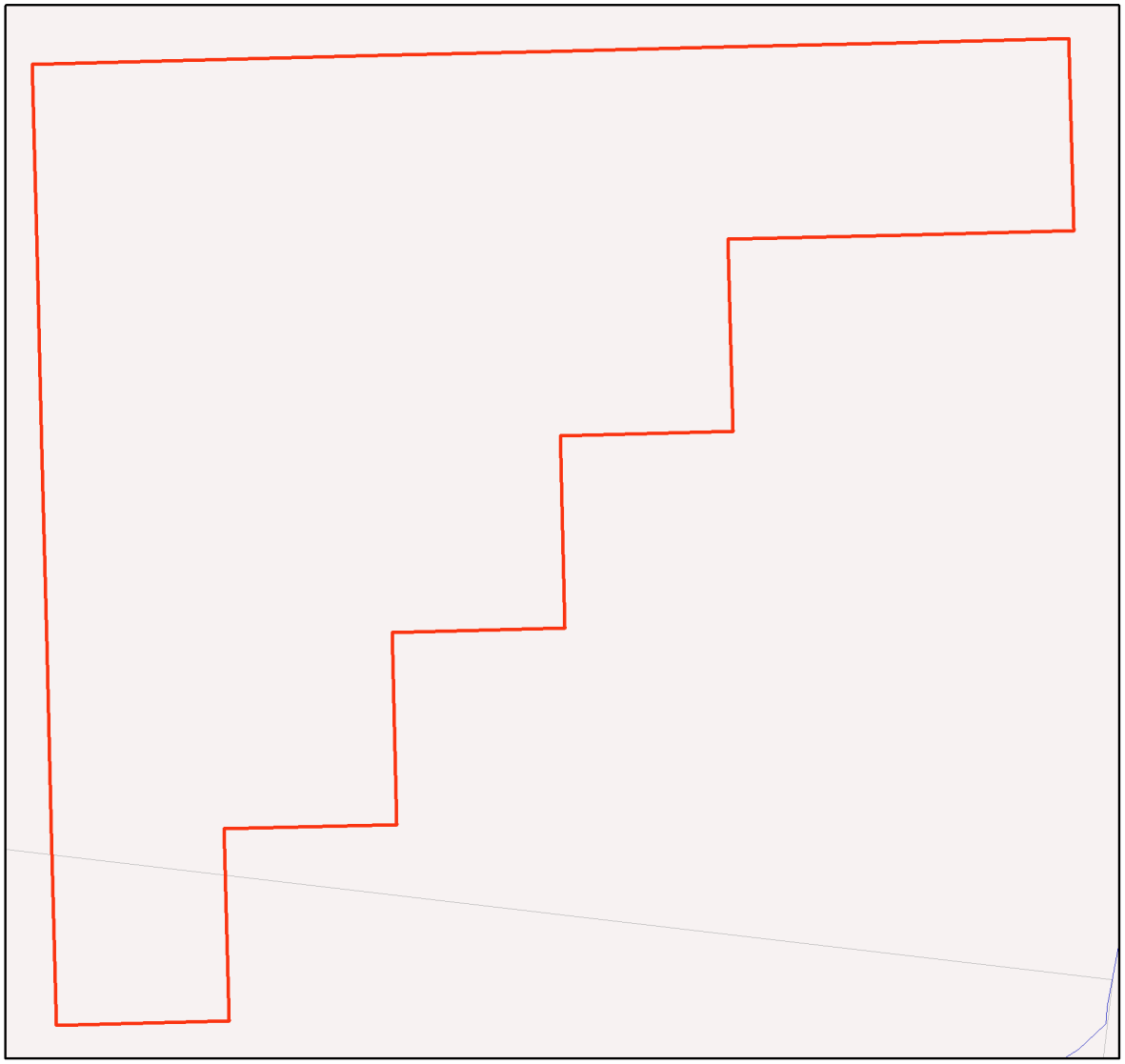
Map 3a - MSES - Species - Threatened (endangered or vulnerable) wildlife and special least concern animals

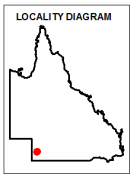


MSES - Species
Threatened (endangered or vulnerable) wildlife and special least concern animals

Area of Interest

- Selected Petroleum Lease (PL)
- Towns
- Freeways/Highways
- Secondary roads
- Major rivers/creeks
- Wildlife habitat (special least concern)
- Wildlife habitat (endangered or vulnerable)

LOCALITY DIAGRAM



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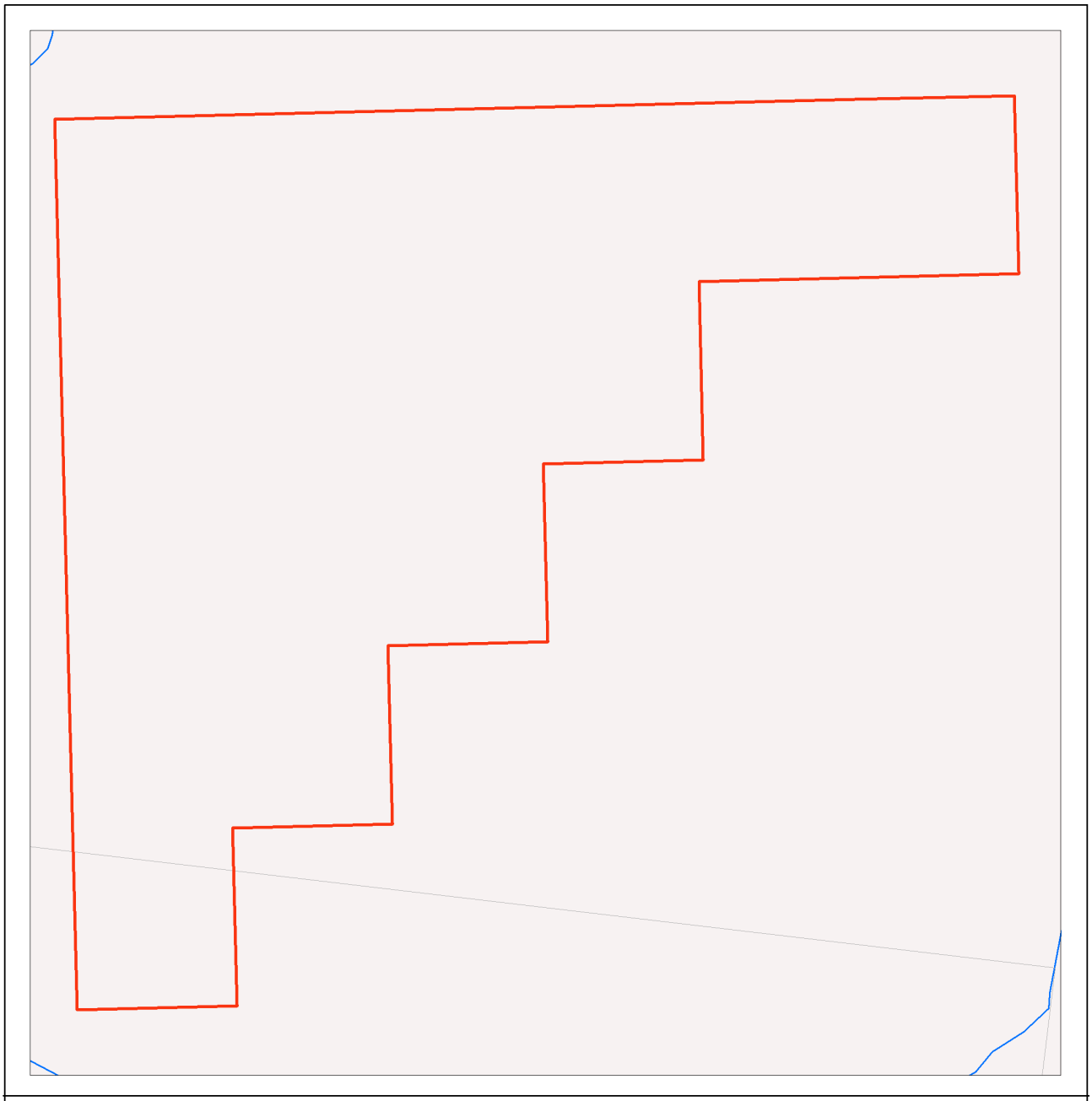
This product is projected into GDA 1994 Queensland Albers

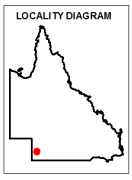
Map 3b - MSES - Species - Koala habitat area (SEQ)



MSES - Species
Koala habitat area (SEQ)

Area of Interest
- Selected Petroleum Lease (PL)
- Towns
- Freeways/Highways
- Secondary roads
- Major rivers/creeks
- Koala habitat area (core)
- Koala habitat area (locally refined)

LOCALITY DIAGRAM



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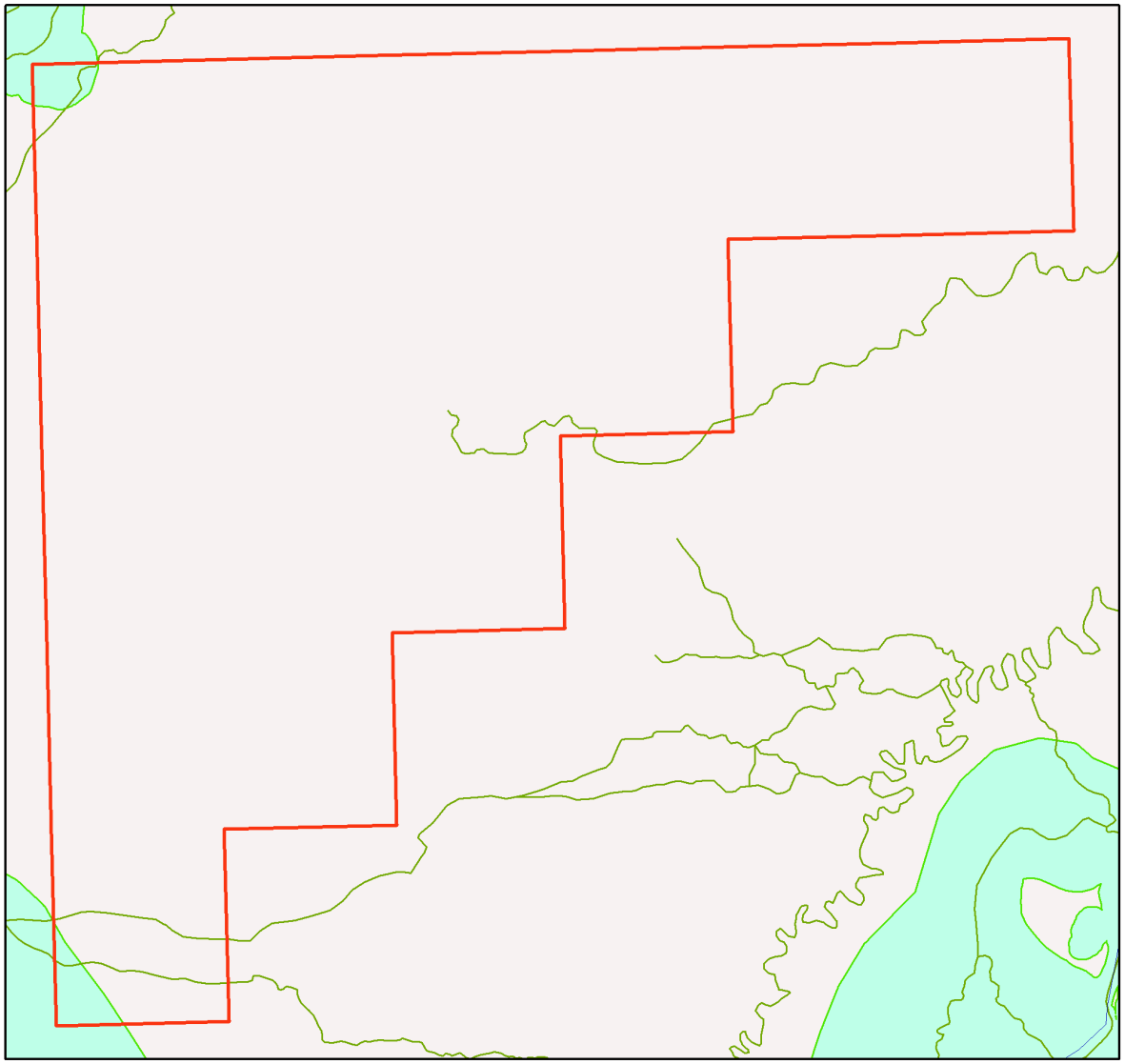
The represented layers for SEQ 'koala habitat area-core' and 'koala habitat area- locally refined' in MSES are sourced directly from the regulatory mapping under the Nature Conservation (Koala) Conservation Plan 2017. Whilst every effort is made to ensure the information remains current, there may be delays between updating versions. Please refer to the original mapping for the most recent version. See https://environment.des.qld.gov.au/wildlife/animals/living-with/koalas/mapping

The koala habitat mapping within South East Queensland uses regional ecosystem linework compiled at a scale varying from 1:25,000 to 1:100,000. Linework should be used as a guide only. The positional accuracy of regional ecosystem data mapped at a scale of 1:100,000 is +/- 100 metres.

