IESC advice for response

IESC 2021-130: Towrie Gas Development (Queensland) (EPBC 2021/8979) – New Development

NO.	IESC COMMENT	RESPONSE/SECTION OF PD
Question 1: Has the proponent provided sufficient documentation for the IESC to be confident that any risks to EPBC-listed springs and GDEs arising from the project are very low, low or moderate? In particular, does the IESC consider that the proponent has supplied sufficient evidence to be confident that the integrity of the Rewan Formation is sufficient to limit hydraulic connectivity between the Bandana Formation and overlying formations, thereby protecting the environmental values associated with these formations from drawdown-related impacts?		
1	The documentation provided is not sufficient for the IESC to be confident that risks to EPBC Act-listed springs and GDEs fall in the very low – moderate category range. Furthermore, while the regional-scale OGIA model is appropriate for predicting potential cumulative impacts, it is inappropriate for assessing impacts at the local scale. Consequently, comprehensive assessment of the risk to EPBC Act-listed springs and other GDEs is not possible with the documentation provided and the available OGIA model.	Refer to responses below regarding specific technical comments and suggestions about the groundwater impact modelling approach. More broadly however, it is not appropriate that the IESC consider that the OGIA groundwater model is not an appropriate tool for quantifying potential risks to water resources at all scales. The purpose of the OGIA model is not just as a cumulative impact assessment tool, as stated by the IESC, but as a risk-screening tool for potential impact to water resources at a range of scales, including potential impact to GDEs. This approach is recognised within the risk assessment methodologies defined in the *Coal Seam Gas - Joint Industry Framework* (JIF). The JIF was collaboratively developed by the federal Department of Agriculture, Water and the Environment and the coal seam gas (CSG) industry, with technical and regulatory advice from the Queensland Government. The JIF manages the impacts of CSG development on groundwater, including maintaining or enhancing groundwater discharge and environmental values at springs which are part of the listed threatened 'community of native species dependent on the natural discharge of groundwater from the Great Artesian Basin' and ensuring the continuing function and environmental value of groundwater dependent ecosystems The JIF sets out specific criteria that determines when a site-specific (or local scale) assessment is required using the OGIA model findings. The assessment presented in the documentation provided by Santos aligns to the risk assessment criteria defined in the JIF.

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		Where sufficient risk is identified by the OGIA model, then a more detailed, local-scale model or site-specific assessment is justified. It is our expectation that approval for Towrie would require Santos to implement the principles set out in the JIF, and in particular regard to an adaptive management approach, throughout the life of the project.
2	Project-specific hydraulic data (e.g., vertical hydraulic conductivity, anisotropy of hydraulic conductivity and storativity) are required to confirm the proponent's assumptions that the integrity of the Rewan Group is sufficient to limit hydraulic connectivity between the Bandanna Formation and overlying formations (i.e., is an aquitard) and will constrain downwards groundwater fluxes that may affect the water table, thereby protecting the environmental values associated with these formations from drawdown-related impacts. For example, the current hydraulic parameter data provided by the proponent is derived from bores within 20 km of the project area; however, data from bores located inside the project area do not appear to be available. The range of hydraulic conductivities provided for the Rewan Group varies by several orders of magnitude across only four tests (KCB 2021, p. 71), indicating local heterogeneity that may alter the aquitard characteristics of the Rewan Group in the project area.	The Rewan Group is identified as a regional aquitard. The *Hydrogeological conceptualisation report for the Surat Cumulative Management Area* (OGIA 2016) identify that the "clay-rich Rewan Group is a persistent regional aquitard and acts as a confining unit for the Bandanna Formation". Further, an estimate of groundwater production from the stratigraphy of the Bowen Basin indicates that the Rewan Group (347 ML/yr) contributes ~5% of total groundwater production from the Bowen Basin (7,118 ML/yr), the lowest of all the Bowen Basin hydrostratigraphic units and with no natural groundwater discharge (Table 16-1 of *Hydrogeological conceptualisation report for the Surat Cumulative Management Area* (OGIA 2016)). This further highlights the regional aquitard characteristics of the Rewan Group. Locally, there are no identified water supply bores within the Project tenure. As identified in the *Towrie Development Area Water Assessment Report* (KCB 2021), multiple attempts at installing water supply bores by landholders in the Towrie project area have been undertaken, however, these bores had to be abandoned, presumably due to inadequate yield even for a stock/domestic bore (Table 7-7 and Figure 7-28 of *Towrie Development Area Water Assessment Report* (KCB 2021)). Within a 25 km radius of the Project tenure, one bore (RN 11669) located adjacent to Moolayember Creek approximately 25 km to the northwest of the Project tenure, has been attributed to the Rewan Group. However, this bore has intersected multiple formations including the alluvium associated with Moolayember Creek and the Rewan Group. The bore report for this bore from the Queensland Groundwater Database identifies that the groundwater associated with this bore is being sourced from the Moolayember Creek alluvium and not the Rewan Group; however, due to the procedure for allocating bore aquifer attribution by OGIA (i.e. attribution is based on the closest stratigraphic unit to the Bandanna Formation intersected by the bore), this bore has been

