Qualitative and Quantitative Tier 3 Assessment

Tributyl Tetradecyl Phosphonium Chloride

In accordance with the Dawson River Release (DRR) Chemical Risk Assessment Framework (CRAF), the assessment for this Tier 3 chemical includes the following components: completing the screening; developing a risk assessment dossier and Predicted No-Effects Concentrations (PNECs) for water and soil; and completing a qualitative and quantitative assessment of risk. Each of these components is detailed within this attachment.

Background

Santos has been releasing treated water to the Dawson River since 2015. The Dawson River Release Scheme[1] is located in the southeast region of the Fairview Arcadia Project Area (FAPA) (within the hub compressor station four (HCS4) gathering network). Coal seam water produced in the HCS4 gathering network is collected and is treated at Reverse Osmosis Plant 2 (ROP2) with the treated permeate stored within a permeate pond prior to release to the Dawson River. The outfall location is located within a tributary gully of the Dawson River, which joins the Dawson River midway between "Dawson's Bend" and Yebna Crossing.

The permeate pond is connected to the outfall location by a 5.3-kilometre (km) pipeline constructed across farmland with the released water flowing down a 2.9 km tributary gully before discharging to the Waterbody (nominal capacity 500 megalitre [ML]) and then flowing 1.8 km before joining the Dawson River at its downstream confluence.

ROP 2 at FAPA is a reverse osmosis plant with a specification designed to produce high quality water for the intended release of treated coal seam water to the Dawson River. The process removes the suspended and dissolved solids through a set of six processes to produce high quality treated water. These include coagulation/clarification, oxidation, filtration, softening, reverse osmosis, and finally adjustment of sodium adsorption ratio (SAR).

Tributyl tetradecyl phosphonium chloride (TTPC) is a component in hydraulic fracturing fluid systems used in stimulation activities. Hydraulic fracturing fluid systems comprise water and chemical additives (including a proppant) blended at the surface of the well lease and injected down the cased well to improve formation permeability, enhancing the gas flow towards the well. The chemical additives are also used to assist well completion by preparing the well or maintain the gas flow to the well (i.e., prevent the swelling of clays within the target hydrocarbon formation).

The purpose and maximum quantity for this chemical in the fluid system is summarised in **Table 1**.

[1] Santos obtained an amendment to the Fairview Arcadia Project Area (FAPA) Environmental Authority (EA) (EPPG00928713) on 31st May 2013 to authorise the release of desalinated produced water from the Fairview reverse osmosis plant (ROP) 2 to the Dawson River – the Dawson River Release Scheme (DRRS).

Table 1 Hydraulic Fracturing Chemicals

Chemical Name	CAS No.	Use	Quantity[1]
Tributyl tetradecyl phosphonium chloride (TTPC)	81741-28-8	biocide	0.00276%

[1] Volume Percent in Treatment (%)
CAS No = Chemical Abstracts Service Number

The assessment of toxicity of this chemical was used to evaluate human health exposure scenarios and is presented in the risk assessment dossier provided in **Attachment 1**. TTPC is not a carcinogen, and, as a result, only a non-carcinogenic oral reference dose (RfD) was calculated. A detailed discussion of the derivation of the oral RfD and drinking water guideline values is presented in the attachment. **Table 2** provides a summary of the derivation.

Table 2 Oral Reference Doses and Derived Drinking Water Guidelines

Constituent (CAS No.)	Study	Critical Effect/ Target Organ(s)	NOAEL (mg/kg-day)	Uncertainty Factors	Oral Reference Dose (mg/kg-day)	Drinking Water Guideline (mg/L)
Tributyl tetradecyl phosphonium chloride (81741-28-8)	90-day rat drinking water	Clinical signs; decreased body weight; decreased food, water consumption	8.66	1,000	0.009	0.03

CAS = Chemical Abstracts Service
mg/kg-day = milligram per kilogram-day
mg/L = milligram per litre
NOAEL = No observed adverse effect level
Refer to **Attachment 1** for information on the key studies selected for oral reference dose and drinking water level development.