0 550 1,100 1,650 2,200 2,750 m

This product is projected into GDA 1994 Queensland Albers

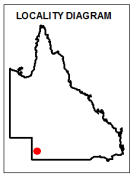
Map 4 - MSES - Regulated Vegetation

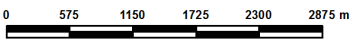


MSES - Regulated Vegetation

Area of Interest

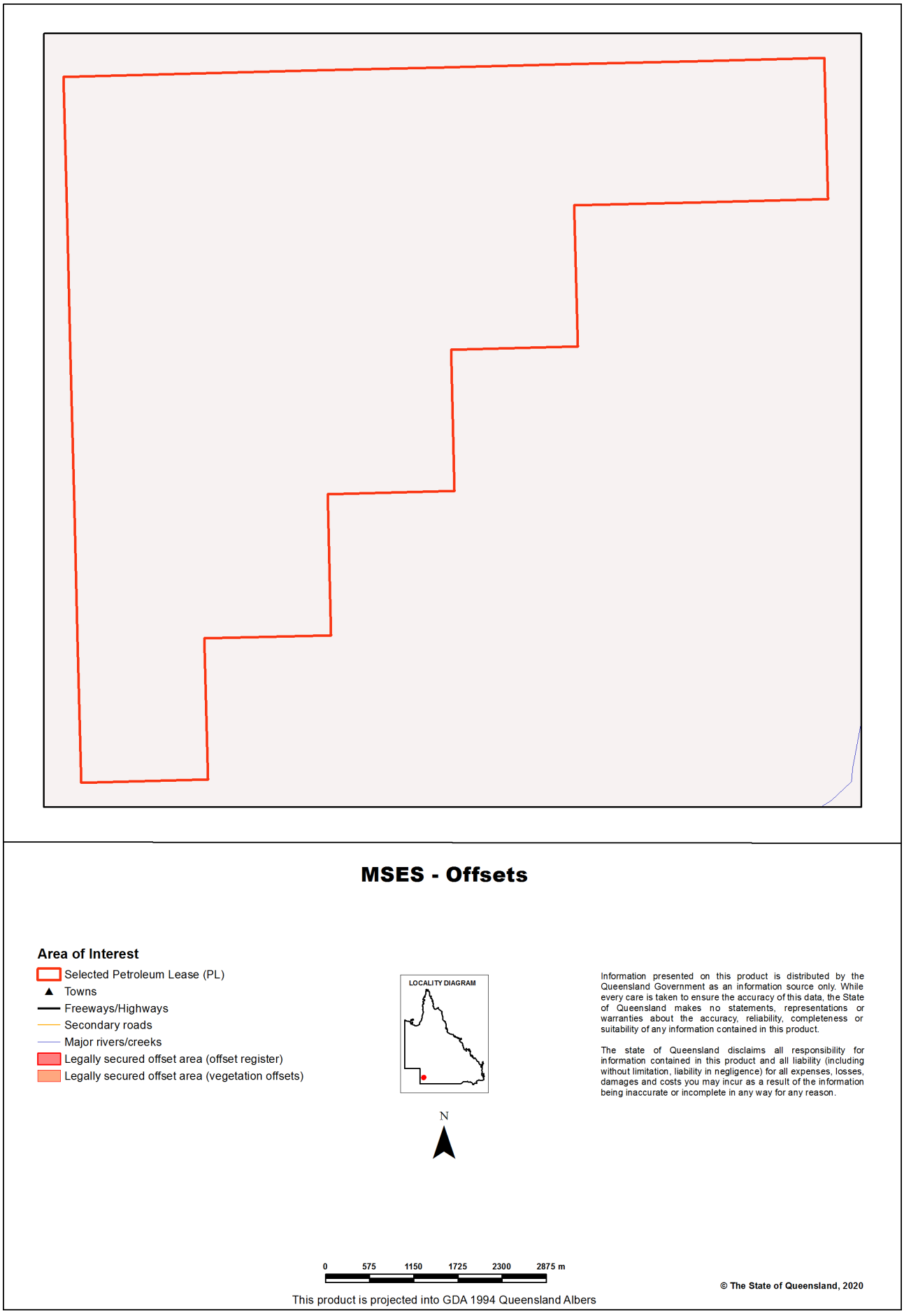
- Selected Petroleum Lease (PL)
- Towns
- Freeways/Highways
- Secondary roads
- Major rivers/creeks
- Regulated vegetation (intersecting a watercourse)
- Regulated vegetation (100m from wetland)
- Regulated vegetation (category B - endangered or of concern)
- Regulated vegetation (category C - endangered or of concern)
- Regulated vegetation (category R - GBR riverine)
- Regulated vegetation (essential habitat)





This product is projected into GDA 1994 Queensland Albers

Map 5 - MSES - Offset Areas



Appendices

Appendix 1 - Matters of State Environmental Significance (MSES) methodology

MSES mapping is a regional-scale representation of the definition for MSES under the State Planning Policy (SPP). The compiled MSES mapping product is a guide to assist planning and development assessment decision-making. Its primary purpose is to support implementation of the SPP biodiversity policy. While it supports the SPP, the mapping does not replace the regulatory mapping or environmental values specifically called up under other laws or regulations. Similarly, the SPP biodiversity policy does not override or replace specific requirements of other Acts or regulations.

The Queensland Government's "Method for mapping - matters of state environmental significance for use in land use planning and development assessment" can be downloaded from:

http://www.ehp.qld.gov.au/land/natural-resource/method-mapping-mses.html .

Appendix 2 - Source Data

The datasets listed below are available on request from:

http://qldspatial.information.qld.gov.au/catalogue/custom/index.page

- Matters of State environmental significance

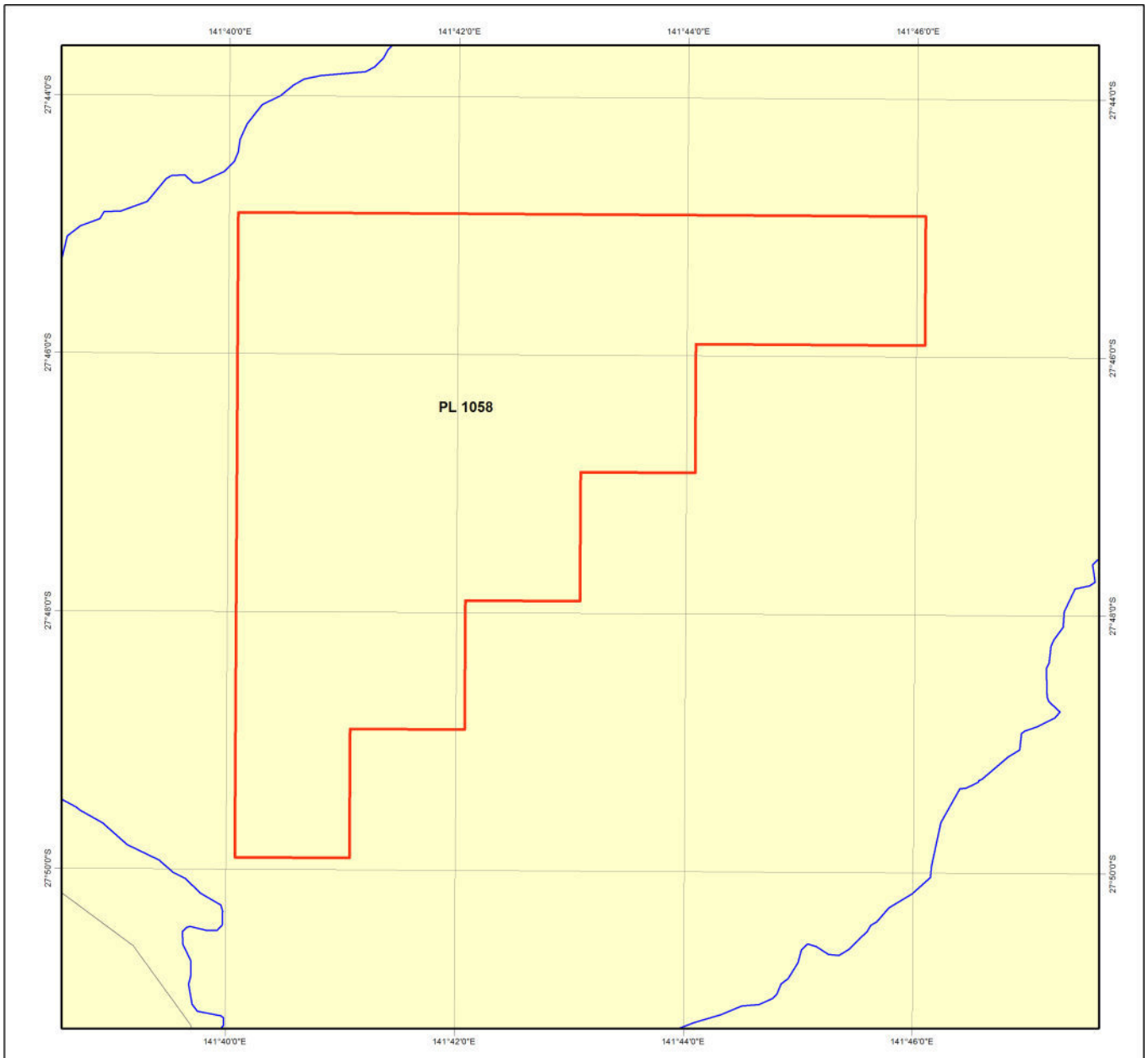
Note: MSES mapping is not based on new or unique data. The primary mapping product draws data from a number of underlying environment databases and geo-referenced information sources. MSES mapping is a versioned product that is updated generally on a twice-yearly basis to incorporate the changes to underlying data sources. Several components of MSES mapping made for the current version may differ from the current underlying data sources. To ensure accuracy, or proper representation of MSES values, it is strongly recommended that users refer to the underlying data sources and review the current definition of MSES in the State Planning Policy, before applying the MSES mapping.

Individual MSES layers can be attributed to the following source data available at QSpatial:

MSES layers	**current QSpatial data (http://qspatial.information.qld.gov.au)**
Protected Areas-Estates and Nature Refuges	- Protected areas of Queensland - Nature Refuges - Queensland
Marine Park-Highly Protected Zones	Moreton Bay marine park zoning 2008
Fish Habitat Areas	Queensland fish habitat areas
Strategic Environmental Areas-designated	Regional Planning Interests Act - Strategic Environmental Areas
HES wetlands	Map of Queensland Wetland Environmental Values
Wetlands in HEV waters	HEV waters: - EPP Water (multiple locations) intent for waters Source Wetlands: - Queensland Wetland Mapping (Current version 4, 2015) Source Watercourses: - Vegetation management watercourse and drainage feature map (1:100000 and 1:250000)
Wildlife habitat (threatened and special least concern)	-WildNet database species records - habitat suitability models (various) - SEQ koala habitat areas under the Koala Conservation Plan 2019
VMA regulated regional ecosystems	Vegetation management regional ecosystem and remnant map
VMA Essential Habitat	Vegetation management - essential habitat map
VMA Wetlands	Vegetation management wetlands map
Legally secured offsets	Vegetation Management Act property maps of assessable vegetation. For offset register data-contact DES
Regulated Vegetation Map	Vegetation management - regulated vegetation management map

Appendix 3 - Acronyms and Abbreviations

AOI	- Area of Interest
DES	- Department of Environment and Science
EP Act	- *Environmental Protection Act 1994*
EPP	- Environmental Protection Policy
GDA94	- Geocentric Datum of Australia 1994
GEM	- General Environmental Matters
GIS	- Geographic Information System
MSES	- Matters of State Environmental Significance
NCA	- *Nature Conservation Act 1992*
RE	- Regional Ecosystem
SPP	- State Planning Policy
VMA	- *Vegetation Management Act 1999*



ENVIRONMENTALLY SENSITIVE AREAS - non-mining resource activities (EP Act)

- Selected Petroleum Lease (PL)

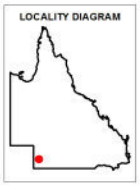
CATEGORY A
- National Parks
- Conservation Parks
- Forest Reserves
- Special Wildlife Reserve
- Wet Tropics World Heritage Area
- Great Barrier Reef Marine Park Area
- Marine Parks other than General Use Zones

CATEGORY B
- Queensland Heritage Register Places
- Ramsar Sites
- Cultural Heritage Registered Areas and DLA's other than Stanbroke
- Special Forestry Areas
- Seaward Side of Highest Astronomical Tide
- Fish Habitat Areas
- Coordinated Conservation Areas
- Endangered Regional Ecosystems - regrowth and remnant (Biodiversity Status)
- General Use Zones of Marine Parks
- Marine Plants

CATEGORY C
- Essential Habitat
- Koala Plan
- Nature Refuges
- Resources Reserve
- State Forests
- Timber Reserves
- Of Concern Regional Ecosystems (remnant biodiversity status)

OTHERS
- Towns
- Roads
- Rivers
- Springs
- Queensland

LOCALITY DIAGRAM



NOTE TO USER: Themes presented in this map are indicative only. Field survey may be required to verify the 'true' spatial extent and value. Not all environmentally sensitive areas are presented in this map. A user should refer to the particular circumstances relevant to their situation to assess the 'completeness' of themes provided.

The user should note that some boundaries and indicated values are ambient or subject to change over time (e.g. regional ecosystem boundaries and conservation status, watercourse mapping etc).

The user should be aware that due to multiple overlapping themes present, some themes/layers may be obscured by others. Ordering in the Legend does not accurately reflect the order by which themes are displayed.

N

0 810 1620 2430 3240 4050 m

This product is projected into GDA 1994 MGA Zone 54

Australian Government

Department of Agriculture, Water and the Environment

EPBC Act Protected Matters Report

This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected.

Information on the coverage of this report and qualifications on data supporting this report are contained in the caveat at the end of the report.

Information is available about Environment Assessments and the EPBC Act including significance guidelines, forms and application process details.

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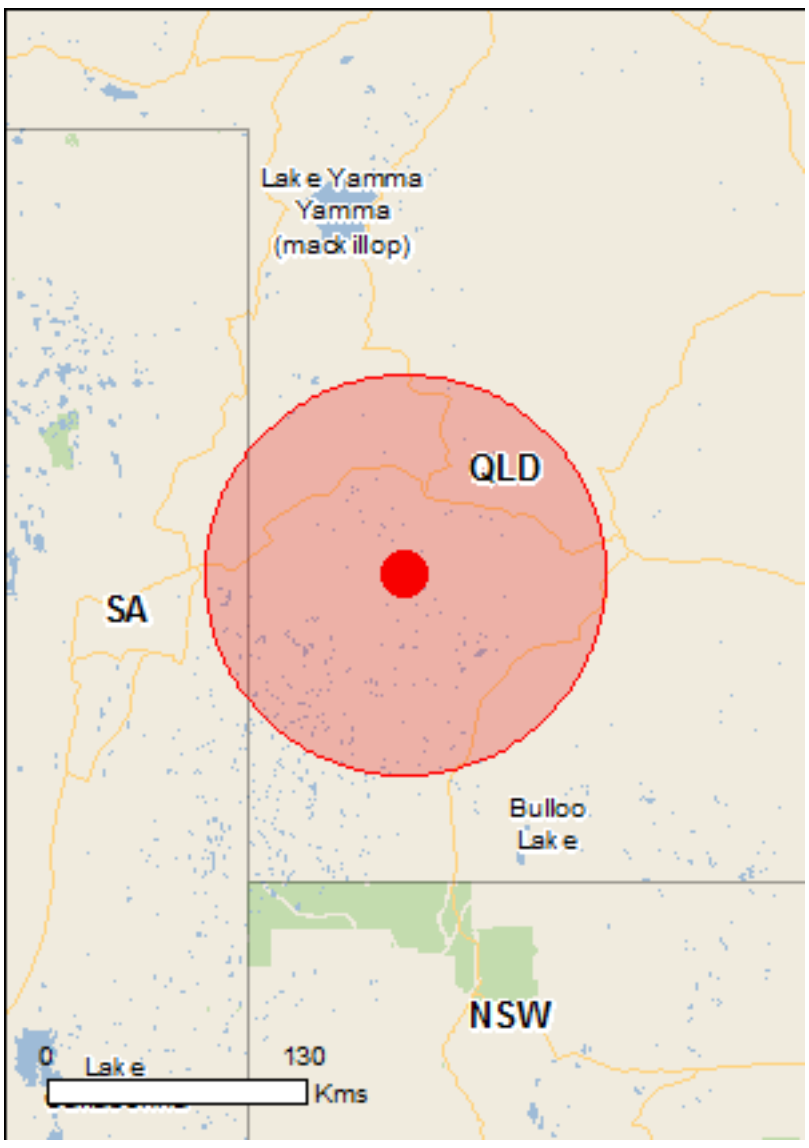
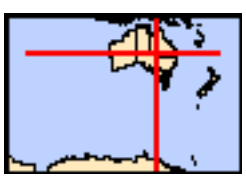


Coordinates

Buffer: 100.0Km



Summary

Matters of National Environmental Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance.

World Heritage Properties:	None
National Heritage Places:	2
Wetlands of International Importance:	1
Great Barrier Reef Marine Park:	None
Commonwealth Marine Area:	None
Listed Threatened Ecological Communities:	None
Listed Threatened Species:	13
Listed Migratory Species:	9

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place. Information on the new heritage laws can be found at http://www.environment.gov.au/heritage

A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species.

Commonwealth Land:	None
Commonwealth Heritage Places:	None
Listed Marine Species:	14
Whales and Other Cetaceans:	None
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Australian Marine Parks:	None

Extra Information

This part of the report provides information that may also be relevant to the area you have nominated.