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		attributed as a Rewan Group bore, even though this is likely not the source of groundwater for the bore water supply. Therefore, locally, the Rewan Group is identified as an aquitard. KCB identified four hydraulic test locations within a 20 km radius of the Project tenure for the Rewan Group unit; comprising one (1) DST and three (3) Core tests. These test locations and associated results were sourced from Figure B-18 of the *Hydrogeological conceptualisation report for the Surat Cumulative Management Area* (OGIA 2016). The referenced hydraulic conductivity range in KCB (2021) (1.27×10^{-6} to 0.127 m/d) was sourced from the legend provided in Figure B-18 of OGIA (2016), where a conservative upper-bound limit of the Figure B-18 was applied (i.e. 100 mD from Core test). However, a review of the *Hydrogeological conceptualisation report for the Surat Cumulative Management Area* (OGIA 2016) indicates that the highest observed hydraulic conductivity of the Rewan Group from a Core test from across the entire Surat CMA is 24 mD (0.03 m/d) (page 255, OGIA (2016)). Therefore, the local hydraulic conductivity range for the Rewan Group in the vicinity of the Project tenure is 1.27×10^{-6} to 0.03 m/d. The maximum observed local hydraulic conductivity for the Rewan Group (0.03 m/d), in the vicinity of the Project tenure, is within the post-calibrated model range for Rewan Group hydraulic conductivity in the Surat CMA Groundwater Model (Figure 7-10 of KCB (2021)). An assessment of the uncertainty in the hydraulic conductivity of the Rewan Group was undertaken in the Surat CMA Groundwater Model as part of a Predictive Uncertainty Analysis process (described in detail in Section 7 of the *Groundwater Modelling Report – Surat Cumulative Management Area* (OGIA 2019)). A "null space Monte Carlo" (NSMC) methodology was adopted as the uncertainty analysis process using the post-calibrated model parameters, which the local hydraulic conductivity for the Rewan Group in the vicinity of the Project tenure is within (see above paragraph). A suite of 450 parameter fields, constrained to the parameter calibration range, were applied to the model resulting in 450 NSMC simulations. The maximum simulated drawdown from each model cell was determined for each of the 450 NSMC simulations to assess the drawdown impacts for the proposed development.

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		Statistical analyses of the 450 NSMC simulations were undertaken to identify the 5th percentile, median and 95th percentile maximum impact drawdown from the Project. The maximum drawdown maps for each of the model layers in the vicinity of the Project tenure for the 5th percentile, median and 95th percentile NSMC simulation results were presented in Figure 8-3 and Figure 8-4 (median) and Appendix V (5th and 95th percentile) of the *Towrie Development Area Water Assessment Report* (KCB 2021). For clarification, the 5th percentile maximum impact drawdown represents a drawdown level where, conceptually, there is a 5% probability that the maximum impact drawdown will be lower than these values; and, for the 95th percentile maximum impact drawdown, there is a 95% probability that the maximum impact drawdown will be less than these values. These results, in particular the 95th percentile results, indicated that there is no propagation of drawdown/depressurisation associated with the proposed Project development, above the Rewan Group (Model Layer 26); including the Clematis Group (Model Layer 25), the Moolayember Formation (Model Layer 24) and the alluvium and Cenozoic (Model Layer 1). Therefore, the local hydraulic conductivity of the Rewan Group in the vicinity of the Project tenure, and the uncertainty associated with this parameter has been adequately incorporated and assessed as part of the *Towrie Development Area Water Assessment Report* (KCB 2021).
3	The current OGIA model cannot reliably predict groundwater dynamics in Layer 1 which are crucial for predicting potential impacts on many water-dependent assets. Furthermore, the proponent has concluded that the regional groundwater system is hydraulically separated from alluvial groundwater, largely based on a single data point in the northeast of the project area, collected in 1969, showing that the water table in the Rewan Group was >21 metres below ground level (mbgl). Water table data from the surrounding region also highlight the considerable variation in water table depth and, therefore, data from one bore should not be relied upon to support this assumption. Additional site-specific water table data (including seasonal variation) and	Although the groundwater dynamics of the shallow alluvium and Cenozoic units represented in Layer 1 of the Surat CMA model is not specifically simulated, the representation of these units as hydrostratigraphic units, which have the potential to be in hydraulic connection with underlying units (e.g. Rewan Group, Clematis Group), is represented in the model. Based on this representation, and the appropriate incorporation of the local hydraulic conductivity of the Rewan Group in the model (along with the assessment of potential uncertainty in the Rewan Group hydraulic conductivity); the Rewan Group is a persistent aquitard in the vicinity of the Project that can mitigate the propagation of drawdown/depressurisation impacts to overlying units