For ecological receptors, the assessment utilises the information presented in the dossiers on the relative toxicity of the aquatic and terrestrial flora and fauna to the chemical. The qualitative assessment focuses on the aquatic invertebrate and fish species within the surface water resources, and the soil flora and fauna associated with releases to the soil. The quantitative assessment includes evaluating the potential risks to these same aquatic and soil ecological receptors, in addition to higher trophic level organisms such as livestock and terrestrial wildlife.

The determination of toxicity reference values (TRVs) was conducted according to the PNEC guidance in the *Environmental Risk Assessment Guidance Manual for Industrial Chemicals* prepared by the Australian Environmental Agency (AEA, 2009). PNECs for freshwater and sediment are developed to assess aquatic receptors, and PNECs for soil are developed for terrestrial receptors.

Table 3 presents the chemical, endpoint, no observed effect concentration (NOEC) (milligrams per litre [mg/L]), assessment factor, and the aquatic PNEC (mg/L). PNECs for sediment and soil are detailed in **Tables 4** and **5,** respectively. Refer to **Attachment 1** for the development of PNECs, or the rational for PNECs that do not have a calculated PNEC.

Table 3 PNECs Water – Tier 3 Chemicals

Constituents	Endpoint	EC_{50} or NOEC (mg/L)	Assessment Factor	$PNEC_{water}$ (mg/L)
Tributyl tetradecyl phosphonium chloride (81741-28-8)	Acute algae	0.019	1,000	1.9×10^{-5}

EC_{50} = effects concentration – 50%
mg/L = milligram per litre
NOEC = no observable effects concentration
PNEC = predicted no effect concentration
Refer to **Attachment 1** for information on the development of PNECs listed above.

Table 4 PNECs Sediment – Tier 3 Chemicals

Constituents	Endpoint	EC_{50} or NOEC (mg/kg wet wt)	Assessment Factor	$PNEC_{sed}$ (mg/kg wet wt)
Tributyl tetradecyl phosphonium chloride (81741-28-8)	[a]	-	-	13

[a]Calculated using equilibrium partitioning method
EC_{50} = effects concentration – 50%
mg/kg wet wt = milligram per kilogram wet weight
NOEC = no observable effects concentration
PNEC = predicted no effect concentration
Refer to **Attachment 1** for information on the development of PNECs listed above.

Table 5 PNECs Soil – Tier 3 Chemicals

Constituents	Endpoint	EC_{50} or NOEC (mg/kg dry wt)	Assessment Factor	$PNEC_{soil}$ (mg/kg dry wt)
Tributyl tetradecyl phosphonium chloride (81741-28-8)	[a]	-	-	11.5

[a]Calculated using equilibrium partitioning method
EC_{50} = effects concentration – 50%
mg/kg dry wt = milligram per kilogram dry weight
NOEC = no observable effects concentration
PNEC = predicted no effect concentration
Refer to **Attachment 2** for information on the development of PNECs listed above.

A detailed assessment of the potential risks posed by this Tier 3 chemical is provided in the following sections.

General Overview

TTPC is a non-oxidising biocide. Information on TTPC in the dossier has been obtained from BWA™ Water Additives, a producer of TTPC. BWA™ Water Additives produces a 5% or 50% aqueous solution of TTPC, which is sold under the product names Bellacide® 355 and Bellacide® 350, respectively. TTPC is classified as a phosphonium cationic surfactant. The molecular structure of TTPC is presented in **Figure 1**.

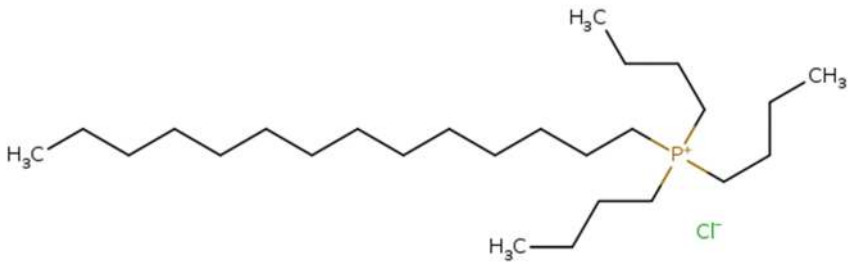

Figure 1 Molecular Structure of TTPC[2]

TTPC is stable over a wide pH range and is not susceptible to photodegradation. It will strongly adsorb to soil and sediment. TTPC is readily biodegradable and is not expected to bioaccumulate.