State and Territory Reserves:	1
Regional Forest Agreements:	None
Invasive Species:	16
Nationally Important Wetlands:	3
Key Ecological Features (Marine)	None

Details

Matters of National Environmental Significance

National Heritage Properties		[Resource Information]
Name	State	Status
Historic		
The Burke, Wills, King and Yandruwandha National Heritage Place	QLD	Listed place
The Burke, Wills, King and Yandruwandha National Heritage Place	SA	Listed place

Wetlands of International Importance (Ramsar)	[Resource Information]
Name	Proximity
Coongie lakes	Within Ramsar site

Listed Threatened Species		[Resource Information]
Name	Status	Type of Presence
Birds		
Amytornis barbatus barbatus		
Bulloo Grey Grasswren, Grey Grasswren (Bulloo) [67065]	Endangered	Species or species habitat known to occur within area
Calidris ferruginea		
Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
Falco hypoleucos		
Grey Falcon [929]	Vulnerable	Species or species habitat known to occur within area
Grantiella picta		
Painted Honeyeater [470]	Vulnerable	Species or species habitat known to occur within area
Pedionomus torquatus		
Plains-wanderer [906]	Critically Endangered	Species or species habitat may occur within area
Pezoporus occidentalis		
Night Parrot [59350]	Endangered	Species or species habitat likely to occur within area
Rostratula australis		
Australian Painted Snipe [77037]	Endangered	Species or species habitat may occur within area
Mammals		
Macrotis lagotis		
Greater Bilby [282]	Vulnerable	Species or species habitat may occur within area
Notomys fuscus		
Dusky Hopping-mouse, Wilkiniti [125]	Vulnerable	Species or species habitat likely to occur within area
Petrogale xanthopus celeris		
Yellow-footed Rock-wallaby (central-western Queensland) [87608]	Vulnerable	Species or species habitat may occur within area
Plants		

Name	Status	Type of Presence
Frankenia plicata [4225]	Endangered	Species or species habitat likely to occur within area
Grevillea kennedyana Flame Spider-flower [6974]	Vulnerable	Species or species habitat may occur within area
Sclerolaena walkeri [16152]	Vulnerable	Species or species habitat likely to occur within area

Listed Migratory Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Migratory Marine Birds		
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Migratory Terrestrial Species		
Motacilla cinerea Grey Wagtail [642]		Species or species habitat may occur within area
Motacilla flava Yellow Wagtail [644]		Species or species habitat may occur within area
Migratory Wetlands Species		
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat known to occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat known to occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat may occur within area
Gallinago hardwickii Latham's Snipe, Japanese Snipe [863]		Species or species habitat may occur within area
Tringa nebularia Common Greenshank, Greenshank [832]		Species or species habitat may occur within area

Other Matters Protected by the EPBC Act

Listed Marine Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Birds		
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat known to occur within area

Name	Threatened	Type of Presence
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Ardea alba Great Egret, White Egret [59541]		Species or species habitat known to occur within area
Ardea ibis Cattle Egret [59542]		Species or species habitat may occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat known to occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat may occur within area
Chrysococcyx osculans Black-eared Cuckoo [705]		Species or species habitat known to occur within area
Gallinago hardwickii Latham's Snipe, Japanese Snipe [863]		Species or species habitat may occur within area
Merops ornatus Rainbow Bee-eater [670]		Species or species habitat may occur within area
Motacilla cinerea Grey Wagtail [642]		Species or species habitat may occur within area
Motacilla flava Yellow Wagtail [644]		Species or species habitat may occur within area
Rostratula benghalensis (sensu lato) Painted Snipe [889]	Endangered*	Species or species habitat may occur within area
Tringa nebularia Common Greenshank, Greenshank [832]		Species or species habitat may occur within area

Extra Information

State and Territory Reserves	[Resource Information]
Name	State
Innamincka	SA

Invasive Species

[Resource Information]

Weeds reported here are the 20 species of national significance (WoNS), along with other introduced plants that are considered by the States and Territories to pose a particularly significant threat to biodiversity. The following feral animals are reported: Goat, Red Fox, Cat, Rabbit, Pig, Water Buffalo and Cane Toad. Maps from Landscape Health Project, National Land and Water Resouces Audit, 2001.

Name	Status	Type of Presence
Birds		
Columba livia Rock Pigeon, Rock Dove, Domestic Pigeon [803]		Species or species habitat likely to occur within area
Passer domesticus House Sparrow [405]		Species or species habitat likely to occur within area
Sturnus vulgaris Common Starling [389]		Species or species habitat likely to occur within area
Mammals		
Bos taurus Domestic Cattle [16]		Species or species habitat likely to occur within area
Camelus dromedarius Dromedary, Camel [7]		Species or species habitat likely to occur within area
Canis lupus familiaris Domestic Dog [82654]		Species or species habitat likely to occur within area
Capra hircus Goat [2]		Species or species habitat likely to occur within area
Equus asinus Donkey, Ass [4]		Species or species habitat likely to occur within area
Equus caballus Horse [5]		Species or species habitat likely to occur within area
Felis catus Cat, House Cat, Domestic Cat [19]		Species or species habitat likely to occur within area
Mus musculus House Mouse [120]		Species or species habitat likely to occur within area
Oryctolagus cuniculus Rabbit, European Rabbit [128]		Species or species habitat likely to occur within area
Sus scrofa Pig [6]		Species or species habitat likely to occur within area
Vulpes vulpes Red Fox, Fox [18]		Species or species habitat likely to occur within area
Plants		
Acacia nilotica subsp. indica Prickly Acacia [6196]		Species or species habitat may occur within area
Cenchrus ciliaris Buffel-grass, Black Buffel-grass [20213]		Species or species habitat may occur within

Name	Status	Type of Presence
		area

Nationally Important Wetlands [Resource Information]

Name	State
Coongie Lakes	SA
Cooper Creek - Wilson River Junction	QLD
Cooper Creek Swamps - Nappa Merrie	QLD

Caveat

The information presented in this report has been provided by a range of data sources as acknowledged at the end of the report.

This report is designed to assist in identifying the locations of places which may be relevant in determining obligations under the Environment Protection and Biodiversity Conservation Act 1999. It holds mapped locations of World and National Heritage properties, Wetlands of International and National Importance, Commonwealth and State/Territory reserves, listed threatened, migratory and marine species and listed threatened ecological communities. Mapping of Commonwealth land is not complete at this stage. Maps have been collated from a range of sources at various resolutions.

Not all species listed under the EPBC Act have been mapped (see below) and therefore a report is a general guide only. Where available data supports mapping, the type of presence that can be determined from the data is indicated in general terms. People using this information in making a referral may need to consider the qualifications below and may need to seek and consider other information sources.

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Threatened, migratory and marine species distributions have been derived through a variety of methods. Where distributions are well known and if time permits, maps are derived using either thematic spatial data (i.e. vegetation, soils, geology, elevation, aspect, terrain, etc) together with point locations and described habitat; or environmental modelling (MAXENT or BIOCLIM habitat modelling) using point locations and environmental data layers.

Where very little information is available for species or large number of maps are required in a short time-frame, maps are derived either from 0.04 or 0.02 decimal degree cells; by an automated process using polygon capture techniques (static two kilometre grid cells, alpha-hull and convex hull); or captured manually or by using topographic features (national park boundaries, islands, etc). In the early stages of the distribution mapping process (1999-early 2000s) distributions were defined by degree blocks, 100K or 250K map sheets to rapidly create distribution maps. More reliable distribution mapping methods are used to update these distributions as time permits.

Only selected species covered by the following provisions of the EPBC Act have been mapped:

- migratory and
- marine

The following species and ecological communities have not been mapped and do not appear in reports produced from this database:

- threatened species listed as extinct or considered as vagrants
- some species and ecological communities that have only recently been listed
- some terrestrial species that overfly the Commonwealth marine area
- migratory species that are very widespread, vagrant, or only occur in small numbers

The following groups have been mapped, but may not cover the complete distribution of the species:

- non-threatened seabirds which have only been mapped for recorded breeding sites
- seals which have only been mapped for breeding sites near the Australian continent

Such breeding sites may be important for the protection of the Commonwealth Marine environment.

Coordinates

-27.78389 141.70621

Acknowledgements

This database has been compiled from a range of data sources. The department acknowledges the following custodians who have contributed valuable data and advice:

-Office of Environment and Heritage, New South Wales
-Department of Environment and Primary Industries, Victoria
-Department of Primary Industries, Parks, Water and Environment, Tasmania
-Department of Environment, Water and Natural Resources, South Australia
-Department of Land and Resource Management, Northern Territory
-Department of Environmental and Heritage Protection, Queensland
-Department of Parks and Wildlife, Western Australia
-Environment and Planning Directorate, ACT
-Birdlife Australia
-Australian Bird and Bat Banding Scheme
-Australian National Wildlife Collection
-Natural history museums of Australia
-Museum Victoria
-Australian Museum
-South Australian Museum
-Queensland Museum
-Online Zoological Collections of Australian Museums
-Queensland Herbarium
-National Herbarium of NSW
-Royal Botanic Gardens and National Herbarium of Victoria
-Tasmanian Herbarium
-State Herbarium of South Australia
-Northern Territory Herbarium
-Western Australian Herbarium
-Australian National Herbarium, Canberra
-University of New England
-Ocean Biogeographic Information System
-Australian Government, Department of Defence
Forestry Corporation, NSW
-Geoscience Australia
-CSIRO
-Australian Tropical Herbarium, Cairns
-eBird Australia
-Australian Government – Australian Antarctic Data Centre
-Museum and Art Gallery of the Northern Territory
-Australian Government National Environmental Science Program
-Australian Institute of Marine Science
-Reef Life Survey Australia
-American Museum of Natural History
-Queen Victoria Museum and Art Gallery, Inveresk, Tasmania
-Tasmanian Museum and Art Gallery, Hobart, Tasmania
-Other groups and individuals

The Department is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

Please feel free to provide feedback via the Contact Us page.

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Appendix B Species lists

B.2 Species lists

Opportunistic fauna observations

Common name	Scientific name	NC Act Status	EPBC Act Status
Birds			
Australasian pratincole	*Stiltia isabella*	Least concern	Marine
Australian raven	*Corvus coronoides*	Least concern	-
Brown falcon	*Falco berigora*	Least concern	-
Brown songlark	*Cincloramphus cruralis*	Least concern	-
Budgerigar	*Melopsittacus undulatus*	Least concern	-
Chestnut-crowned babbler	*Pomatostomus ruficeps*	Least concern	-
Emu	*Dromaius novaehollandiae*	Least concern	-
Galah	*Eolophus roseicapilla*	Least concern	-
Masked woodswallow	*Artamus personatus*	Least concern	-
Nankeen kestrel	*Falco cenchroides*	Least concern	Marine
Orange chat	*Epthianura aurifrons*	Least concern	-
Spotted harrier	*Circus assimilis*	Least concern	-
Tree martin	*Petrochelidon nigricans*	Least concern	Marine
Wedge-tailed eagle	*Aquila audax*	Least concern	-

Appendix C Likelihood of occurrence assessments

Likelihood of Occurrence for Matters of National Environmental Significance

Species	EPBC Act Status[1]	NC Act Status[1]	Habitat	Likelihood of occurence[2]
Flora				
Frankenia plicata	E	LC	The species grows in a range of habitats, including on small hillside channels, which take the first run-off after rain (DEWHA 2008a). In the Simpson Desert, the species has been recorded predominantly from swales of loamy sands to clay (DEWHA 2008a). This species is found in a wide range of vegetation communities that have good drainage (DEWHA 2008a).	**Unlikely to occur** The PL is outside of the current known distribution of the species. The species has not been recorded within Queensland (Queensland Herbarium 2019b).
Sclerolaena walkeri	V	LC	The species is known to occur on saline river channels, flats and floodplains (Department of the Environment, Water, Heritage and the Arts 2008b).	**Possible occurrence** The PL contains broadly suitable habitat for the species. The nearest records of the species, which are approximately 120 km south-west of the PL are from the Bulloo River Floodplain (ALA 2019). The nearest record of the species within the Cooper Creek floodplain are from approximately 280 km to the north-east.
Birds				
Common sandpiper *Actitis hypoleucos*	Marine, Migratory	SLC	The species has been recorded from a wide range of wetland habitats, of varying levels of salinity (DEE 2019). The species typically forages in shallow water and on bare soft mud at the edges of wetlands (DEE 2019).	**Possible occurrence** The PL is likely to contain ephemeral wetlands within channels of the Cooper Creek floodplain, primarily following flood events. The species may temporarily use these ephemeral wetlands while present. The species has not been recorded within 100 km of the PL within the Queensland Government WildNet database.

Species	EPBC Act Status[1]	NC Act Status[1]	Habitat	Likelihood of occurence[2]
Grey falcon *Falco hypoleucos*	V	V	Habitat for the species is generally timbered lowland plains that are crossed by tree-lined watercourses, and adjacent to treeless areas, grasslands and open woodlands that are used for foraging (Garnett, Szabo & Dutson 2011). Key habitat is identified as Acacia shrublands that are crossed by tree-lined watercourses (Garnett, Szabo & Dutson 2011).	**Unlikely to occur** The PL is not mapped to contain Acacia shrublands, which are the preferred habitat for the species. In addition, the species has not been recorded within 100 km of the PL within the Queensland Government WildNet database.
Grey grasswren (bulloo) *Amytornis barbatus barbatus*	E	E	The species occurs on periodically-inundated swampy floodplains (DEE 2019). It inhabits patches of dense vegetation that are comprised of lignum thickets, 1.0 to 2.5 m tall, with clumps of *Eragrostis australasica*, about 1 or 2 m tall, and/or clumps of *Atriplex nummularia* (DEE 2019). It also sometimes occurs in areas of *Halosarcia pergranulata* that lie adjacent to more typical habitat (DEE 2019).	**Likely to occur** The Cooper Creek floodplain is known to support grey grasswren; however, the subspecies status of this population is uncertain (Black *et al*. 2011; DEE 2019). The Cooper Creek population may comprise either the Bulloo subspecies (*Amytornis barbatus barbatus*), listed as endangered under the EPBC Act; or the Diamantina subspecies (*Amytornis barbatus diamantina*), not listed under the EPBC Act. In light of this uncertainty, for the purposes of this report, the grey grasswren population has been assumed to comprise the endangered Bulloo subspecies.
Fork-tailed swift *Apus pacificus*	Marine, Migratory	SLC	The species is predominantly aerial and occurs over inland areas and occasionally above the foothills in coastal areas with dry and open habitat (DEE 2019). The species can also occur over low scrub, heathland, saltmarsh and riparian woodlands and are associated with low pressure systems that favour the occurrence of insect prey (DEE 2019).	**Likely to occur** The species is a wide-ranging and nomadic aerial feeder. The species is likely to occur within the airspace above the PL while foraging. The species does not breed in Australia (DEE 2019).