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	additional supporting evidence on the hydraulic separation between the regional system and alluvial groundwater are required. This information is important as it pertains directly to drawdown risks for GDEs that may be reliant on alluvial groundwater.	(Clematis Group; Moolayember Formation; and, alluvium and Cenozoic units). Other lines of evidence, in addition to the local hydraulic conductivity, that identify the local Rewan Group as an aquitard include: ▪ There are no water supply bores within the Towrie project area; and, any attempts to install water supply bores have resulted in the bores being "Abandoned and Destroyed" (see Table 7-7 and Figure 7-28 of Towrie Development Area Water Assessment Report (KCB 2021)). This justifies the lack of groundwater level data from the Rewan Group in the vicinity of the Towrie Project. ▪ Natural groundwater discharge from the Rewan Group in the form of surface expressions (e.g. springs, natural wetlands, mapped TGDEs etc) have not been identified across the outcrop area within the vicinity of the Project tenure. ▪ The only potential TGDEs that have been mapped within the Towrie project area are located in the northeast (see Figure 7-26 of Towrie Development Area Water Assessment Report (KCB 2021)). These TGDEs are associated with the potential thickening of the alluvium associated with Brown River – Arcadia Creek, and the confluence of six watercourses in this area (see Figure 7-27 of Towrie Development Area Water Assessment Report (KCB 2021)). The Rewan Group cannot be in hydraulic connection with the overlying alluvium and Cenozoic units otherwise surface expressions of groundwater discharge and TGDEs would be anticipated across the entire region, which they are not.
4	A local-scale model underpinned by project-specific data will enable a more comprehensive assessment of the risks to water-dependent assets (e.g., terrestrial GDEs). Should this additional information and modelling indicate that the risk of drawdown impacting GDEs is high, then the work outlined in Paragraphs 7, 8 and 9 needs to be conducted.	As identified in Item 2 above, local hydraulic parameter data, in particular for the Rewan Group, have been incorporated into the Surat CMA model. Further, a comprehensive assessment of the parameter data in the form of Predictive Uncertainty Analysis has been undertaken and indicates a low risk to water-dependent assets as a result of drawdown impacts from the