The Persistent, Bioaccumulative and Toxic (PBT) assessment for TTPC is included in the dossier provided in **Attachment 1**. Based on physico-chemical properties and screening data detailed below, the overall conclusion was that TTPC is not a PBT substance.

Human Health Hazards

TTPC exhibits moderate acute toxicity by the oral route, but is highly toxic by the inhalation route. It is corrosive to the skin and eyes, but it is not a skin sensitiser.

No systemic toxic effects were noted in a 90-day rat drinking water study. In rats, developmental toxicity was shown to occur at oral dose levels that were not maternally toxic; whereas, in rabbits, developmental toxicity occurred only at maternally toxic doses. TTPC was not mutagenic in a bacterial reverse mutation (Ames) test. There are no carcinogenicity studies on TTPC.

A 90-day rat drinking water study has been conducted on a product containing TTPC. Based on a review of this study, toxicological reference values were derived for TTPC. The drinking water guideline value derived for TTPC using the non-carcinogenic oral RfD is 0.03 mg/L.

TTPC may be present in treated water (permeate). Managed release of treated water to the Dawson River would have the potential to affect surface water within the river. As the Dawson River meanders through large areas that are uncontrolled, exposures could potentially occur to downstream agricultural workers and residents.

[2] Source https://chem.nlm.nih.gov/chemidview/image/81741-28-8?size=3

There is low potential for human receptors to be exposed to TTPC in Dawson River discharge. The combination of mixing/dilution, storage (and associated biodecay) prior to treatment, treatment and retention (and associated biodecay) following treatment are all key components that will reduce the potential risk to potential receptors from discharges to surface water. For example, the concentration of stimulation fluid chemicals in flowback water would be diluted by at least 90% in the water feed pond due to the aggregation of produced water from other wells within one pond. During water treatment, concentrations would be further reduced by efficiencies of the reverse osmosis system.

Finally, there are no public access points to Dawson River within 1.4 km downstream of the most downstream release location, and while there may be some fishing by local landowners in this reach, other forms of secondary recreation are unlikely. Currently, there is no irrigation in the immediate vicinity of the Waterbody, with the closest irrigation being approximately 5km to the west. There is a water supply scheme in the Dawson River that supplies irrigators but this is located 250 km downstream, with a search of the Department of Natural Resources, Mines and Energy (DNRME) now Department of Resources (DoR), data base indicating that the nearest licensed surface water take for irrigation is 71 km downstream noting this licence provides authority to extract from an 'Unnamed tributary of the Dawson River', not the Dawson River. The nearest surface water domestic water supply entitlement is 244 km downstream (AECOM, 2019).

Environmental Hazards

TTPC has a very high acute toxicity concern to aquatic organisms, namely fish, invertebrates and algae. To birds, TTPC is highly toxic on an acute basis and slightly toxic on a subacute dietary basis. Under typical environmental conditions, the chemical is readily biodegradable and has a low potential for bioaccumulation.

Experimental toxicity data on water organisms was available for three trophic levels to calculate a PNEC for water. However, there are no toxicity data for soil or sediment-dwelling organisms. Therefore, PNECS for soil and sediment were calculated using the equilibrium partitioning method.

As described in the previous section (Human Health Hazards), managed release of treated water to the Dawson River would have the potential to affect surface water within the river. As released treated water would become part of the regional surface water resource (i.e., Dawson River water quality and flow), ecological resources (livestock and native flora and fauna) are potential receptors. Specifically, potential receptors include:

1. Aquatic ecological receptors within Dawson River downstream of the release point
2. Livestock and wildlife that may access Dawson River surface water

Stock access to large portions of the Waterbody is permitted and has been observed. The banks of the Waterbody are severely degraded and lack riparian vegetation due to cattle access/activity. Similarly, cattle access the Dawson River for water at numerous places within and downstream of the receiving environment (frc environmental, 2021).

There is limited extraction of water for general farm supply downstream of the release location to the Dawson River. There is one licensed surface water take for agriculture within the extent of the release location area. Santos is in regular direct communication with the landholder and is not aware of any abstraction being undertaken under this licence to date. In addition, the nearest downstream

agricultural area is located approximately 7 km downstream of the release location to the Dawson River.