Species	EPBC Act Status[1]	NC Act Status[1]	Habitat	Likelihood of occurence[2]
Eastern great egret *Ardea alba modesta*	Marine	LC	The species occurs in a wide range of wetland habitats (for example inland and coastal, freshwater and saline, permanent and ephemeral, open and vegetated, large and small, natural and artificial) (DEE 2019). These include swamps, marshes, margins of rivers and lakes, damp or flooded grasslands, pastures or agricultural lands; reservoirs, sewage treatment ponds, drainage channels, salt pans, salt lakes, salt marshes, estuarine mudflats, tidal streams, mangrove swamps, coastal lagoons and offshore reefs (DEE 2019).	**Possible occurrence** The PL is likely to contain ephemeral wetlands within channels of the Cooper Creek floodplain, primarily following flood events. The species may temporarily use these ephemeral wetlands while present. The species has not been recorded within 100 km of the PL within the Queensland Government WildNet database.
Cattle egret *Ardea ibis*	Marine	LC	Typical habitat for the species comprises tropical and temperate grasslands, wooded lands and terrestrial wetlands (DEE 2019). High numbers have been observed in moist, low-lying poorly drained pastures with an abundance of high grass; it avoids low grass pastures (DEE 2019). It has been recorded on earthen dam walls and ploughed fields (DEE 2019). It is commonly associated with the habitats of farm animals, particularly cattle, but also pigs, sheep, horses and deer (DEE 2019). It uses predominately shallow, open and fresh wetlands including meadows and swamps with low emergent vegetation and abundant aquatic flora (DEE 2019). They have sometimes been observed in swamps with tall emergent vegetation (DEE 2019).	**Possible occurrence** The PL is likely to contain ephemeral wetlands within channels of the Cooper Creek floodplain, primarily following flood events. The species may temporarily use these ephemeral wetlands while present. The species has not been recorded within 100 km of the PL within the Queensland Government WildNet database.

Species	EPBC Act Status[1]	NC Act Status[1]	Habitat	Likelihood of occurence[2]
Sharp-tailed sandpiper *Calidris acuminata*	Marine, Migratory	SLC	The species typically inhabits muddy edges of shallow fresh or brackish wetlands, with inundated or emergent sedges, grass, saltmarsh or other low vegetation (DEE 2019). This includes lagoons, swamps, lakes and pools near the coast, and dams, waterholes, soaks, bore drains and bore swamps, saltpans and hypersaline saltlakes inland (DEE 2019). The species may use flooded paddocks, sedgelands and other ephemeral wetlands, but vacate these habitats during dry conditions (DEE 2019). Marine habitats for the species include intertidal mudflats in sheltered bays, inlets, estuaries or seashores, and also swamps and creeks lined with mangroves (DEE 2019). Sometimes occur on rocky shores and rarely on exposed reefs (Higgins & Davies 1996).	**Likely to occur** The PL is likely to contain ephemeral wetlands within channels of the Cooper Creek floodplain, primarily following flood events. The species may temporarily use these ephemeral wetlands while present. The species has previously been recorded within 100 km of the PL.
Curlew sandpiper *Calidris ferruginea*	CE, Marine, Migratory	E	In Australia, this species usually forages and roosts in intertidal mudflats in sheltered coastal areas, such as estuaries, bays, inlets and lagoons, and also around non-tidal swamps, lakes and lagoons near the coast, and ponds in saltworks and sewage farms (DEE 2019).	**Possible occurrence** The PL is likely to contain ephemeral wetlands within channels of the Cooper Creek floodplain, primarily following flood events. The species may temporarily use these ephemeral wetlands while present. The species has not been recorded within 100 km of the PL within the Queensland Government WildNet database.
Pectoral sandpiper *Calidris melanotos*	Marine, Migratory	SLC	Typical habitat for the species comprises shallow fresh to saline wetlands, including coastal lagoons, estuaries, bays, swamps, lakes, inundated grasslands, saltmarshes, river pools, creeks, floodplains and artificial wetlands (DEE 2019). The species is usually found in coastal or near coastal habitat but occasionally further inland (DEE 2019). Also recorded in swamp overgrown with lignum (DEE 2019).	**Possible occurrence** The PL is likely to contain ephemeral wetlands within channels of the Cooper Creek floodplain, primarily following flood events. The species may temporarily use these ephemeral wetlands while present. The species has not been recorded within 100 km of the PL within the Queensland Government WildNet database.

Species	EPBC Act Status[1]	NC Act Status[1]	Habitat	Likelihood of occurence[2]
Black-eared cuckoo *Chrysococcyx osculans*	Marine	LC	The species inhabits drier woodlands and scrublands, including mallee, mulga, lignum, saltmarsh and riverside thickets (Pizzey & Knight 2007).	**Likely to occur** The PL is likely to contain suitable habitat for the species, including lignum thickets. While the species has not been recorded within 100 km of the PL within the Queensland Government WildNet database, the PL is within the species distribution and a public record of the species occurs within the Cooper Creek Floodplain at Innamincka Road (ALA 2019).
Latham's snipe, japanese snipe *Gallinago hardwickii*	Marine, Migratory	SLC	In Australia the species typically occurs in permanent and ephemeral wetlands up to 2000 m above sea-level (DEE 2019). They usually inhabit open, freshwater wetlands with low, dense vegetation (e.g. swamps, flooded grasslands or heathlands, around bogs and other water bodies) (DEE 2019). However, they can also occur in habitats with saline or brackish water, in modified or artificial habitats, and in habitats located close to humans or human activity (DEE 2019). Various other freshwater habitats can be used including bogs, waterholes, billabongs, lagoons, lakes, creek or river margins, river pools and floodplains (DEE 2019).	**Possible occurrence** The PL is likely to contain ephemeral wetlands within channels of the Cooper Creek floodplain, primarily following flood events. The species may temporarily use these ephemeral wetlands while present. The species has not been recorded within 100 km of the PL within the Queensland Government WildNet database.
Painted honeyeater *Grantiella picta*	V	V	The species forages on mistletoes in eucalypt forests/woodlands, riparian woodlands of black box and river red gum, box-ironbark-yellow gum woodlands, acacia-dominated woodlands, paperbarks, casuarinas, callitris, and trees on farmland or gardens. The species prefers woodlands which contain a higher number of mature trees, as these host more mistletoes (DEE 2019).	**Unlikely to occur** Mapped vegetation within the PL is largely unsuitable for the species as it is primarily dominated by lignum, ephemeral grassland, ephemeral forbland and sand dunes containing scattered trees. In addition, the species has not been recorded within 100 km of the PL within the Queensland Government WildNet database.

Species	EPBC Act Status[1]	NC Act Status[1]	Habitat	Likelihood of occurence[2]
Rainbow bee-eater *Merops ornatus*	Marine	LC	Occurs mainly in open forests and woodlands, shrublands, and in various cleared or semi-cleared habitats, including farmland and areas of human habitation (Higgins 1999). It usually occurs in open, cleared or lightly-timbered areas that are often, but not always, located in close proximity to permanent water (DEE 2019). The species is known to occur in a wide variety of other habitats, including mangroves, grasslands, wetlands, vine thickets and heathlands (DEE 2019).	**Likely to occur** The PL contains suitable habitat for the species and the species has been previously recorded within 100 km of the PL (ALA 2019).
Grey wagtail *Motacilla cinerea*	Marine, Migratory	SLC	Near running water in disused quarries, sandy and rocky streams in escarpments and rainforests, sewage ponds, ploughed fields, airfields (Pizzey & Knight 2007).	**Unlikely to occur** The species is an uncommon vagrant to Australia. In addition, the PL is unlikely to contain suitable habitat for the species.
Yellow wagtail *Motacilla flava*	Marine, Migratory	SLC	The species typically inhabits short grass and bare ground; swamp margins, sewage ponds, saltmarshes, playing fields, airfields, ploughed land and town lawns (Pizzey & Knight 2007). The species is regularly recorded as a summer migrant to coastal northern Australia (Pizzey & Knight 2007).	**Unlikely to occur** The species is an uncommon vagrant to Australia. In addition, the PL is unlikely to contain suitable habitat for the species.

Species	EPBC Act Status[1]	NC Act Status[1]	Habitat	Likelihood of occurence[2]
Plains-wanderer *Pedionomus torquatus*	CE	V	The species typically occurs within sparse, treeless, lowland native grasslands which usually occur on hard red-brown clay soils (Department of the Environment (DotE) and the Department of Environment, Water and Natural Resources (DEWNR) 2016). Grassland structure is much more important than floristic composition with the species showing a strong preference for sites with approximately 50% bare ground and most vegetation less than 5 cm in height and some widely-spaced plants up to 30 cm (DotE & DEWNR 2016). The species occasionally occurs in other types of habitat such as in stubble; amongst low cereal crops; and in low, sparse chenopod shrubland (DotE & DEWNR 2016).	**Possible occurrence** Vegetation within the PL is likely to include sparsely treed native grasslands; however, the soil composition of the PL is marginally suitable for the species and the species has not been recorded within 100 km of the PL within the Queensland Government WildNet database.
Night parrot *Pezoporus occidentalis*	E	E	Queensland records for the species are typically associated with *spinifex triodia hummock* grasslands, *Astrebla spp.* grasslands, shrubby samphire and chenopod associations and occasional areas with *Acacia cambagei* or *A. aneura* (TSSC 2016). Roosting and nesting sites are consistently reported as within clumps of dense vegetation, primarily old and large Spinifex clumps, but sometimes other vegetation types (TSSC 2016).	**Possible occurrence** The PL is likely to contain suitable foraging habitat for the species, particularly *Astrebla* spp. grasslands. While the species has not been recorded within 100 km of the PL, the species is highly cryptic with an uncertain present day distribution.

Species	EPBC Act Status[1]	NC Act Status[1]	Habitat	Likelihood of occurence[2]
Glossy ibis *Plegadis falcinellus*	Marine, Migratory	SLC	The species typically inhabits freshwater marshes at the edges of lakes and rivers, lagoons, flood-plains, wet meadows, swamps, reservoirs, sewage ponds, rice-fields and cultivated areas under irrigation (DEE 2019). The species is occasionally found in coastal locations such as estuaries, deltas, saltmarshes and coastal lagoons (DEE 2019). Sometimes recorded in wooded swamps, artificial wetlands (such as irrigated fields), and in mangroves for breeding (DEE 2019). Feeds in very shallow water (DEE 2019).	**Likely to occur** The PL is likely to contain ephemeral wetlands within channels of the Cooper Creek floodplain, primarily following flood events. The species may temporarily use these ephemeral wetlands while present. The species has previously been recorded within 100 km of the PL.
Australian painted snipe *Rostratula australis*	E, Marine	V	Generally inhabits shallow terrestrial freshwater (occasionally brackish) wetlands, including temporary and permanent lakes, swamps and claypans (DEE 2019). They also use inundated or waterlogged grassland or saltmarsh, dams, rice crops, sewage farms and bore drains (DEE 2019). The species has been recorded to sometimes utilise areas that are lined with trees, or that have some scattered fallen or washed-up timber (Marchant & Higgins 1993). Breeding occurs in shallow wetlands with areas of bare wet mud and both upper and canopy cover nearby, typically from or near small islands in fresh water wetlands (DEE 2019).	**Possible occurrence** The PL is likely to contain ephemeral wetlands within channels of the Cooper Creek floodplain, primarily following flood events. The species may temporarily use these ephemeral wetlands while present. The species has not been recorded within 100 km of the PL within the Queensland Government WildNet database.
Gull-billed tern *Gelochelidon nilotica*	Marine, Migratory	SLC	The species inhabits beaches, mudflats, brackish wetlands, including inland wetlands, grasslands, crops, ploughed fields and airfields (Pizzey and Knight 2007). The species usually breeds in small colonies on islands in inland lakes (Pizzey and Knight 2007).	**Likely to occur** The PL is likely to contain ephemeral wetlands within channels of the Cooper Creek floodplain, primarily following flood events. The species may temporarily use these ephemeral wetlands while present. The species has previously been recorded within 100 km of the PL.

Species	EPBC Act Status[1]	NC Act Status[1]	Habitat	Likelihood of occurence[2]
Common greenshank *Tringa nebularia*	Marine, Migratory	SLC	The species occurs in all types of wetlands (Higgins & Davies 1996). Typical habitat for this species a wide variety of inland wetlands and sheltered coastal habitats of varying salinity (DEE 2019), including sheltered coastal habitats, typically with large mudflats and saltmarsh, mangroves or seagrass, both permanent and ephemeral terrestrial wetlands, including swamps, lakes, dams, rivers, creeks, billabongs, waterholes and inundated floodplains, claypans and saltflats (DEE 2019).	**Possible occurrence** The PL is likely to contain ephemeral wetlands within channels of the Cooper Creek floodplain, primarily following flood events. The species may temporarily use these ephemeral wetlands while present. The species has not been recorded within 100 km of the PL within the Queensland Government WildNet database.
Mammals				
Ghost bat *Macroderma gigas*	V	E	The species occurs across a range of habitats, from arid Pilbara to tropical savanna woodlands and rainforests (DEE 2019). During the daytime they roost in caves, rock crevices and old mines (DEE 2019). Roost sites used permanently are generally deep natural caves or disused mines with a relatively stable temperature of 23˚–28˚C and a moderate to high relative humidity of 50–100 percent (DEE 2019). The average foraging distance is approximately 2 km from the daytime roost (DEE 2019).	**Unlikely to occur** The PL is unlikely to support suitable roosting habitat for the species. In addition, suitable roosting habitat is unlikely to occur within the foraging distance of the PL.
Greater bilby *Macrotis lagotis*	V	E	The remaining populations of the greater bilby occupy three main habitats: open tussock grassland on uplands and hills, *Acacia aneura* (mulga) woodland/shrubland growing on ridges and rises, and hummock grassland in plains and alluvial areas (TSSC 2016b).	**Unlikely to occur** The PL is outside of the current known distribution of the species (TSSC 2016b).

Species	EPBC Act Status[1]	NC Act Status[1]	Habitat	Likelihood of occurence[2]
Dusky hopping-mouse, wilkiniti *Notomys fuscus*	V	E	This species inhabits a variety of soft sandy habitats, preferring sand dunes, hills and ridges with cane grass (*Ophiuros exaltatus*), sandhill wattle (*Acacia ligulata*), nitrebush (*Nitraria billardiera*), sticky hopbush (*Dodonea viscose*) and other annual and perennial shrubs (DEWHA 2008b).	**Possible occurrence** While the PL is outside of the current known distribution of the species (DEWHA 2008d; ALA 2019), suitable habitat is likely to occur within the PL.
Yellow-footed rock-wallaby *Petrogale xanthopus celeris*	V	V	The yellow-footed rock-wallaby (central-western Queensland) is mostly nocturnal, and shelters during the day in caves and rock crevices (TSSC 2016). It is closely associated with rugged rocky areas, along the edges of low sandstone tablelands and hills, typically with low Acacia woodlands or shrublands (TSSC 2016c).	**Unlikely to occur** The PL is unlikely to support suitable rocky habitat for the species.

[1] EPBC Act = Environment Protection and Biodiversity Conservation Act 1999; NC Act = Nature Conservation Act 1992. E-Endangered, V-Vulnerable, NT-Near Threatened, SLC-Special Least Concern

[2] **Known** to occur: species were recorded during field surveys. **Likely** to occur: suitable habitat to support the species is present and the species has previously been recorded within the desktop search extent. **Possible** occurrence: The PL is within the species known distribution and suitable habitat to support the species is present; however, the species has not previously been recorded within the desktop search extent; and/or, suitable habitat is degraded or of limited extent, thereby reducing the likelihood of the species occurrence. **Unlikely** to occur: the PL does not comprise suitable habitat for the species, or is outside of the species known distribution.