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		proposed Project development. This highlights that a local-scale model is not warranted for this assessment as the risk of impact is considered low. Notwithstanding the justification above for not requiring a local-scale model, the proposed approach for further assessment based on risk does not align with the risk framework presented in the *Coal Seam Gas – Joint Industry Framework Managing impacts to groundwater resources in the Surat Cumulative Management Area under EPBC Act approvals* (JIF) (Australian Government 2021). The criteria specified in the JIF identifies a risk threshold for when a proponent must undertake a 'preliminary risk assessment' and 'supplementary risk assessment' for terrestrial GDEs (more than 0.2 of drawdown in the outcrop of the formation); which is based on groundwater model predictions as an initial screening tool. Groundwater level drawdown is not predicted in the source aquifer for any terrestrial GDEs in the vicinity of the Project tenure.
5	If the assumption that the Rewan Group is a sufficient aquitard cannot be verified with the project-specific hydraulic data (Paragraph 2) and appropriate model uncertainty analysis, then an update to the regional OGIA model is required (to assess the project's contribution to cumulative impacts). Further, groundwater modelling should investigate the role of heterogeneity in the Rewan Group aquitard and its control on limiting drawdown of the water table.	This comment has been addressed in the response in Item 2 above, and further supported by the response provided in Item 3.
6	It is unclear whether construction of infrastructure (which will cover up to 10% of the tenure) and associated surface water abstractions may reduce recharge rates in aquifers within the project area via altered flow timings or volumes. Rates and spatial patterns of recharge may be particularly important for GDEs associated with alluvial aquifers, with the degree of this reliance corresponding with natural seasonal and interannual fluctuations in recharge volumes. This may be especially relevant in a system where alluvial groundwater is hydraulically separated from the regional water table. Reduced recharge may decrease groundwater availability for GDEs and cause similar material impacts to groundwater drawdown. The proponent has relied on	Figure 7-27 of the *Towrie Development Area Water Assessment Report* (KCB 2021) identifies GDEs within the Project tenure in the northeast of the tenure. These GDEs are mapped as low confidence terrestrial GDEs associated with the alluvium of Brown River – Arcadia Creek. As addressed above, the alluvium is identified to not be in connection with the underlying Triassic units. Recharge to the alluvium associated with Brown River – Arcadia Creek occurs via direct rainfall infiltration on the alluvium outcrop or via infiltration losses from the watercourse during flow events. Reduction in the recharge rate to the alluvium is not predicted to occur as a result of the project development because:

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	recharge estimates from OGIA, which did not include alluvial data (KCB 2021, p. 74). The proponent should assess recharge rates in the alluvium based on field data and discuss how the project may impact recharge mechanisms (e.g., abstraction of surface water or altered surface runoff and flow regimes due to associated infrastructure).	▪ Recharge inhibiting infrastructure associated with the Project (e.g. hard-stand/low permeability well pads) are not permitted within the bed and banks of watercourses under condition B5 of the Environmental Authority (P-EA-100130995), and therefore, would not impact direct rainfall infiltration on the alluvium outcrop; and, ▪ Where possible, surface water runoff will be diverted around proposed Project infrastructure and allowed to flow to downstream watercourses. Therefore, no discernible impacts to the recharge rate to the alluvium as a result of decreasing infiltration from watercourses during flow events due to Project development, is anticipated. ▪ Surface water abstraction will only occur from farm dams, including the constructed wetland, when supplies are abundant and surplus to existing user requirements. No water will be abstracted from watercourses. Abstraction for Santos' activities will not substantially reduce water levels in the constructed wetland or availability of water for recharge, particularly compared to the natural fluctuations that occur seasonally (refer to Plate 7, p65 of Preliminary Documentation – Attachment E – Ecology Assessment).
Question 2: If the IESC is not confident in the above, what are the key potential impacts to matters of national environmental significance associated with the proposal and what additional work needs to be undertaken to quantify key risks?		
7	Potentially reduced alluvial recharge and increased drawdown in the shallow aquifers may impact terrestrial GDEs via reduced groundwater availability to phreatic vegetation. If the Rewan Group is not an effective aquitard in the project area (see response to Question 1), drawdown in the Bandanna Formation may also cause downwards groundwater fluxes in formations overlying the Rewan Group, including the alluvium. To better understand risks of a lowered water table to terrestrial GDEs, including possible groundwater-dependent TECs, the proponent should conduct field-based surveys in areas mapped as potential GDEs to identify	This comment has been addressed in the response in Item 2 above, and further supported by the response provided in Item 3.