Biological monitoring has identified the presence of Matters of National Environmental Significance (MNES) receptor white-throated snapping turtle (*Elseya albagula*) in two upstream locations (at site DRR2 on Hutton Creek and at site DRR1 on Dawson River). The presence of MNES receptor Fitzroy River Turtle (*Rheodytes leukops*) has not been identified.

The potential for exposure of sensitive receptors, including MNES, is low. Released produced water mixes with surface water in a manner that is protective of aquatic receptors within the Dawson River (AECOM, 2019). Treated water releases from the permeate ponds are less than 18 megalitre (ML)/day with Santos undertaking periodic releases. Releases are currently dictated by treated effluent production rates. Perennial base flow in the Dawson River downstream of Dawson's Bend at the Dawson River discharge point has been assessed as 21 ML/day. Baseflow in the Dawson River is associated with spring discharges.

Risk Characterisation

The purpose of the risk characterisation portion of the assessment is to provide a conservative estimate of the potential risk resulting from exposure to TTPC that may occur during hydraulic fracturing and work over activities. The risk characterisation evaluates the toxicity of this chemical and characterises the risk of the chemical assessed for specific exposure pathways identified in the previous sections.

A two-stage process is employed during risk characterization. First, risk ratios are developed for the chemical for potentially complete exposure pathways associated with applicable release scenarios. The risk ratio is calculated by dividing the exposure point concentration (EPC) by the applicable risk-based screening level (drinking water level or PNECs for aquatic and terrestrial receptors). If the ratio of exceedance of screening levels is less than 1.0, then there are no anticipated adverse effects associated with the exposure scenario evaluated. No risk / hazard reduction measures are required. There should be no need for further management controls on the chemical additional to those already in place (DoEE, 2017).

If the ratio is greater than 1.0, then further quantitative analysis is conducted. Consistent with the assessment framework, quantitative assessment of risk will consider only Tier 3 chemicals in end use determination.

Exposure Point Concentration Calculations

A quantitative mass balance calculation was undertaken to estimate the potential concentrations of stimulation chemicals containing TTPC within diluted produced water. For the mass balance calculation, vendor disclosure forms were used to determine the percentage of TTPC in the pre-injection fluid. **Table 6** presents the estimated pre-injection fluid concentration.

Table 6 Mass Balance Estimates for TTPC

Chemical Name	CAS No.	Estimated Pre-injection fluid concentration (mg/L)
Tributyl tetradecyl phosphonium chloride (TTPC)	81741-28-8	0.28

CAS No = Chemical Abstracts Service Number
mg/L = milligram per litre

The mass balance of TTPC was then used to estimate potential EPCs for the evaluation of releases of treated water to the Dawson River. The potential EPCs have been conservatively estimated.

First, an estimated chemical concentration in the produced water from a recently hydraulically fractured well was calculated assuming 20% of the mass returned in the flowback water to the surface at a point in time and was conservatively diluted with 150% of the injected volume of return water. The water from recently hydraulic fractured wells (10% of volume) was diluted in the Water Management Facility (WMF) water feed pond influent by wells that did not contain detectable concentrations of these constituents. This EPC was then adjusted based on biodegradation rates to calculate the theoretical EPCs for two exposure time periods (0 and 30 days) which represent no storage/no degradation (Day 0) and a bounding estimate which considers degradation during storage at the WMF. The biodegradation information was obtained from the OECD ready tests (OECD, 1992) that were developed as a first-tier testing scheme to provide preliminary screening of organic chemicals. The ready tests are stringent screening tests that are conducted under aerobic conditions in which a high concentration of the test substance is used, and biodegradation is measured by non-specific parameters including dissolved organic carbon, biochemical oxygen demand and carbon dioxide production. **Attachment 2, Table 1** includes the environmental fate information that was used to assess biodegradation of the chemical.

The concentrations in the water feed pond were then further reduced by a factor of 99% to account for efficiencies in the WMF system.

Finally, a nominal dilution factor of 2 was assumed to account for dilution into the receiving water body as well as the retention, attenuation or degradation mechanisms that would occur between the permeate pond and Waterbody and the Waterbody and Dawson River. The use of a dilution factor or mixing ratio is consistent with the approved mixing zone described in the Santos 2013 report *Dawson River Release Scheme – Environmental Authority Amendment Application – Supporting Information*.