Likelihood of Occurrence for Matters of State Environmental Significance

Species	EPBC Act Status[1]	NC Act Status[1]	Habitat	Likelihood of occurence[2]
Flora				
Rhodanthe rufescens	-	NT	Occurrence records for the species have identified habitat to include *Acacia aneura* and *A. cambagei* woodland, with soil types including pale brown clay, red loamy soil and on a low ridgetop (ALA 2019).	**Unlikely to occur** The PL does not contain suitable habitat for the species. The species has not been previously recorded within similar alluvial floodplain habitat (ALA 2019).
Birds				
Common sandpiper *Actitis hypoleucos*	Marine, Migratory	SLC	The species has been recorded from a wide range of wetland habitats, of varying levels of salinity (DEE 2019). The species typically forages in shallow water and on bare soft mud at the edges of wetlands (DEE 2019).	**Possible occurrence** The PL is likely to contain ephemeral wetlands within channels of the Cooper Creek floodplain, primarily following flood events. The species may temporarily use these ephemeral wetlands while present. The species has not been recorded within 100 km of the PL within the Queensland Government WildNet database.

Species	EPBC Act Status[1]	NC Act Status[1]	Habitat	Likelihood of occurence[2]
Grey grasswren (bulloo) *Amytornis barbatus barbatus*	E	E	The species occurs on periodically-inundated swampy floodplains (DEE 2019). It inhabits patches of dense vegetation that are comprised of lignum thickets, 1.0 to 2.5 m tall, with clumps of *Eragrostis australasica*, about 1 or 2 m tall, and/or clumps of *Atriplex nummularia* (DEE 2019). It also sometimes occurs in areas of *Halosarcia pergranulata* that lie adjacent to more typical habitat (DEE 2019).	**Likely to occur** The Cooper Creek floodplain is known to support grey grasswren; however, the subspecies status of this population is uncertain (Black *et al*. 2011; DEE 2019). The Cooper Creek population may comprise either the Bulloo subspecies (*Amytornis barbatus barbatus*), listed as endangered under the NC Act; or the Diamantina subspecies (*Amytornis barbatus diamantina*), listed as near threatened under the NC Act. In light of this uncertainty, for the purposes of this report, the grey grasswren population has been assumed to comprise the endangered Bulloo subspecies.
Fork-tailed swift *Apus pacificus*	Marine, Migratory	SLC	The species is predominantly aerial and occurs over inland areas and occasionally above the foothills in coastal areas with dry and open habitat (DEE 2019). The species can also occur over low scrub, heathland, saltmarsh and riparian woodlands and are associated with low pressure systems that favour the occurrence of insect prey (DEE 2019).	**Likely to occur** The species is a wide-ranging and nomadic aerial feeder. The species is likely to occur within the airspace above the PL while foraging. The species does not breed in Australia (DEE 2019).

Species	EPBC Act Status[1]	NC Act Status[1]	Habitat	Likelihood of occurence[2]
Sharp-tailed sandpiper *Calidris acuminata*	Marine, Migratory	SLC	The species typically inhabits muddy edges of shallow fresh or brackish wetlands, with inundated or emergent sedges, grass, saltmarsh or other low vegetation (DEE 2019). This includes lagoons, swamps, lakes and pools near the coast, and dams, waterholes, soaks, bore drains and bore swamps, saltpans and hypersaline saltlakes inland (DEE 2019). The species may use flooded paddocks, sedgelands and other ephemeral wetlands, but vacate these habitats during dry conditions (DEE 2019). Marine habitats for the species include intertidal mudflats in sheltered bays, inlets, estuaries or seashores, and also swamps and creeks lined with mangroves (DEE 2019). Sometimes occur on rocky shores and rarely on exposed reefs (Higgins & Davies 1996).	**Likely to occur** The PL is likely to contain ephemeral wetlands within channels of the Cooper Creek floodplain, primarily following flood events. The species may temporarily use these ephemeral wetlands while present. The species has previously been recorded within 100 km of the PL.
Curlew sandpiper *Calidris ferruginea*	CE, Marine, Migratory	E	In Australia, this species usually forages and roosts in intertidal mudflats in sheltered coastal areas, such as estuaries, bays, inlets and lagoons, and also around non-tidal swamps, lakes and lagoons near the coast, and ponds in saltworks and sewage farms (DEE 2019).	**Possible occurrence** The PL is likely to contain ephemeral wetlands within channels of the Cooper Creek floodplain, primarily following flood events. The species may temporarily use these ephemeral wetlands while present. The species has not been recorded within 100 km of the PL within the Queensland Government WildNet database.
Pectoral sandpiper *Calidris melanotos*	Marine, Migratory	SLC	Typical habitat for the species comprises shallow fresh to saline wetlands, including coastal lagoons, estuaries, bays, swamps, lakes, inundated grasslands, saltmarshes, river pools, creeks, floodplains and artificial wetlands (DEE 2019). The species is usually found in coastal or near coastal habitat but occasionally further inland (DEE 2019). Also recorded in swamp overgrown with lignum (DEE 2019).	**Possible occurrence** The PL is likely to contain ephemeral wetlands within channels of the Cooper Creek floodplain, primarily following flood events. The species may temporarily use these ephemeral wetlands while present. The species has not been recorded within 100 km of the PL within the Queensland Government WildNet database.

Species	EPBC Act Status[1]	NC Act Status[1]	Habitat	Likelihood of occurence[2]
Grey falcon *Falco hypoleucos*	V	V	Habitat for the species is generally timbered lowland plains that are crossed by tree-lined watercourses, and adjacent to treeless areas, grasslands and open woodlands that are used for foraging (Garnett, Szabo & Dutson 2011). Key habitat is identified as Acacia shrublands that are crossed by tree-lined watercourses (Garnett, Szabo & Dutson 2011).	**Unlikely to occur** The PL is not mapped to contain Acacia shrublands, which are the preferred habitat for the species. In addition, the species has not been recorded within 100 km of the PL within the Queensland Government WildNet database.
Latham's snipe, japanese snipe *Gallinago hardwicki*i	Marine, Migratory	SLC	In Australia the species typically occurs in permanent and ephemeral wetlands up to 2000 m above sea-level (DEE 2019). They usually inhabit open, freshwater wetlands with low, dense vegetation (e.g. swamps, flooded grasslands or heathlands, around bogs and other water bodies) (DEE 2019). However, they can also occur in habitats with saline or brackish water, in modified or artificial habitats, and in habitats located close to humans or human activity (DEE 2019). Various other freshwater habitats can be used including bogs, waterholes, billabongs, lagoons, lakes, creek or river margins, river pools and floodplains (DEE 2019).	**Possible occurrence** The PL is likely to contain ephemeral wetlands within channels of the Cooper Creek floodplain, primarily following flood events. The species may temporarily use these ephemeral wetlands while present. The species has not been recorded within 100 km of the PL within the Queensland Government WildNet database.
Painted honeyeater *Grantiella picta*	V	V	The species forages on mistletoes in eucalypt forests/woodlands, riparian woodlands of black box and river red gum, box-ironbark-yellow gum woodlands, acacia-dominated woodlands, paperbarks, casuarinas, callitris, and trees on farmland or gardens. The species prefers woodlands which contain a higher number of mature trees, as these host more mistletoes (DEE 2019).	**Unlikely to occur** Mapped vegetation within the PL is largely unsuitable for the species as it is primarily dominated by lignum, ephemeral grassland, ephemeral forbland and sand dunes containing scattered trees. In addition, the species has not been recorded within 100 km of the PL within the Queensland Government WildNet database.

Species	EPBC Act Status[1]	NC Act Status[1]	Habitat	Likelihood of occurence[2]
Major Mitchell's cockatoo *Lophochroa leadbeateri*	-	V	The species prefers semi-arid and arid regions, typically occurring in dry woodlands dominated by *Eucalyptus, Callitris* and *Casuarina spp.* (Curtis & Dennis 2012).	**Possible occurrence** Mapped vegetation within the PL is largely unsuitable for the species as it is primarily dominated by lignum, ephemeral grassland and ephemeral forbland. Areas mapped as containing *Eucalyptus coolabah* dominated vegetation occur adjacent to the least. As such, there is potential for the species to intermittently traverse the lease.
Grey wagtail *Motacilla cinerea*	Marine, Migratory	SLC	Near running water in disused quarries, sandy and rocky streams in escarpments and rainforests, sewage ponds, ploughed fields, airfields (Pizzey & Knight 2007).	**Unlikely to occur** The species is an uncommon vagrant to Australia. In addition, the PL is unlikely to contain suitable habitat for the species.
Yellow wagtail *Motacilla flava*	Marine, Migratory	SLC	The species typically inhabits short grass and bare ground; swamp margins, sewage ponds, saltmarshes, playing fields, airfields, ploughed land and town lawns (Pizzey & Knight 2007). The species is regularly recorded as a summer migrant to coastal northern Australia (Pizzey & Knight 2007).	**Unlikely to occur** The species is an uncommon vagrant to Australia. In addition, the PL is unlikely to contain suitable habitat for the species.

Species	EPBC Act Status[1]	NC Act Status[1]	Habitat	Likelihood of occurence[2]
Plains-wanderer *Pedionomus torquatus*	CE	V	The species typically occurs within sparse, treeless, lowland native grasslands which usually occur on hard red-brown clay soils (Department of the Environment (DotE) and the Department of Environment, Water and Natural Resources (DEWNR) 2016). Grassland structure is much more important than floristic composition with the species showing a strong preference for sites with approximately 50% bare ground and most vegetation less than 5 cm in height and some widely-spaced plants up to 30 cm (DotE & DEWNR 2016). The species occasionally occurs in other types of habitat such as in stubble; amongst low cereal crops; and in low, sparse chenopod shrubland (DotE & DEWNR 2016).	**Possible occurrence** Vegetation within the PL is likely to include sparsely treed native grasslands; however, the soil composition of the PL is marginally suitable for the species and the species has not been recorded within 100 km of the PL within the Queensland Government WildNet database.
Night parrot *Pezoporus occidentalis*	E	E	Queensland records for the species are typically associated with *spinifex triodia hummock* grasslands, *Astrebla spp.* grasslands, shrubby samphire and chenopod associations and occasional areas with *Acacia cambagei* or *A. aneura* (TSSC 2016). Roosting and nesting sites are consistently reported as within clumps of dense vegetation, primarily old and large Spinifex clumps, but sometimes other vegetation types (TSSC 2016).	**Possible occurrence** The PL is likely to contain suitable foraging habitat for the species, particularly *Astrebla spp.* grasslands. While the species has not been recorded within 100 km of the PL, the species is highly cryptic with an uncertain present day distribution.

Species	EPBC Act Status[1]	NC Act Status[1]	Habitat	Likelihood of occurence[2]
Glossy ibis *Plegadis falcinellus*	Marine, Migratory	SLC	The species typically inhabits freshwater marshes at the edges of lakes and rivers, lagoons, flood-plains, wet meadows, swamps, reservoirs, sewage ponds, rice-fields and cultivated areas under irrigation (DEE 2019). The species is occasionally found in coastal locations such as estuaries, deltas, saltmarshes and coastal lagoons (DEE 2019). Sometimes recorded in wooded swamps, artificial wetlands (such as irrigated fields), and in mangroves for breeding (DEE 2019). Feeds in very shallow water (DEE 2019).	**Likely to occur** The PL is likely to contain ephemeral wetlands within channels of the Cooper Creek floodplain, primarily following flood events. The species may temporarily use these ephemeral wetlands while present. The species has previously been recorded within 100 km of the PL.
Australian painted snipe *Rostratula australis*	E, Marine	V	Generally inhabits shallow terrestrial freshwater (occasionally brackish) wetlands, including temporary and permanent lakes, swamps and claypans (DEE 2019). They also use inundated or waterlogged grassland or saltmarsh, dams, rice crops, sewage farms and bore drains (DEE 2019). The species has been recorded to sometimes utilise areas that are lined with trees, or that have some scattered fallen or washed-up timber (Marchant & Higgins 1993). Breeding occurs in shallow wetlands with areas of bare wet mud and both upper and canopy cover nearby, typically from or near small islands in fresh water wetlands (DEE 2019).	**Possible occurrence** The PL is likely to contain ephemeral wetlands within channels of the Cooper Creek floodplain, primarily following flood events. The species may temporarily use these ephemeral wetlands while present. The species has not been recorded within 100 km of the PL within the Queensland Government WildNet database.
Gull-billed tern *Gelochelidon nilotica*	Marine, Migratory	SLC	The species inhabits beaches, mudflats, brackish wetlands, including inland wetlands, grasslands, crops, ploughed fields and airfields (Pizzey and Knight 2007). The species usually breeds in small colonies on islands in inland lakes (Pizzey and Knight 2007).	**Likely to occur** The PL is likely to contain ephemeral wetlands within channels of the Cooper Creek floodplain, primarily following flood events. The species may temporarily use these ephemeral wetlands while present. The species has previously been recorded within 100 km of the PL.

Species	EPBC Act Status[1]	NC Act Status[1]	Habitat	Likelihood of occurence[2]
Common greenshank *Tringa nebularia*	Marine, Migratory	SLC	The species occurs in all types of wetlands (Higgins & Davies 1996). Typical habitat for this species a wide variety of inland wetlands and sheltered coastal habitats of varying salinity (DEE 2019), including sheltered coastal habitats, typically with large mudflats and saltmarsh, mangroves or seagrass, both permanent and ephemeral terrestrial wetlands, including swamps, lakes, dams, rivers, creeks, billabongs, waterholes and inundated floodplains, claypans and saltflats (DEE 2019).	**Possible occurrence** The PL is likely to contain ephemeral wetlands within channels of the Cooper Creek floodplain, primarily following flood events. The species may temporarily use these ephemeral wetlands while present. The species has not been recorded within 100 km of the PL within the Queensland Government WildNet database.
Mammals				
Ghost bat *Macroderma gigas*	V	E	The species occurs across a range of habitats, from arid Pilbara to tropical savanna woodlands and rainforests (DEE 2019). During the daytime they roost in caves, rock crevices and old mines (DEE 2019). Roost sites used permanently are generally deep natural caves or disused mines with a relatively stable temperature of 23°–28°C and a moderate to high relative humidity of 50–100 percent (DEE 2019). The average foraging distance is approximately 2 km from the daytime roost (DEE 2019).	**Unlikely to occur** The PL is unlikely to support suitable roosting habitat for the species. In addition, suitable roosting habitat is unlikely to occur within the foraging distance of the PL.
Greater bilby *Macrotis lagotis*	V	E	The remaining populations of the greater bilby occupy three main habitats: open tussock grassland on uplands and hills, *Acacia aneura* (mulga) woodland/shrubland growing on ridges and rises, and hummock grassland in plains and alluvial areas (TSSC 2016b).	**Unlikely to occur** The PL is outside of the current known distribution of the species (TSSC 2016b).

Species	EPBC Act Status[1]	NC Act Status[1]	Habitat	Likelihood of occurence[2]
Dusky hopping-mouse, wilkiniti *Notomys fuscus*	V	E	This species inhabits a variety of soft sandy habitats, preferring sand dunes, hills and ridges with cane grass (*Ophiuros exaltatus*), sandhill wattle (*Acacia ligulata*), nitrebush (*Nitraria billardiera*), sticky hopbush (*Dodonea viscose*) and other annual and perennial shrubs (DEWHA 2008b).	**Possible occurrence** While the PL is outside of the current known distribution of the species (DEWHA 2008d; ALA 2019), suitable habitat is likely to occur within the PL.
Yellow-footed rock-wallaby *Petrogale xanthopus celeris*	V	V	The yellow-footed rock-wallaby (central-western Queensland) is mostly nocturnal, and shelters during the day in caves and rock crevices (TSSC 2016). It is closely associated with rugged rocky areas, along the edges of low sandstone tablelands and hills, typically with low Acacia woodlands or shrublands (TSSC 2016c).	**Unlikely to occur** The PL is unlikely to support suitable rocky habitat for the species.
Short-beaked echidna *Tachyglossus aculeatus*	-	SLC	The species occurs throughout Australia in a wide variety of habitats; wherever there is a supply of ants and termites, upon which it feeds (Van Dyck & Strahan 2008). The species usually seeks shelter under thick bushes, in hollow logs, under piles debris, or occasionally in a rabbit burrow (Van Dyck & Strahan 2008).	**Likely to occur** The PL contains suitable habitat for the species and the species has been previously recorded within 100 km of the PL.