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	the degree of groundwater-dependence (if any), identify likely source aquifers, and map GDE distribution in relation to the water table (including seasonal and interannual variations). These surveys could follow the methods described in Doody et al. (2019), and will permit the risk of drawdown-related impacts to potential GDEs to be conceptualised and assessed more accurately, to better quantify the risks to these water-dependent assets.	
8	Stygofauna, if present, may be similarly affected by drawdown and reduced alluvial recharge. Stygofauna often facilitate useful ecosystem functions such as nutrient cycling (Saccò et al. 2019) and are likely to be present in shallow aquifers, particularly in the alluvium. However, the proponent has not conducted stygofauna sampling. As stygofauna diversity and abundance may decrease with drawdown, reduced recharge and/or altered groundwater quality, the proponent should sample stygofauna using methods described in Doody et al. (2019) and collect groundwater quality data to derive an appropriate baseline dataset against which to assess potential impacts and quantify risks of the project.	This comment has been addressed in the response in Item 2 above, and further supported by the response provided in Item 3. Drawdown in the stygofauna habitat (i.e. alluvium) is not predicted to occur as a result of Project development. Therefore, the risk of impact to potential stygofauna communities is very low.
9	The proponent provides a conceptual model of the hydrological and hydrogeological systems of the project area and surrounds, portrayed as a broad diagrammatic cross-section of the project area and the underlying geological formations (Figure 7-30, KCB 2021, p. 102). However, this conceptual model does not illustrate the potential impact pathways, their associated risks and the likely modifying factors associated with the proposed development. The IESC recommends that the proponent provides an ecohydrological conceptual model showing possible impact pathways and their potential environmental consequences, spatially georeferenced to a map of the project area and the current cross-sectional diagram. This would help communicate what and where impacts may occur during and after the project, underpin a quantitative risk assessment and could be used to guide selection and application of cost-effective monitoring and mitigation strategies.	The hydrogeological conceptualisation provided in Towrie Development Area Water Assessment Report (KCB 2021), and further supported by the responses provided in Items 2 and 3 above identifies the Rewan Group as a “persistent” local aquitard within the vicinity of the Project tenure. The uncertainty of the local hydraulic conductivity of the Rewan Group, and the basis for the aquitard characteristics, was assessed as part of the Surat CMA model Predictive Uncertainty Analysis. The system conceptualisation and the results of the Surat CMA model predictive simulations, including uncertainty analysis simulations, do not identify impact pathways. As a result, the development of an ecohydrological conceptual model is not warranted.

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10	Linear infrastructure will cross ephemeral watercourses on-site. The information provided regarding the standard designs and risk assessments relating to this infrastructure does not adequately address the extent to which this infrastructure may impact flow and sediment regimes. Details of these designs should be provided together with a quantitative risk assessment.	Santos assesses stabilisation risks for all pipeline watercourse crossings during the field development planning process to inform crossing design. The assessment considers: ▪ Watercourse cross-section geometry at the crossing location ▪ Watercourse catchment area ▪ Watercourse longitudinal slope (bed slope/channel slope) at the crossing location. The assigned risk level is a function of cross section geometry and flow erosivity (i.e. crossings with steeper banks and larger catchment areas/greater flow have higher risk levels). The crossing design is chosen based on assigned risk. Standard designs for low, medium and high-risk crossings are included in Appendix B of the Environmental Management Plan (Attachment F). Pipelines are buried and will preferentially be built during periods of no flow. As such, no impacts to flow are expected. Road/access track crossings are designed to comply with Queensland's existing framework for "waterway barrier works" under the *Planning Act 2016* (Qld). Under the Planning Act, only "accepted development", which complies with specific standards may be carried out without a permit from the Department of Agriculture and Fisheries (DAF). These standards include (but are not limited to): ▪ Development work minimises impacts to waterways and fish habitat through the following actions: ○ Minimise disturbance to the instream bed and banks e.g. use geofabric as a work base, ○ If it is necessary to remove vegetation, aim to cut vegetation no lower than ground level and leave the root in the ground to aid in stabilisation. If deep excavation is required during construction the roots may only be removed within the construction footprint area.

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		○ Minimise the area of land disturbed or compacted ○ Ensure the least volume of soil or sediment is disturbed Limit the use of machinery within waterways ○ Use machinery no greater than the capacity required for the purpose ○ Implement sediment and erosion protection measures ○ Undertake works at times that minimise disruption to fish migration and the flowering and fruiting of marine plants ▪ Impacts on water quality are to be minimised by undertaking the works to the standard set out in the current version of the Best Practice Erosion and Sediment Control, published by the International Erosion Control Association, Australasia.' ▪ For any part of the waterway bed or banks adjacent to the works that has been altered by the waterway barrier works, the site is restored and/or rehabilitated so that as a minimum: ○ Stability and profiles of the bed and banks are re-instated to natural stream profiles and stability within five (5) business days of the completion of the works ○ The waterway bed is retained with natural substrate or reconstructed with substrate comparable to the natural substrate size and consistency ○ Site conditions allow the rapid re-establishment of native vegetation and cover or native species are replanted to re-establish the natural plant community Typically, bed level crossings are used for access tracks.
11	The IESC notes that the proponent intends to extract water from the constructed wetland for construction purposes, and that the monitoring of this extraction will be undertaken in liaison with landholders. There are insufficient details of this proposed	The "constructed wetland" is a farm dam used by the landholder for agricultural water supply. There is also evidence of the constructed wetland being completely dry based on factors not associated with Santos activities (refer to Plate 7, p65 of Preliminary Documentation – Attachment E – Ecology