These estimated surface water EPCs were used to derive EPCs for sediment using the equilibrium partitioning method. **Attachment 2, Table 1** includes the equation and environmental fate information used to derive the sediment EPC.

Release Scenario Assessment

There is no potentially complete exposure pathway to sources of drinking water; however, as a conservative measure, the theoretical concentrations for the release scenarios were compared to human health toxicity-based screening levels to screen for potential effects as a result of a release to surface water used as a drinking water source. The results of this comparison, including the ratio of

exceedance of screening levels, is presented in **Attachment 2, Table 2**. As detailed in the table, the risk ratio did not exceed the target level of 1 for any of the scenarios.

Theoretical concentrations were also compared to the PNEC for aquatic receptors. **Attachment 2, Table 3** presents the results of this comparison, including the ratio of exceedance of screening levels. As detailed in the table, the risk ratio did not exceed the target level of 1 for any of the scenarios.

The primary land use within the development area is agricultural (grazing on improved or unimproved pastures), and it is sparsely populated. To further evaluate potential risks to non-MNES receptors (mammals and avian), additional quantitative analysis of the managed releases to Dawson River was conducted.

Terrestrial receptors evaluated for exposure to Dawson River discharge include domesticated livestock, large mammalian wildlife and small mammalian wildlife. Beef cattle were used to evaluate domesticated livestock, kangaroos were evaluated for large mammalian wildlife, and dingos were evaluated for small mammalian wildlife. The cattle egret was selected to evaluate avian exposures. Exposure assumptions, TRVs and total intake calculations are detailed in **Attachment 2, Tables 4, 5, 6 and 7**. **Attachment 2, Table 4** presents the calculated risk estimates for the kangaroo. **Attachment 2, Table 5** presents the calculated risk estimates for the dingo. **Attachment 2, Table 6** presents the calculated risk estimates for the cattle. **Attachment 2, Table 7** presents the calculated risk estimates for the cattle egret. As indicated in the tables, the calculated HQ for TTPC did not exceed the risk threshold level of 1 for any of the scenarios evaluated.

Cumulative Impacts

The potential for cumulative impacts associated with chemicals used during stimulation activities is limited. Residual chemicals may be entrained within produced water and subsequently transported for water treatment at a WMF. However, these chemicals are removed by the treatment systems; and, therefore, no additional risk is provided during managed releases to Dawson River. Likewise, the presence of water treatment chemicals at the point of produced water storage or during managed releases to the Dawson River also poses no significant increase in risk.

Tier 3 chemicals which trigger persistence and bioacummulative thresholds are considered to be chemicals with a potential for cumulative impacts. As noted earlier and discussed in detail in the dossier (**Attachment 2**), TTPC does not meet the criteria for persistence or bioaccumulation. Further, estimated concentrations in surface water and sediment were less than PNECs. Thus, there is negligible incremental risk posed by the use of this Tier 3 chemical and the existing management and monitoring controls are appropriate to ensure that the risk to MNES (and non MNES) receptors remains low.

Uncertainty Analysis

The procedures and assumptions used to assess potential human health risks in this Tier 3 assessment are subject to a wide variety of uncertainties. However, the presence of uncertainty is inherent in the risk assessment process, from the sampling and analysis of the chemical in environmental media to the assessment of exposure and toxicity, and risk characterisation. Accordingly, it is important to note that the risks presented within this Tier 3 assessment are based on numerous conservative assumptions in order to be protective of human health and the

environment, and to ensure that the risks presented herein are more likely to be overestimated rather than underestimated.

The discussion detailed in **Table 7** below provides an evaluation of uncertainty for this Tier 3 assessment, including elements previously discussed within this assessment.