[1] EPBC Act = Environment Protection and Biodiversity Conservation Act 1999; NC Act = Nature Conservation Act 1992. E-Endangered, V-Vulnerable, NT-Near Threatened, SLC-Special Least Concern

[2] **Known** to occur: species were recorded during field surveys. **Likely** to occur: suitable habitat to support the species is present and the species has previously been recorded within the desktop search extent. **Possible** occurrence: The PL is within the species known distribution and suitable habitat to support the species is present; however, the species has not previously been recorded within the desktop search extent; and/or, suitable habitat is degraded or of limited extent, thereby reducing the likelihood of the species occurrence. **Unlikely** to occur: the PL does not comprise suitable habitat for the species, or is outside of the species known distribution.

Appendix D MNES significant impact assessment

D.2 MNES significant impact assessment

Definitions and terminology

Term	Definition under the EPBC Act
Important population	A population that is necessary for a species' long-term survival and recovery. This may include populations identified as such in recovery plans, and/or that are: key source populations either for breeding or dispersal populations that are necessary for maintaining genetic diversity, and/or populations that are near the limit of the species range.
Habitat critical to the survival of the species	Areas that are necessary: for activities such as foraging, breeding, roosting, or dispersal for the long-term maintenance of the species or ecological community (including the maintenance of species essential to the survival of the species or ecological community, such as pollinators) to maintain genetic diversity and long term evolutionary development, or for the reintroduction of populations or recovery of the species or ecological community. Such habitat may be, but is not limited to: habitat identified in a recovery plan for the species or ecological community as habitat critical for that species or ecological community; and/or habitat listed on the Register of Critical Habitat maintained by the minister under the EPBC Act.
Invasive species	An introduced species, including an introduced (translocated) native species, which out-competes native species for space and resources or which is a predator of native species. Introducing an invasive species into an area may result in that species becoming established. An invasive species may harm listed threatened species or ecological communities by direct competition, modification of habitat or predation.

MNES significant impact assessment for grey grasswren

MNES Significant Impact Guideline criteria for endangered species	Response
Lead to a long-term decrease in the size of a population	**No significant impact** The proposed disturbance will require the clearing of approximately 11.6 ha of grey grasswren habitat, which represents 5.2% of the grey grasswren habitat identified within the PL. The proposed disturbance is unlikely to lead to a long-term decrease in the size of a population as: • Suitable habitat for the species is widely available within the PL and the surrounding Cooper Creek floodplain • Lignum, which is the key habitat feature for the species, rapidly re-establishes within disturbed areas following flood events (Dawson et al. 2017; Higgisson et al. 2018). Approximately 3.9 ha of the disturbance footprint is proposed for rehabilitation, which includes pipeline right of ways, sump pits and a proportion of the lease areas. These areas are expected to re-establish to suitable habitat for grey grasswren • Management measures have been identified to mitigate impacts on the species habitat (Section 5.3.3)
Reduce the area of occupancy of the species	**No significant impact** The proposed clearing comprises a minimal proportion of the overall area of occupancy of the species and will not impact connectivity of suitable habitat.
Fragment an existing population into two or more populations	**No significant impact** The project is unlikely to impact the movement of grey grasswren individuals among habitat areas within and surrounding the PL.

MNES Significant Impact Guideline criteria for endangered species	Response
Adversely affect habitat critical to the survival of a species	**No significant impact** Habitat critical to the survival of the grey grasswren is identified as swampy floodplains dominated by lignum (*Duma florulenta*) and swamp canegrass (*Eragrostis australasica*), where these plants form dense thickets of 1 m or greater in diameter and 1-2 m in height (DotE 2014). The precautionary principle was applied to consider all grey grasswren habitat mapped within the PL to be habitat critical to the survival of the species. The project is unlikely to significantly affect habitat critical to the survival of the species as: • Suitable habitat for the species is widely available within the PL and the surrounding Cooper Creek floodplain • Lignum, which is the key habitat feature for the species, rapidly re-establishes within disturbed areas following flood events (Dawson et al. 2017; Higgisson et al. 2018). Approximately 3.9 ha of the disturbance footprint is proposed for rehabilitation, which includes pipeline right of ways, sump pits and a proportion of the lease areas. These areas are expected to re-establish to suitable habitat for grey grasswren • Management measures have been identified to mitigate impacts on the species habitat (Section 5.3.3)
Disrupt the breeding cycle of a population	**No significant impact** Given the small area of suitable habitat to be impacted by the proposed works in comparison to the large extent of suitable habitat within and surrounding the PL, the proposed works will not disrupt the breeding cycle of a population of the species. In addition, management measures have been identified to mitigate impacts on the species habitat (Section 5.3.3).
Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	**No significant impact** Given suitable habitat for the species is widely available within the PL and the surrounding region the proposed vegetation clearing is unlikely to lead to a long-term decrease in the size of the local grey grasswren population.
Result in invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species' habitat	**No significant impact** Feral predators (cats and foxes), pigs and rabbits are listed as threatening processes to the species (DotE 2014). The project is unlikely to increase the abundance of these invasive species above their current levels or result in the introduction of new invasive species.
Introduce disease that may cause the species to decline	**No significant impact** Disease is not listed as a potential threat to the species (DotE 2014; DEE 2019). The project is unlikely to introduce a disease that may cause the species to decline.

MNES Significant Impact Guideline criteria for endangered species	Response
Interfere with the recovery of the species	**No significant impact** The proposed works are unlikely to interfere with the recovery of the species due to the minimal impact on the grey grasswren population. No actions proposed are in contrast to the specific recovery actions for the species (DotE 2014; DEE 2019).

Appendix E MSES significant residual impact assessment

E.2 MSES significant residual impact assessment

Definitions and terminology

Term	Definition under the EO Act
Habitat	An area occupied, or periodically or occasionally occupied, by any species, population or ecological community and includes all the different aspects (both biotic and abiotic) used by species during the different stages of their life cycles.
Long-term decrease	Any decline in a local population that is greater than which would be apparent without the action being present.
Population	An occurrence of the species in a particular area. In relation to *Endangered*, *Vulnerable* and *Special Least Concern* species, occurrences include but are not limited to: • a geographically distinct regional population, or collection of local populations; or • a population, or collection of local populations, that occurs within a particular bioregion.

Significant residual impact assessment for grey grasswren

MSES Significant Residual Impact Guideline criteria. The action is likely to:	Response
Lead to a long-term decrease in the size of a local population	**No significant impact** The proposed disturbance will require the clearing of approximately 11.6 ha of grey grasswren habitat, which represents 5.2% of the grey grasswren habitat identified within the PL. A SRI to the species is unlikely as: • Suitable habitat for the species is widely available within the PL and the surrounding Cooper Creek floodplain • Lignum, which is the key habitat feature for the species, rapidly re-establishes within disturbed areas following flood events (Dawson et al. 2017; Higgisson et al. 2018). Approximately 3.9 ha of the disturbance footprint is proposed for rehabilitation, which includes pipeline right of ways, sump pits and a proportion of the lease areas. These areas are expected to re-establish to suitable habitat for grey grasswren • Management measures have been identified to mitigate impacts on the species habitat (Section 5.3.3)
Reduce the extent of occurrence of the species	**No significant impact** The proposed clearing comprises a minimal proportion of the overall extent of occurrence of the species and will not impact connectivity of suitable habitat.
Fragment an existing population	**No significant impact** The project is unlikely to impact the movement of grey grasswren individuals among habitat areas within and surrounding the PL and is unlikely to fragment the local grey grasswren population.
Result in genetically distinct populations forming as a result of habitat isolation	**No significant impact** The project is unlikely to impact the movement of grey grasswren individuals among habitat areas within and surrounding the PL.
Result in invasive species that are harmful to an endangered or vulnerable species becoming established in the endangered or vulnerable species' habitat	**No significant impact** Feral predators (cats and foxes), pigs and rabbits are listed as threatening processes to the species (DotE 2014). The project is unlikely to increase the abundance of these invasive species above their current levels or result in the introduction of new invasive species.
Introduce disease that may cause the population to decline	**No significant impact** Disease is not listed as a potential threat to the species (DotE 2014; DEE 2019). The project is unlikely to introduce a disease that may cause the species to decline.

MSES Significant Residual Impact Guideline criteria. The action is likely to:	Response
Interfere with the recovery of the species.	**No significant impact** The proposed works are unlikely to interfere with the recovery of the species due to the minimal impact on the grey grasswren population. No actions proposed are in contrast to the specific recovery actions for the species (DotE 2014; DEE 2019).
Cause disruption to ecologically significant locations (breeding, feeding, nesting, migration or resting sites) of a species.	**No significant impact** The precautionary principle was applied to consider all grey grasswren habitat mapped within the PL to represent ecologically significant locations for the species as this habitat predominantly comprises lignum dominated communities that are used at all stages of the grey grasswren lifecycle. The project is unlikely to cause disruption to ecologically significant locations as: • Suitable habitat for the species is widely available within the PL and the surrounding Cooper Creek floodplain • Lignum, which is the key habitat feature for the species, rapidly re-establishes within disturbed areas following flood events (Dawson et al. 2017; Higgisson et al. 2018). Approximately 3.9 ha of the disturbance footprint is proposed for rehabilitation, which includes pipeline right of ways, sump pits and a proportion of the lease areas. These areas are expected to re-establish to suitable habitat for grey grasswren • Management measures have been identified to mitigate impacts on the species habitat (Section 5.3.3)

Significant residual impact assessment for echidna

MSES Significant Residual Impact Guideline criteria. The action will result in:	Short-beaked echidna
A long-term decrease in the size of a local population	**No significant impact** The proposed disturbance will require the clearing of approximately 116 ha of echidna habitat. As the species is widely distributed and has no particular habitat preferences, except for the supply of ants and termites (Van Dyck & Strahan 2008), the project is unlikely to lead to a long-term decrease in the local population of the species.
A reduced extent of occurrence of the species	**No significant impact** As the species is widely distributed and has no particular habitat preferences, except for the supply of ants and termites (Van Dyck & Strahan 2008), the project is unlikely to reduce the extent of occurrence of the species.
Fragmentation of an existing population	**No significant impact** The project will have negligible impact on the species local and regional movement.
Reduced gene flow among populations	**No significant impact** The project will have negligible impact on the species local and regional movement.
Disruption to ecologically significant locations (breeding, feeding or nesting sites) of a species	**No significant impact** The proposed disturbance will require the clearing of approximately 116 ha of echidna habitat, which is likely to include breeding, feeding and nesting habitat. However, as the species is widely distributed and has no particular habitat preferences, except for the supply of ants and termites (Van Dyck & Strahan 2008), the project is unlikely to lead to a long-term decrease in the local population of the species.

Significant residual impact assessment for regulated vegetation within the PL

MSES	Disturbance type	Residual impact criteria	Significant residual impact assessment
Regulated vegetation - within 100 m of a Vegetation Management Wetland	Linear	20 m wide in a sparse or very sparse RE; or 25 m wide in a grassland RE. Clearing must also occur within the wetland or within 50 m of the defining bank to trigger an SRI (as described in Section 5.3.2).	**No significant impact** As discussed in Section 5.3.2 (Table 6), where disturbance occurs in Vegetation Management Wetlands and within 50 m of the defining bank, it will comply with SRI clearing limits. Flowline Right of Ways (RoW) will cause temporary disturbance of up to 16 m in width. 13 m of the flowline RoW width will be reinstated as soon as practicable following installation (inclusive of reinstatement of trenches where flowlines are buried). Access tracks will be up to 13 m wide.
	Non-linear	2 ha within a sparse or very sparse RE; or 5 ha within in a grassland RE. Clearing must also occur within the wetland or within 50 m of the defining bank to trigger an SRI (as described in Section 5.3.2.	**No significant impact** As discussed in Section 5.3.2 (Table 6), where disturbance occurs in Vegetation Management Wetlands and within 50 m of the defining bank, it will comply with SRI clearing limits. Well pads will be up to 1.65 ha.

Regulated vegetation - intersecting a watercourse	Linear	20 m wide in a sparse or very sparse RE; or 25 m wide in a grassland RE. Clearing must also occur within the defined distance or within 5 m of the defining bank to trigger an SRI (as described in Section 5.3.2.	**No significant impact** As discussed in Section 5.3.2 (Table 6), where disturbance occurs within the defined distance of Vegetation Management Watercourses and Drainage Features and within 5m of the defining bank, it will comply with SRI clearing limits Flowline Right of Ways (RoW) will cause temporary disturbance of up to 16 m in width. 13m of the flowline RoW width will be reinstated as soon as practicable following installation (inclusive of reinstatement of trenches where flowlines are buried). Access tracks will be up to 13 m wide. Flowlines and access tracks will be restricted as much as practicable at watercourse crossings.
	Non-linear	2 ha within a sparse or very sparse RE; or 5 ha within a grassland RE. Clearing must also occur within the defined distance or within 5 m of the defining bank to trigger an SRI (as described in Section 5.3.2.	**No significant impact** As discussed in Section 5.3.2 (Table 6), where disturbance occurs within the defined distance of Vegetation Management Watercourses and Drainage Features and within 5m of the defining bank, it will comply with SRI clearing limits. Well pads will be up to 1.65 ha.

Significant residual impact assessment for high ecological significance wetlands

The PL contains High Ecological Significance (HES) wetlands mapped within the map of Queensland wetland environmental values under the *Environmental Protection (Water and Wetland Biodiversity) Policy 2019*. Areas of HES wetland have been deemed present where wetland values, primarily wetland REs were ground-truthed within the site (refer to Section 4.2.3). The proposed works will result in disturbance up to approximately 0.9 ha of Queensland Government Mapped HES wetlands.

Assessment against the SRI criteria for wetlands and watercourses within the SRI Guideline is provided within the below table.

Environmental attribute	Significant residual impact (SRI) assessment
Areas of the wetland or watercourse being destroyed or artificially modified	**SRI unlikely** While the proposed works will result in the clearing of vegetation in up to approximately 0.9 ha of Queensland Government mapped HES wetlands, a SRI is unlikely as: • During detailed design stages, infrastructure will be micro-sited to minimise impacts to HES wetlands. • Construction and rehabilitation works will be timed to occur outside of flood periods, which will minimise impacts on wetland values. • Approximately 0.3 ha of disturbed area will be immediately rehabilitated post-disturbance, which includes pipeline Right of Ways and a portion of disturbance for well leases and sump pits. • Pipeline reinstatement will retain the topsoil profile and existing seed bank wherever practicable. Vegetation communities that will be disturbed include an abundance of ephemeral herbs and grasses, which naturally remain dormant within the soil and germinate following flood events. As such, natural rehabilitation processes will typically lead to the reinstatement of a vegetation community consistent with the pre-disturbance vegetation. • The success and timing of natural rehabilitation will largely depend on the occurrence of rainfall and flooding processes i.e. extended periods of natural drought (i.e. el Niño events) followed by periods of high rainfall / flooding (i.e. la Nina events) are characteristic of the region. • Vegetation communities within which the clearing will occur contain limited woody vegetation, which minimises impact to soil stability. • The proposed works are unlikely to affect the hydrological processes of the wetland as: – no drilling is proposed in waterway channels – the small extent of disturbance is unlikely to significantly affect water movement, erosion and sedimentation processes – rehabilitation of pipelines will be completed when no surface water is expected to be present on site and outside of flood events/inundation periods – all non-essential infrastructure will be decommissioned and rehabilitated prior to the onset of flood events/inundation periods (wherever practicable and safe to do so); and – access tracks, infrastructure and seismic lines located, prepared and constructed to maintain pre-existing surface water flows. Culverts and floodways installed where required.