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	monitoring for the IESC to be able to assess that the constructed wetland's important habitat values will be fully protected and that a quantitative risk assessment can be done. The proponent should outline an appropriate monitoring approach, integrated with assessments of habitat quality and water regime (Paragraphs 12 and 13), to ensure that the cumulative effects of water extraction do not compromise the ecohydrological requirements and aquatic values of this wetland. The results of baseline data and subsequent monitoring information can be used to refine the quantitative risk assessment.	Assessment). Santos will only extract water from this and other farm dams for construction purposes with the permission from the landholder when water supplies are abundant. Compared to the current use by the landholder, the impact of Santos' activities will be negligible. No specific monitoring of water quality within the constructed wetland is proposed given Santos' minimal use .
Question 3: In addition to the above, does the IESC consider that risks to MNES relating to surface water storage (including offsite impacts) and hydraulic fracturing have been adequately assessed? In particular, impacts related to overtopping and unintended discharge of produced water and hydraulic fracturing fluid stored in offsite storage ponds.		
12	The model used by the proponent to forecast water production was not provided and apparently did not incorporate altered climatic conditions (e.g., frequency and scale of extreme rainfall events) that would be expected to be associated with climate change. This is highly relevant because the main intended water storage facility, Mt Kingsley Dam, has limited freeboard considering the forecasted water production (KCB 2021, p. 33). Should overtopping of this facility occur, surface water quality in the neighbouring Ironbark Creek and the constructed wetland may be impacted, together with riparian vegetation and other biota (Paragraph 13) associated with these water-dependent assets. Given these risks, the IESC recommends that a baseline assessment be undertaken of surface water quality and water regime in the constructed wetland and Ironbark Creek. Subsequently, comprehensive surface water quality monitoring needs to be undertaken for an appropriate period during and following construction to detect and guide mitigation of potential impacts to their riparian vegetation and aquatic habitats.	Mount Kingsley Dam is classified as a "Regulated Structure" under the relevant Environmental Authority and was designed, constructed and certified in accordance with the "Manual for Assessing Hazardous Categories and Hydraulic Performance of Dams" (version 1, February 2012) ("The Manual"). Mount Kingsley Dam is a turkey nest structure for the containment of produced water and has been designed to minimise inflows from rain or stormwater. Overland flows from the northwest and southeast have been diverted away from the storage by diversion bunds designed to divert peak flows up to and including 0.0005 Annual Exceedance Probability (AEP) flood event (1 in 2000 year). The turkey's nest design and diversion of overland flow results in only rainfall that falls within the dam crest entering the storage. Mount Kingsley Dam has a Maximum Operating Volume (MOV) of 225 ML (refer Table 12-1). Once MOV is reached, CSG produced water flows into the storage ceases (i.e. wells are turned down) until the volume returns to below the MOV. Above the MOV there is 30 ML of Design Storage Allowance (DSA) volume available—designed to store 100% runoff from a 3-month wet season in accordance with The Manual—before the Full Supply Volume (FSV)

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<tr><td></td><td></td><td>(spillway level) is reached. This is designed to specifically minimise the likelihood of release from a regulated dam.

Above the MOV is the Mandatory Reporting Level (MRL) which is the level at which Mount Kingsley Dam has a remaining volume equivalent to the Extreme Storm Storage (ESS) allowance (short-duration, intense rainfall event). For Mount Kingsley Dam this is the 72-hour duration storm with an AEP of 0.01 (1 in 100 year). When MRL is reached, Santos must notify the Department of Environment and Science (DES) immediately to minimise actual or potential environmental harm.

Table 12-1: Mount Kingsley Dam storage volumes
<table>
<tr><th>Level</th><th>Storage Volume (ML)</th><th>Height from Dam Crest (m)</th></tr>
<tr><td>MOV (DSA)</td><td>225.3 ML</td><td>1.66 m</td></tr>
<tr><td>MRL</td><td>241.7 ML</td><td>1.32 m</td></tr>
<tr><td>FSL (Spillway)</td><td>254.8</td><td>1.05 m</td></tr>
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Santos reviewed climate change projections for the Maranoa Region local government area published by the Queensland Government to determine the potential effects of climate change on its water balance modelling. The projections, which were based on Climate Change in Australia data, indicate that under both low and high emissions scenarios, temperatures are likely to increase, and winter and summer rainfall is likely to decrease (State of Queensland, 2019).