Table 7 Evaluation of Uncertainty – TTPC

Risk Characterisation Component	Description of Uncertainty	Magnitude of Uncertainty	Effect on Risk Assessment
Hazard Assessment –COPC concentrations	The concentrations of COPCs in residual stimulation fluids were estimated based on previous operations and may not accurately estimate the concentrations of COPCs in the future. Detailed discussions with Santos occurred to identify a conservative estimate of the COPC; however, there is the potential that the empirical concentrations would differ than those presented in the risk assessment.	Low	This assumption may overestimate or underestimate the calculated risks to receptors, dependent on-site-specific conditions.
Exposure Assessment	The use of the food consumption relationship with body weight for mammalian and avian receptors.	Low to Medium	Low to medium potential to underestimate or overestimate risk
Toxicity Assessment	The use of acute toxicity data (rather than chronic toxicity data) to calculate PNECs for water and no data to calculate PNECs for soil and sediment.	Medium	Medium to high potential to overestimate risks.
Toxicity Assessment	The use of toxicity values in a risk assessment is based on extrapolations from animal data, adjust factors for inherent uncertainty in the toxicological estimate and use of surrogate toxicity criteria	Low	Low potential to underestimate risk
Toxicity Assessment	The use of LOAEL/NOAEL for calculation of the TRVs	Low to Medium	Low to medium potential to underestimate or overestimate risk
Toxicity Assessment	The use of the allometric scaling method to estimate the population-level effects on wildlife based on individual level of exposures.	Low to Medium	Low to medium potential to underestimate or overestimate risk

References

AECOM. 2019. Revised Boron Site-Specific Water Quality Criterion – Dawson River Release Scheme. Letter from B. Goldsworthy and N. Lee to A. Lavery. 12 July 2019.

Australian Environmental Agency (AEA). (2009). Environmental Risk Assessment Guidance Manual for Industrial Chemicals, Commonwealth of Australia. Available: http://www.nepc.gov.au/resource/chemical-risk-assessment-guidance-manuals

Department of the Environment and Energy (DoEE). (2017). Exposure draft: Risk Assessment Guidance Manual: for chemicals associated with coal seam gas extraction. Commonwealth of Australia, available at http://www.environment.gov.au/water/coal-and-coal-seam-gas/national-assessment-chemicals/consultation-risk-assessment-guidance-manual

frc environmental. 2021. Santos GLNG Dawson River Watercourse Releases: Receiving Environment Monitoring Program. April 2021.

OECD. (1992). Test No. 301: Ready Biodegradability. (Biodégradabilité Facile.) Paris: OECD Publishing.

Santos, 2013. Dawson River Release Scheme – Environmental Authority Amendment Application – Supporting Information. May 2013.

Attachment 1 Risk Assessment Dossier

TRIBUTYL TETRADECYL PHOSPHONIUM CHLORIDE

This dossier on tributyl tetradecyl phosphonium chloride (TTPC) presents the most critical studies pertinent to the risk assessment of TTPC in its use in hydraulic fracturing fluids. This dossier does not represent an exhaustive or critical review of all available data. Where possible, study quality was evaluated using the Klimisch scoring system (Klimisch *et al.*, 1997).

Screening Assessment Conclusion – TTPC was not identified in chemical databases used by NICNAS as an indicator that the chemical is of concern and is not a PBT substance. However, TTPC was assessed as a tier 3 chemical for acute toxicity and as a tier 3 chemical for chronic toxicity. Therefore, TTPC is classified overall as a **tier 3** chemical and requires a quantitative risk assessment for end uses.

1 BACKGROUND

TTPC is a non-oxidising biocide. TTPC is stable over a wide pH range and is not susceptible to photodegradation. It will strongly adsorb to soil and sediment. TTPC is readily biodegradable and is not expected to bioaccumulate. TTPC has a very high acute toxicity concern to aquatic organisms.

2 CHEMICAL NAME AND IDENTIFICATION

Chemical Name (IUPAC): Tributyl(tetradecyl)phosphonium chloride

CAS RN: 81741-28-8

Molecular formula: $C_{26}H_{56}PCl$

Molecular weight: 435.15 g/mol

Synonyms: Tributyl tetradecyl phosphonium chloride; TTPC; tri-n-butyltetradecylphosphonium chloride; Bellacide 350; Bellacide 355

3 PHYSICO-CHEMICAL PROPERTIES

Key physical and chemical properties for the substance are shown in Table 1.