Environmental attribute	Significant residual impact (SRI) assessment
A measurable change in water quality of the wetland or watercourse—for example a change in the level of the physical and/or chemical characteristics of the water, including salinity, pollutants, or nutrients in the wetland or watercourse, to a level that exceeds the water quality guidelines for the waters	**No significant impact** The proposed works are unlikely to affect the water quality of wetlands within the PL as: • no drilling is proposed in waterway channels • the small extent of disturbance in unlikely to affect water movement, erosion and sedimentation processes • rehabilitation of pipelines will be completed when no surface water is expected to be present on site and outside of flood events/inundation periods • all non-essential infrastructure will be decommissioned and rehabilitated prior to the onset of flood events/inundation periods (wherever practicable and safe to do so) • no activities proposed involve the discharge of water (point or diffuse sources) or the construction or operation of regulated dams and other major infrastructure (i.e. separator ponds, permanent camps); and • Fuel, oil and chemical storage and handling undertaken in accordance with Australian standards and guidelines (i.e. in bunded areas) and in small volumes wherever practicable.
The habitat or lifecycle of native species, including invertebrate fauna and fish species, dependent upon the wetland being seriously affected	**No significant impact** The proposed works will be scheduled to be completed when no surface water is expected to be present within the PL and outside of flood events/inundation periods. The Cooper Creek floodplain wetlands undergo natural boom-bust cycles after, during and following flood events. The possible diversion or interception of overland flow from surface infrastructure and area of cleared vegetation is negligible in the context of surrounding habitats and is unlikely to impact habitat or lifecycle of native species.
A substantial and measurable change in the hydrological regime or recharge zones of the wetland, e.g. a substantial change to the volume, timing, duration and frequency of ground and surface water flows to and within the wetland	**No significant impact** The proposed works will be scheduled to be completed when no surface water is expected to be present within the PL and outside of flood events/inundation periods. The possible diversion or interception of overland flow from surface infrastructure is negligible when considering the small footprint of proposed works compared to the catchment area and water movement. Groundwater modelling and assessment has identified groundwater dependent ecosystems are unlikely to be affected.
An invasive species that is harmful to the environmental values of the wetland being established (or an existing invasive species being spread) in the wetland	**No significant impact** The project is unlikely to increase the abundance of invasive species above their current levels or result in the introduction of new invasive species. Weed management measures have been identified within Section 5.3.

Significant residual impact assessment for Strategic Environmental Area

The majority of the PL is located within a 'designated precinct' of the Channel Country SEA. The proposed works will result in disturbance to approximately 116 ha of SEA. Under the *Regional Planning Interests Act 2014*, a resource activity is determined to have an 'impact' on a SEA if the impact affects:

- a feature, quality, characteristic or other attribute of the area; or
- the suitability of land in the area to be used for a particular purpose.

Assessment against the SRI criteria for SEAs within the SRI Guideline is provided within the below table.

Significant residual impact assessment for Channel Country SEA environmental attributes

Environmental attribute	Significant residual impact (SRI) assessment
The natural hydrologic processes of the area characterised by: • natural, unrestricted flows in and along stream channels and the channel network in the area; and • overflow from stream channels and the channel network onto the flood plains of the area, or the other way; and • natural flow paths of water across flood plains connecting waterholes, lakes and wetlands in the area; and • groundwater sources, including the Great Artesian Basin and springs, that support waterhole persistence and ecosystems in the area.	**SRI unlikely** The proposed development is unlikely to significantly affect natural hydrologic processes as: • no drilling is proposed in waterways • the small extent of disturbance in unlikely to affect water movement, erosion and sedimentation processes • rehabilitation of pipelines will be completed when no surface water is expected to be present on site and outside of flood events/inundation periods • all non-essential infrastructure will be decommissioned and rehabilitated prior to the onset of flood events/inundation periods (wherever practicable and safe to do so) • possible diversion or interception of overland flow from surface infrastructure (i.e. borrow pits) is negligible when considering the small footprint of proposed works compared to the catchment area and water movement; and • access tracks, infrastructure and seismic lines located, prepared and constructed to maintain pre-existing surface water flows. Culverts and floodways installed where required.

Environmental attribute	Significant residual impact (SRI) assessment
The natural water quality in the stream channels and aquifers and on flood plains in the area.	**SRI unlikely** The proposed development is unlikely to significantly affect natural water quality as, typically: • proposed drilling locations are set back from the surrounding Cooper Creek channels • drilling will be scheduled to be completed when no surface water is expected to be present on site and outside of flood events/inundation periods • the width of linear infrastructure corridors through waterway crossings has been restricted to the minimum width practicable, which is below the maximum width of SRI to regulated vegetation – intersecting a watercourse • no activities proposed involve the discharge of water (point or diffuse sources) or the construction or operation of regulated dams and other major infrastructure (i.e. separator ponds, permanent camps) • groundwater modelling and assessment has identified groundwater dependent ecosystems are unlikely to be affected; and • additional management and contingency measures for fuels/chemicals and unplanned releases of contaminants are identified within the Regional Interests Development Application Assessment Report.
The beneficial flooding of land that supports flood plain grazing and ecological processes in the area.	**SRI unlikely** The proposed development is unlikely to significantly affect the hydrological processes and flooding in the area as: • possible diversion or interception of overland flow from surface infrastructure (i.e. borrow pits) is negligible when considering the small footprint of proposed works compared to the catchment area and water movement; and • construction activities will be temporary in nature and will be scheduled to be completed when no surface water is expected to be present on site and outside of flood events/inundation periods.

Appendix D - South-West Queensland Stimulation Impact Monitoring Program

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South-West Queensland

Stimulation Impact Monitoring Program

Date	Rev	Reason For Issue	Author	Checked	Approved
17/06/2020	0	Approved for use	AS	AL	SO
16/08/2021	1	Administrative changes	AL	AS	PW

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Abbreviations and Units

Acronym	Description
EA	Environmental Authority
EC	electrical conductivity
EHS	Environment, Health and Safety
EP Act	*Environment Protection Act 1994*
EPP	Environmental Protection Policy
EPP Water	*Environmental Protection (Water Quality) Policy 2009*
EV	Environmental Value
GAB	Great Artesian Basin
GDE	Groundwater Dependant Ecosystem
GED	General Environmental Duty
HFRA	Hydraulic Fracturing Risk Assessment
LOR	Limit of Reporting
NATA	National Associated of Testing Authorities
SIMP	Stimulation Impact Monitoring Program
SMS	Santos Management System
SWQ	South West Queensland
TDS	total dissolved solids
TPH	total petroleum hydrocarbons
TRH	total recoverable hydrocarbons

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1.0 Introduction

This Stimulation Impact Monitoring Program (SIMP) has been prepared to meet relevant requirements of the Well Construction, Maintenance and Stimulation Activities Schedule of Santos' Cooper Basin Environmental Authorities (EAs). Table 1 details these EA requirements with reference to the relevant section of this SIMP.

Table 1 – Stimulation Impact Monitoring Program Requirements

Number*	Condition	Section
K7 (j)	An assessment of the appropriate limits of reporting for all water quality indicators relevant to stimulation monitoring in order to accurately assess the risks to environmental values of groundwater.	Section 5
K8	***Water Quality Baseline Monitoring*** Prior to undertaking any stimulation activity, a baseline bore assessment must be undertaken of the water quality of: (a) landholders' active groundwater bores (subject to access being permitted by the landholder) that are within a two (2) kilometre radius from the location of the stimulation initiation point within the target formation; and (b) any other bore that could potentially be adversely impacted by the stimulation activity(ies) in accordance with the findings of the risk assessment required by conditions (K6) and (K7).	Section 2 Section 2 Section 2
K9	Baseline bore assessments required in condition (K8) must include the minimum water quality analytes and physico-chemical parameters identified in the Baseline Assessment Guideline and any restricted stimulation fluids as defined in the *Environmental Protection Act 1994*, as amended from time to time, in order to establish baseline water quality.	Section 5
K10	***Stimulation Impact Monitoring Program*** A Stimulation Impact Monitoring Program must be developed prior to the carrying out of stimulation activities which must be able to detect adverse impacts to quality from stimulation activities and must consider the findings of the risk assessment required by conditions (K6) and (K7) that relate to stimulation activities and must include, as a minimum, monitoring of: (a) the stimulation fluids to be used in stimulation activities at sufficient frequency and which sufficiently represents the quantity and quality of the fluids used; (b) flow back waters from stimulation activities at sufficient frequency and which sufficiently represents the quality of that flow back water; and (c) all bores in accordance with condition (K8).	This Document Section 5.0 Section 3.2 Section 3.3 Section 4
K11	The Stimulation Impact Monitoring Program must provide for monitoring of: (a) analytes and physico-chemical parameters relevant to stimulation baseline bore assessments required by conditions (K8) and (K9); and	Section 5 Section 2

Number*	Condition	Section
	(b) any other analyte or physico-chemical parameters that will enable detection of adverse water quality impacts and the inter-connection with a non-target aquifer as a result of stimulation activities if an aquifer is present within 200 metres above or below the target formation(s) and is spatially located within a two (2) kilometre radius from the location of the stimulation initiation point.	Section 3.3
K12	The Stimulation Impact Monitoring Program must provide for monitoring of the bores in condition (K10)(c) at the following minimum frequency: (a) monthly for the first six (6) months subsequent to stimulation activities being undertaken; then (b) annually for the first five (5) years subsequent to stimulation activities being undertaken or until analytes and physico-chemical parameters listed in condition (K9) are not detected in concentrations above baseline bore monitoring data on two (2) consecutive monitoring occasions.	Section 4 Section 4 Section 4

** Condition numbering may change between EAs.*

Stimulation is defined in Santos Cooper Basin EAs and means a technique used to increase the permeability of natural underground reservoir that is undertaken above the formation pressure and involves the addition of chemicals. Stimulation includes hydraulic fracturing / hydrofraccing, fracture acidizing and the use of proppant treatments.

An overview of the monitoring described in this Stimulation Impact Monitoring Program, including groundwater bore baseline monitoring (pre-stimulation monitoring), stimulation source water, stimulation fluid and flowback monitoring, and post-stimulation monitoring is provided in Figure 1.

The certification of this SIMP by a suitably qualified person is provided in Attachment A.

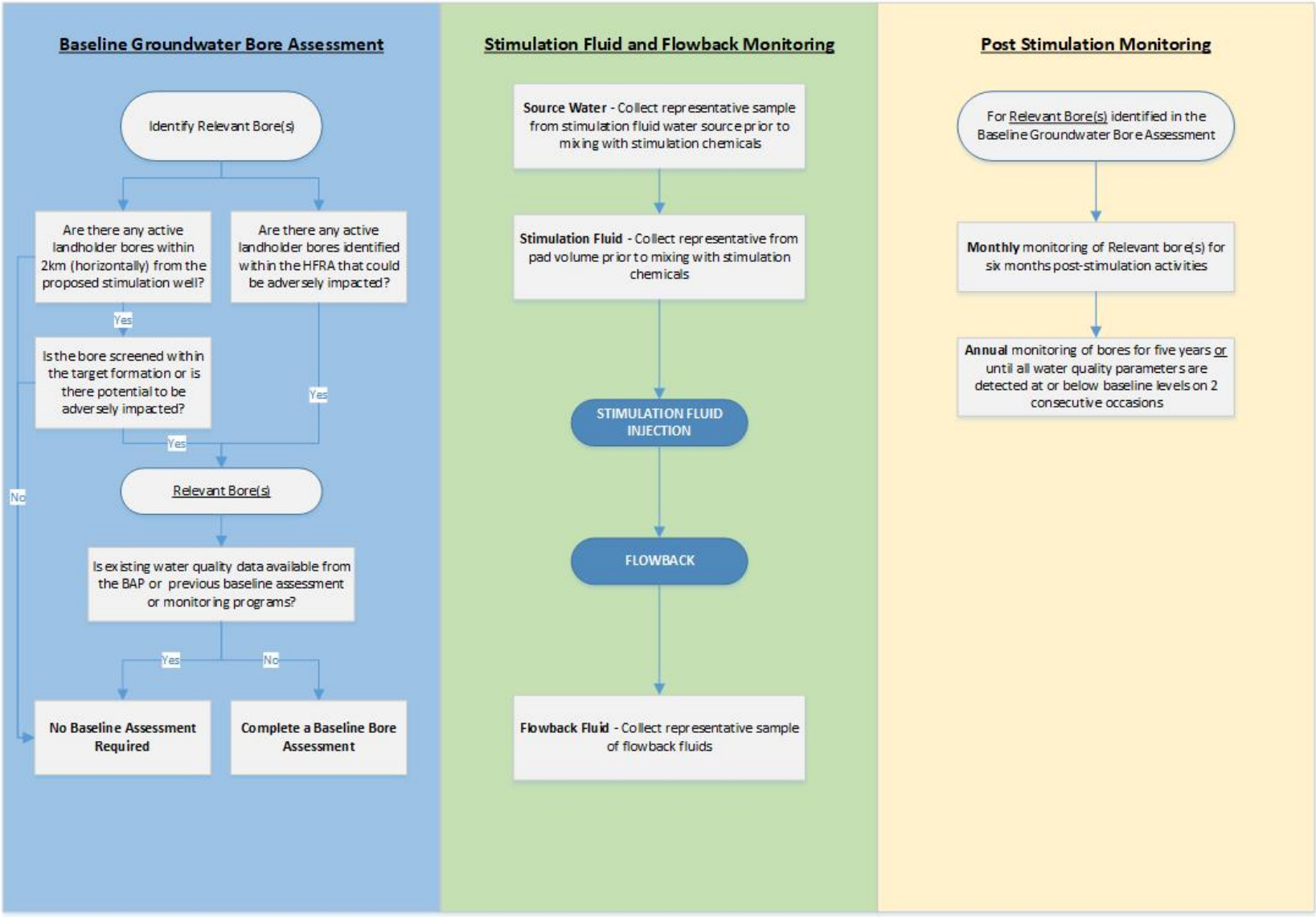

Figure 1 – Stimulation Monitoring Overview

2.0 Baseline Groundwater Bore Assessment

Prior to undertaking stimulation activities a baseline groundwater bore assessment is be undertaken as follows:

1. Determine the target depth and formation of proposed stimulation activity.
2. Complete a search of Santos WebGIS and Queensland Government Groundwater Database (e.g. QLD Globe) to determine the potential presence of landholder groundwater bores screened within the target formation and spatially located within two (2) kilometres of the well to be fractured.
3. Identify other bores from the Hydraulic Fracturing Risk Assessment (HFRA) that could potentially be adversely impacted by the proposed stimulation activity.
4. For groundwater bores identified in Steps 2 and 3 (relevant bore(s)), review existing bore information obtained during:
    a) baseline assessment plan (BAP);
    b) regional monitoring assessments; and
    c) previous baseline monitoring.
5. If existing baseline water quality data identified in Step 4 is not available for the relevant bore(s), a representative baseline groundwater sample is to be collected prior to the stimulation activity.