While it is noted that the intensity of heavy rainfall events is likely to increase (State of Queensland, 2019), there is little consensus across climate models on the effects of climate change on rainfall patterns in Eastern Australia. Waha et al. (2022) describe possible climate futures for Australia’s mid-latitude regions, including the Northern Murray Darling Basin region where the project area lies. They found winter and spring rainfall likely to decrease</td></tr>
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		(with high and moderate confidence respectively) under both low and high emissions scenarios. There was far less model certainty for summer rainfall—both increases and decreases by mid-century are plausible and there was not enough evidence to confidently predict the direction of change. Given the rainfall projection uncertainty, and despite there being evidence that rainfall is likely to decrease at least in winter and spring, Santos has assumed no change in climatic conditions. Santos will continue assessing its water storage needs based and will invest in additional storage capacity if additional storage is required due to increased production volumes or changes in climatic conditions.
13	The proponent should conduct field-based sampling for aquatic biota (including invertebrates) in the constructed wetland and, when flowing, Ironbark Creek before, during and for an appropriate time after the proposed project. These data will provide baseline and subsequent monitoring information to allow the proponent to verify the predicted lack of impacts due to reduced water quality, altered flows or volumes, sedimentation and/or riparian zone clearance associated with the project.	See above. There is negligible risk of impact to aquatic biota associated with all proposed activities. The direct and indirect impact pathways to surface waters are very limited and do not warrant continuous surface water monitoring. Flow monitoring is conducted approximately 45 km downstream of the Project tenure on the Brown River at Station No. 130502B (Brown River at Lake Brown). Monitoring records from the stream gauging station, presented in Figure 6-5. Figure 6-6 and Figure 6-7 of *Towrie Development Area Water Assessment Report* (KCB 2021), indicate that flow within Brown River is ephemeral with flow occurring approximately 27% of the year. Based on the upstream location of the Project tenure relative to the stream gauging station, the watercourse flow events within the Project tenure are likely to be limited and less than what is observed at the gauging station. Therefore, opportunities to undertake sampling within Ironbark Creek during flow events are rare.
14	Although the proponent describes actions to be undertaken following chemical spills and accidents (EHS Support 2021, App. 10), such events are not considered in the risk assessment for chemicals used on-site. Additionally, a key monitoring strategy proposed for hydraulic stimulation activities includes sampling	In the assessment of exposure pathways and risks, only authorised operational activities have been considered (i.e. activities that are authorised under the Queensland Environmental Authority and EPBC approval if granted). This is consistent with the approved Chemical Risk Assessment Framework for the GLNG – Gas Field Development Project (EPBC2012/6615).

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	source water, stimulation fluids, and flowback water for geogenic compounds. However, the IESC considers the sampling suite for flowback monitoring is insufficient for ensuring water quality objectives are met, and recommends also monitoring major ions, organics and naturally occurring radioactive materials.	Accidental release scenarios have not been included; however, the outcomes of the assessments have been used to inform emergency response actions which are provided in Appendix 10 of the Chemical Risk Assessment Framework (Appendix A of Attachment E to Preliminary Documentation). The chemical toxicological profiles (dossiers) and Safety Data Sheets (SDS) provide critical information for first responders and have soil and surface water criteria developed to aid in future management/remediation activities if required. In the event of an accidental release, Santos will implement environmental emergency response procedures and contain the release and remediate/rehabilitate any impacts. In the development of the risk assessment(s), management procedures and controls were considered, with numerous processes and procedures implemented to ensure risks are managed to acceptable levels. All chemical management and storage is conducted in accordance with best practice. This includes storage and transport only in manufacture supplied containers, transport of chemicals only by licensed transporters, inspection and testing of all hoses and equipment prior to use and provision of spill containment and spill response equipment at well pads. Risks relating to the use of chemicals is associated with properties of the chemicals and the volumes in use. The tiered assessment structure provides for a systematic assessment of these risks. Tier 1 chemicals by virtue of their properties, require no additional assessment as standard management practices are more than sufficient to mitigate risks to an acceptable level. Tier 2 and Tier 3 chemicals provide a sequentially higher level of risk due to their potentially lower biodegradability and higher toxicity and a systematic assessment of risk associated with their use is provided. In the context of management of accidental releases sufficient information is provided to address appropriate management and remediation once the spill has been contained and accessible chemical residuals removed.