Table 1 Overview of the Physico-chemical Properties of TTPC

Property	Value	Klimisch score	Reference
Physical state at 20°C and 101.3 kPa	Clear, colourless liquid	4	BWA Water Additives (2016)
Boiling Point	100°C*	4	BWA Water Additives (2016)
Specific Gravity	0.98 – 1.00 @ 20°C	4	BWA Water Additives (2016)

Property	Value	Klimisch score	Reference
Partition Coefficient (log K_{ow})	2.45	4	BuruEnergy
Viscosity	55-65 mm^2/s @ 25°C	4	BWA Water Additives (2016)

*5% aqueous solution of TTPC

TTPC is a non-oxidising biocide. Information on TTPC in this dossier has been obtained from BWA™ Water Additives, a producer of TTPC. BWA™ Water Additives produces a 5% or 50% aqueous solution of TTPC, which is sold under the product names Bellacide® 355 and Bellacide® 350, respectively.

4 DOMESTIC AND INTERNATIONAL REGULATORY INFORMATION

A review of international and national environmental regulatory information was undertaken (Table 2). This chemical is listed on the Australian Inventory of Chemical Substances – AICS (Inventory). No conditions for its use were identified. No specific environmental regulatory controls or concerns were identified within Australia and internationally for TTPC.

Table 2 Existing International Controls

Convention, Protocol or other international control	Listed Yes or No?
Montreal Protocol	No
Synthetic Greenhouse Gases (SGG)	No
Rotterdam Convention	No
Stockholm Convention	No
REACH (Substances of Very High Concern)	No
United States Endocrine Disrupter Screening Program	.No
European Commission Endocrine Disruptors Strategy	No

5 ENVIRONMENTAL FATE SUMMARY

A. Summary

TTPC is stable over a wide pH range and is not susceptible to photodegradation. It will strongly adsorb to soil and sediment. TTPC is readily biodegradable and is not expected to bioaccumulate.

B. Partitioning

TTPC is considered stable to hydrolysis at environmentally relevant pH values and therefore, hydrolysis is not expected to be a significant route of transformation in waterbodies. In addition, TTPC is not expected to undergo photolysis. Based on its negligible vapour pressure, volatilization of TTPC from moist soil or water surfaces is not expected (Health Canada, 2018).

C. Biodegradation

OECD Ready Biodegradability studies conducted by the United States Environmental Protection Agency (USEPA) for re-registration of TTPC as a biocide determined that TTPC degraded with a first-order half-life of 6.6 hours (USEPA, 2018).

D. Environmental Distribution

No experimental studies are available for determining the K_{oc} of TTPC. Using KOCWIN in EPISuite™ (USEPA, 2017), the estimated K_{oc} value for TTPC using the MCI method is 4.555×10^7 L/kg.

E. Bioaccumulation

No bioaccumulation studies are available on TTPC. TTPC is not expected to bioaccumulate based on the experimental log K_{ow} of 2.45 (Buruenergy). [Kl. Score = 4]

6 HUMAN HEALTH HAZARD ASSESSMENT

A. Summary

TTPC exhibits moderate acute toxicity by the oral route, but is highly toxic by the inhalation route. It is corrosive to the skin and eyes, but it is not a skin sensitiser. No target organ effects were noted in a 90-day rat drinking water study. TTPC was not mutagenic in a bacterial reverse mutation (Ames) test. There are no carcinogenicity studies on TTPC. In rats, developmental toxicity was shown to occur at oral dose levels that were not maternally toxic; whereas, in rabbits, developmental toxicity occurred only at maternally toxic doses.

B. Acute Toxicity

An oral LD_{50} in rats for Bellacide 350 (50% aq. solution of TTPC) was reported to be >1,002 mg/kg (BWA Water Additives, 2011) [Kl. score = 4]. An oral LD_{50} in rats for Bellacide 355 (5% aqueous solution of TTPC) was reported to be >4,000 mg/kg (BWA Water Additives, 2016). [Kl. score = 4]

The 4-hour inhalation LC_{50} in male and female rats for a 50% aq. solution of TTPC was <0.05 mg/L (aerosol). The mass median aerodynamic diameter for the aerosol was 1.93 µm (Cytec, 2012) [Kl. score = 1]. The 1-hour inhalation LC_{50} in male and female rats for a 50% aq. solution of TTPC is 0.227 mg/L (aerosol). The mass median aerodynamic diameter for the aerosol was 1.92 µm (Cytec, 2013) [Kl. score = 1].