One sample is to be collected from each relevant bore and is to be analysed for the analytical suite detailed in Table 2, Section 5.

It is important to note that restrictions to sampling such as land access or surface equipment present at the bore (such as pumps) may occur.Where sampling cannot be undertaken due to land access, physical restrictions or insufficient water, baseline water quality may be extrapolated from relevant surrounding bores.

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3.0 Stimulation Fluid and Flowback Monitoring

Monitoring of stimulation fluids during the stimulation activity is to be performed at sufficient frequency and which represents the quality and quantity of source water, stimulation fluid and flowback.

3.1 Stimulation Water Source Sampling

Source water to be used for stimulation activities is to be sampled prior to the commencement of the stimulation operations to confirm that water quality is suitable for use in stimulation activities.

One source water sample is to be collected per stimulation activity and is to be analysed for the analytical suite detailed in Table 3, Section 5. For locations where water is regularly sourced, frequency of source water sampling may be reduced.

3.2 Stimulation Fluid Sampling

Stimulation fluids must not include restricted stimulation fluids as prescribed by the *Environmental Protection Act 1994*.

Service providers must provide confirmation (i.e. laboratory analysis, statutory declaration), that restricted stimulation fluids are not present in the stimulation fluid pad volume prior to the stimulation activity being undertaken.

One stimulation fluid sample per stimulation activity on each well is to be taken from the pad volume prior to the addition of the slurry volume and analysed for the analytical suite detailed in Table 3, Section 5.

3.3 Flowback Sampling

Post stimulation activities, representative flowback sampling is to be undertaken on a case by case basis and is to be completed when flowback or produced water is recovered at surface.

A flowback or produced water sample is to be collected post stimulation on each well and to be analysed for the analytical suite detailed in Table 4, Section 5.

The HFRA indicated limited interconnection based on the competence of the confining units in isolating hydrocarbon reservoirs from overlying and underlying aquifers. The HFRA also concluded incomplete exposure pathways to landholder bores.

If an aquifer is present within 200 metres above or below the target formation(s) and is spatially located within a two (2) kilometre radius from the location of the stimulation initiation point, additional flowback monitoring may be required to enable detection of potential adverse water quality impacts and the potential inter-connection with a non-target aquifer. Monitoring requirements are to be assessed on a case by case basis in consideration of the analytical suite detailed in Table 2, Section 5.

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4.0 Post-Stimulation Groundwater Bore Monitoring

Where relevant bores have been identified in Section 2, post-stimulation groundwater monitoring is to be undertaken at the following frequencies:

- monthly for the first 6 months subsequent to the stimulation activities being undertaken; then
- annually for the first 5 years subsequent to the stimulation activities being undertaken or until analytes and physico-chemical parameters are not detected in concentrations above baseline bore monitoring data on 2 consecutive occasions.

Groundwater from relevant bores is to be analysed for the analytical suite detailed in Table 2, Section 5.

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5.0 Analytical Testing

The HFRA identifies the following environmental values (EVs) of groundwater for the Project Area:

- town supply;
- stock and domestic water supply;
- sandstone aquifers of the Great Artesian Basin (GAB); and
- Groundwater Dependant Ecosystems (GDEs).

Water/stimulation fluid sampling parameters provided in Table 2, Table 3, and Table 4 are considered appropriate for assessing the risks to the abovementioned EVs and to detect potential adverse impacts to (water) quality from stimulation activities. The standard laboratory limits of reporting (LOR) for analytes presented in Tables 2, 3 and 4 are acceptable for the purposes of evaluating monitoring data and assessment of the risk to the EVs of groundwater identified in the HFRA. The standard LOR for the identified parameters are provided as Attachment B.

Samples are to be collected in general accordance with the Queensland Government *Monitoring and Sampling Manual* and appropriate guidelines as required by Santos Cooper Basin EAs.

All samples will be analysed at National Association of Testing Authorities (NATA) accredited laboratories.

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Table 2 – Baseline Groundwater Bore Sampling Parameters

Physical Parameters	Ions	Metals (T&D)	Alkalinity	Dissolved Gases and Others
pH (field and laboratory)	Calcium	Aluminium	Total alkalinity as CaCO3	Carbon dioxide (field)*
		Arsenic		
Temperature (field only)	Chloride	Barium	Bicarbonate as CaCO3	Methane*
		Beryllium		
Electrical conductivity (field and laboratory)	Fluoride	Boron	Carbonate as CaCO3	Hydrogen sulphide*
		Cadmium		
		Chromium		
Total dissolved solids (laboratory only)	Magnesium	Cobalt	Hydroxide as CaCO3	Volatile organic compounds (VOC)
		Copper		
	Potassium	Iron	Total hardness as CaCO3	Polycyclic Aromatic Hydrocarbons (PAH)
		Lead		
	Sodium	Manganese		Total recoverable hydrocarbons (TRH)
	Sulphate	Mercury		
		Molybdenum		
		Nickel		
		Selenium		
		Uranium		
		Vanadium		
		Zinc		

* Where the presence of dissolved gases is detected in the field (via the use of a multi-parameter gas detector), a dissolved gas sample must be collected through a flow-through cell, or if not practicable then in accordance with methods outlined in section 7.2 of *Groundwater sampling and analysis – A Field Guide (Sundaram, et al., 2009).*

The concentration of PAHs or restricted stimulation fluids detected in monitoring per Section 3.2 and Table 3, is not measured in relation to source water. The restrictions on PAHs and/or restricted stimulation fluids apply to stimulation fluid (concentrate) prior to being mixed with water (source water). As such the concentration of PAH or restricted stimulation fluids in the source water is to be subtracted from thestimulation fluid analytical results.

Table 3 – Source Water and Stimulation Fluid Sampling Parameters

Physical Parameters	Ions	Metals (T&D)	Alkalinity	Dissolved Gases and Others
pH (field* and laboratory)	Chloride	Barium	Total alkalinity as CaCO3	Volatile organic compounds (VOC)
Temperature (field* only)			Bicarbonate as CaCO3	PAH – Super Ultra trace (0.005µg/L – 0.02µg/L)
Electrical conductivity (field* and laboratory)			Carbonate as CaCO3	Total recoverable hydrocarbons (TRH)
Total dissolved solids (laboratory only)			Hydroxide as CaCO3	
			Total hardness as CaCO3	

*source water only

Table 4 – Flowback Water Sampling Parameters

Physical Parameters	Ions	Metals (T&D)	Alkalinity
pH (field and laboratory)	Chloride	Barium	Total alkalinity as CaCO3
Temperature (field only)			Bicarbonate as CaCO3
Electrical conductivity (field and laboratory)			Carbonate as CaCO3
Total dissolved solids (laboratory only)			Hydroxide as CaCO3
			Total hardness as CaCO3

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6.0 Roles and Responsibilities

Santos personnel are responsible for the environmental performance of their activities, for complying with relevant approval/permit requirements and for ensuring that all environmental objectives associated with the work are achieved.

All Santos personnel and contractors must also be mindful of:

- Environmental Authority requirements as stipulated in the Cooper Basin EAs;
- the General Environmental Duty (GED) as outlined in section 319 of the *Environmental Protection Act 1994* (EP Act),

Roles, responsibilities and accountabilities specific to Stimulation Activities are defined as per SMS Compliance.

A summary of responsibilities for the Stimulation Impact Monitoring Program is provided inTable 5.

Table 5 – Roles and Responsibilities

Responsible Person	Responsibility
Santos Drilling and Completions Manager	Manage Drilling and Completion activities in accordance with Santos Management Systems (SMS)
Principal Environmental Adviser / Team Leader	Implement Stimulation Impact Monitoring Program
	Maintain management systems, processes and procedures
	Ensure SIMP data is recorded and maintained in Santos data management system (EQuIS)
	Implement monitoring outlined in the SIMP
	Perform water quality data review as required
	Schedule assurance audits to ensure compliance with the EAs
	Manage reporting in accordance with EAs
Santos Drilling and Completions Team Leader	Implement the Stimulation Activities as per this document
	Maintain records in accordance with the SIMP
	Manage procedures for Stimulation Activities
	Manage staff and confractor compliance with the SIMP
All Employees and Contractors	Comply with EHS legal obligations and other requirements that are applicable to Santos' operations and activities.

7.0 Evaluation and Review

7.1 Implementation

The implementation and effectiveness of this monitoring program and associated plans and procedures will be regularly assessed to ensure:

- Santos is demonstrating compliance with legal and landholder obligations;
- the overall monitoring strategy remains relevant and up to date; and
- the plan and procedures adequately manage the respective environmental issue.

Effectiveness can be assessed by a number of methods as shown in Table 6.

Table 6 – Methods to Assess Legal and Procedural Effectiveness

Assessment Tool	Description
Checklists – Santos Compliance Management System	Checklists, developed to reflect legal and procedural requirements / outcomes will be used by individual Santos assets/departments to assess and manage compliance. The results of the checklists will be evaluated for common non-conformances that may be resolved through procedural change or by implementing another measure or process.
Audits	Conduct internal and/or third party audits to formally assess the level of compliance with both regulatory requirements and with Santos procedures. Audit outcomes are used to develop corrective actions, which may include changes to procedures.
Review of Incidents	A review of internal incidents, near misses or hazards will be undertaken to identify recurrences of similar incident types. This may highlight a requirement for a change in an existing procedure, require the development of a new procedure or by implementation of another measure or process to address the recurring issue.
Review of Data	Analyse all relevant data collected for negative and/or common trends that may be prevented by procedural changes or by implementing another measure or process.

7.2 Review

The SIMP is a living document and the performance of the SIMP shall be reviewed at least every five years or sooner if any of the following occur:

- the plan is not adequately managing identified issues;
- legislative requirements change; and/or
- the area(s) of activity changes.

Similarly, the plan may also be reviewed on an ‘as needs’ basis:

- in the case that there are significant changes to conditions at any site; and/or
- changes to standard limit of reporting for relevant analytes.

As a minimum the review shall take into consideration monitoring frequency, locations, changes to water qualities and/or quantities as a result of Santos’ forward plan of operations.

Reviews and changes to the SIMP are to be communicated to relevant Santos personnel.

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ATTACHMENT A: Certification

Statutory Declaration

Resource activities other than mining

Declaration of compliance for written documents

A statutory declaration is a written statement of facts that is sworn or declared under the Oaths Act 1867. *This statutory declaration has been prepared to declare the authority holders compliance with the provisions of the* Environmental Protection Act 1994 *(EP Act) or an environmental authority condition that stipulates the requirement to submit a certified written document to the administering authority.*

Oaths Act 1867

QUEENSLAND
TO WIT

Re: Written documents relating to an environmental authority for a resource activity other than mining under the *Environmental Protection Act 1994*.

Written document: South-West Queensland Stimulation Impact Monitoring Program, dated August 2021

(Insert type of document, e.g. contingency plan for emergency environmental incidents)

Subject matter: Compliance with Environmental Authority conditions as per Table 1 within the written document.

(Insert subject matter, e.g. compliance with environmental authority number PEN1001222222)

Authority holder: Santos Ltd

I, _____

of, _____

ABN 46 640 294 485

Statutory Declaration

Declaration of compliance for written documents

in the State of Queensland do solemnly and sincerely declare that:

1. I am a suitably qualified person as defined in the environmental authority; having professional qualifications, training, skills and experience relevant to the subject matter and can give authoritative assessment, advice and analysis relative to the subject matter using the relevant protocols, standards, methods or literature. A copy of my curriculum vitae is Annexure A to this declaration[1];
2. The authority holder has fully complied with the requirements of environmental authority conditions in Table 1 of the South-West Queensland Stimulation Impact Monitoring Program, dated August 2021
3. All relevant material has been considered in preparing the South-West Queensland Stimulation Impact Monitoring Program, dated August 2021
4. The content of the South-West Queensland Stimulation Impact Monitoring Program, dated August 2021 is accurate and true.
5. The South-West Queensland Stimulation Impact Monitoring Program, dated August 2021 meets the requirements of the Environmental Authority conditions as per Table 1 within the written document .

And I make this solemn declaration conscientiously believing the same to be true, and by virtue of the provisions of the *Oaths Act 1867*.

Taken and declared before me, at _____

(Insert name of town or city and suburb)

this 20th day of _____ in the year 2021

(Insert day, e.g. 18th) (Insert year)

[1] The signatory does need to initial each page of the annexure, but it does need to be marked with the following:
"This is the [*insert name of document]* or a copy of the [insert name of document] marked with the letter "A" referred to in the Statutory Declaration [insert sworn/taken/affirmed/solemnly declared] before me at [insert day] of [insert month], [insert year].

Approved By

Signature	Date

Director
Energy Regulation and Implementation Unit
Environmental Protection Act 1994
Department of Environment and Heritage Protection

Enquiries:
Energy Regulation and Implementation Unit
(Level 7, 400 George Street)
Department of Environment and Heritage Protection
Regular or registered post:
GPO Box 2454, Brisbane QLD 4001
Courier or hand delivery:
Level 3, 400 George Street, Brisbane QLD 4000
Telephone: (07) 3330 5619
Facsimile: (07) 3330 5634

Santos

ATTACHMENT B: Standard Laboratory Limits of Reporting

Physical Parameter	Standard LOR[1] mg/L	Metals (T&D)	Standard LOR[1] mg/L	Dissolved Gases and Others	Standard LOR[1] mg/L
pH (field and laboratory)	0.01	Aluminium	0.01	Carbon dioxide	1
		Arsenic	0.001	Methane	0.01
Temperature (field only)	-	Barium	0.001	Hydrogen sulphide	0.1
		Beryllium	0.001		
Electrical conductivity (laboratory)	1 µS/cm	Boron	0.05	Volatile organic compounds (VOC)	0.001 - 0.05
		Cadmium	0.0001		
Total dissolved solids (laboratory only)	10	Chromium	0.001	Polycyclic Aromatic Hydrocarbons (PAH)[2]	0.0005 - 0.001
		Cobalt	0.001		
Calcium	1	Copper	0.001	Benzene	0.001
Chloride	1	Iron	0.05	Toluene	0.002
Fluoride	0.1	Lead	0.001	Ethylbenzene	0.002
Magnesium	1	Manganese	0.001	Meta- & para-Xylene	0.002
Potassium	1	Mercury	0.0001		
Sodium	1	Molybdenum	0.001	Ortho-Xylene	0.002
Sulphate	1	Nickel	0.001	Total Xylene	0.002
Total alkalinity as CaCO3	1	Selenium	0.01	Naphthalene	0.005
Bicarbonate as CaCO3	1	Uranium	0.001	Total recoverable hydrocarbons (TRH)	0.02 - 0.1
Carbonate as CaCO3	1	Vanadium	0.01		
Hydroxide as CaCO3	1	Zinc	0.005		
Total hardness as CaCO3	1				

[1] LOR sourced from ALS for water sample analysis and reported in mg/L unless other units stated
- It should be noted that revisions to standard limit of reporting for specific analytes will occur over time
- LOR may be raised by the laboratory during analysis due to matrix interferences
[2] Note whilst standard LOR for PAH are considered acceptable for the purposes of evaluating monitoring data and assessment of the risk to the EVs of groundwater, the EA may require reduced LORs