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		In accordance with State and Commonwealth requirements Santos has designed and implemented a monitoring program that includes sampling and analysis of source water, hydraulic fracturing fluids and flowback/produced water. A sampling suite has been developed based on the chemistry of the hydraulic fracturing fluid systems and the Queensland regulatory requirement to assess the quality of water and specifically flowback as it is returned to surface. Further, all produced water (including flow back) is managed in accordance with Queensland regulatory requirements with no direct discharges of flowback to the environment. Treatment and beneficial reuse are the only State approved options for management of flowback and produced water. In accordance with the regulatory requirement for beneficial reuse, Santos has completed numerous assessments and developed management and monitoring plans to ensure that the treatment and reuse of produced water and flowback poses no unacceptable risks to the environment. These plans have specific monitoring and assessment requirements for the raw and treated water and receiving environment soils and surface water (if applicable) and consider and detail appropriate analysis requirements and water quality objectives for the respective release.
15	The majority of produced water and hydraulic fracturing fluids will be managed and treated using the existing approved Arcadia water management facility in the adjacent petroleum lease. The proponent does not propose discharging produced water to watercourses; however, the following should be clarified to ensure that impacts to surface waters are minimised. a. The proponent has not specified the intended volume or quality of produced water to be held in concrete tanks on-site which will be untreated and used for operational activities such as dust suppression. This should be provided to better understand the risks of potential impacts to surface water quality. b. The proponent intends to dispose of waste salts in off-site licensed facilities (KCB 2021, p. 34). It is very likely that this	a) Up to four, approximately 0.08 ML sized, mobile tanks would be used on site during fracture stimulation for hydraulic fracturing fluid preparation and temporary produced water storage. At the end of the stimulation process, the fluid and water would be trucked away to treatment sites and the tanks would be mobilised to the next well site. Tanks of up to 5 ML in volume may be constructed on site for temporary storage of produced water. These would be located outside of the 1% Annual Exceedance Probability flood extent and in accordance with the Constraints Protocol. Produced water quality is described in section 3.3.1.1 of the Water Assessment Report (Preliminary Documentation – Attachment D). b) As described in section 3.3.1.2 of the Water Assessment Report (Preliminary Documentation – Attachment D), most of the produced water generated by the proposed activity will be transferred to Santos' produced

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	brine will also include other contaminants, including metals, hydrocarbons and radionuclides, particularly if filtration plants' solids are disposed of in brine ponds. Noting this, the IESC remains concerned about the legacy issues of brine management and disposal because long-term storage constitutes a residual risk, particularly from leaks and seepages. Whether this occurs on- or off-site is immaterial to these risks and the proponent should provide sufficient information regarding their licensed facilities to be confident that no off-site impacts will occur. The IESC recommends that the proponent monitor water quality and volume of leaks and seepages, and continue to investigate beneficial reuse options for the brine.	water management facilities on neighbouring tenures. Brine generated at these facilities will be stored in the Bottle Tree dam, or another future dam, approved as part of the Gladstone Liquefied Natural Gas (GLNG) Project (EPBC 2008/4059). Bottle Tree dam is clay and double high-density polyethylene (HDPE) lined. A leak detection and collection system is located below the primary and above the secondary HDPE liners, which flows to an internal collection sump that reports (via return pump) back to the dam. Three seepage monitoring bores are installed around the dam to detect any seepage into shallow groundwater systems. These bores are monitored at least annually. Sampling is carried out in accordance with the Queensland Government's *Monitoring and Sampling Manual 2009 – Environmental Protection (Water) Policy 2009*; and *Groundwater Sampling and Analysis – A Field Guide* (2009:27 GeoCat #6890.1). The Queensland Government, in collaboration with industry, landholder and environmental groups, is currently investigating potential long-term management solutions for brine generated by the CSG industry and is set to release a draft Action Plan in March 2022.

References

State of Queensland (2019) *Climate change in the Maranoa and District region, version 1*, viewed 7 March 2022 online: https://www.qld.gov.au/__data/assets/pdf_file/0027/67914/maranoa-climate-change-impact-summary.pdf

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