C. Irritation

Both Bellacide 350 (50% aq. solution TTPC) and Bellacide 355 (5% aq. solution TTPC) are considered to be corrosive to the skin and eyes (BWA Water Additives, 2011 and 2015). [Kl. score = 4]

D. Sensitisation

TTPC is not considered to be a skin sensitiser (BWA Water Additives, 2011 and 2015). [Kl. score = 4]

E. Repeated Dose Toxicity

Oral

A 90-day rat drinking water study has been conducted on a product containing TTPC. The LOAEL for the active ingredient (TTPC) is 27.2 and 32.3 mg/kg-day in males and females, respectively, based on various clinical signs and significantly reduced body weights, feed and water consumption. The NOAEL for this study is 8.66 mg/kg-day (USEPA, 2006). [Kl. score = 2]

Inhalation

No data are available.

Dermal

No data are available.

F. Genotoxicity

In vitro Studies

TTPC was not mutagenic in a reverse mutation bacterial (Ames) test (BWA Water Additives, 2015). [Kl. score = 4]

In vivo Studies

No studies are available.

G. Carcinogenicity

No studies are available.

H. Reproductive Toxicity

No studies are available.

I. Developmental Toxicity

Female Tif:RAIf(SPF) rats were dosed by oral gavage with 0, 20, 60 or 120 mg/kg Belclene® [50% active ingredient: TTPC] during gestational days (GD) 6-15. In the high-dose group, there were two possible treatment-related spontaneous deaths (GD 9 and 14) and another death on GD 15 due to an intubation error. Clinical signs included dyspnea in one mid-dose and four high-dose animals, and vaginal bleeding in one mid-dose female on GD 15. In the high-dose group, maternal body weight gain was significantly lower during the treatment period (GD 6-15) and throughout the gestational period (GD 0-20). Mean food consumption was significantly reduced during GD 6-11 for both the mid- and high-dose animals. The number of females with implantations and the number of implantations/females were similar across all groups. Embryonic and fetal deaths were similar between treated and control groups. There were no soft tissue changes. There was an increased incidence of incomplete ossification of the 5th sternebra in the mid- and high-dose groups. The

NOAELs for maternal and developmental toxicity for the active ingredient TTPC in this study is 30 and 10 mg/kg-day, respectively (USEPA, 2006). [Kl. score = 2]

Female chinchilla rabbits were dosed by oral gavage with 0, 7.5, 22.5 or 45 mg/kg Belclene® [50% active ingredient: TTPC] during GD 6-18. In the mid- and high-dose groups, body weight gain was significantly reduced during GD 6-18 and feed consumption was reduced during GD 6-11. Fetal body weights were significantly reduced in the mid-(males only) and high-dose groups. There was also an increased incidence of delayed ossification of the hindlimb phalangeal nuclei in the mid- and high-dose groups. The NOAEL for maternal and developmental toxicity for the active ingredient TTPC in this study is 3.75 mg/kg-day (USEPA, 2006). [Kl. score = 2]

J. Derivation of Toxicological Reference and Drinking Water Guidance Values

The toxicological reference values developed for TTPC follow the methodology discussed in enHealth (2012). The approach used to develop drinking water guidance values is described in the Australian Drinking Water Guidelines (ADWG, 2011).

Non-Cancer

Oral

The NOAEL from a rat 90-day drinking water study based on various clinical signs and significantly reduced body weight and reduced feed and water consumption is 8.66 mg a.i./kg-day (USEPA, 2006). This NOAEL will be used to derive the oral reference dose.

Oral Reference Dose (oral RfD)

Oral RfD = NOAEL / (UF_A x UF_H x UF_L x UF_{Sub} x UF_D)

Where:
UF_A (interspecies variability) = 10
UF_H (intraspecies variability) = 10
UF_L (LOAEL to NOAEL) = 1
UF_{Sub} (subchronic to chronic) = 10
UF_D (database uncertainty) = 1

Oral RfD = 8.66/(10 x 10 x 1 x 10 x 1) = 8.66/1000 = 0.009 mg/kg-day

Drinking water guidance value

Drinking water guidance value = (animal dose) x (human weight) x (proportion of intake from water) / (volume of water consumed) x (safety factor)

Using the oral RfD,

Drinking water guidance value = (oral RfD) x (human weight) x (proportion of water consumed) / (volume of water consumed)

Where:
Human weight = 70 kg (ADWG, 2011)
Proportion of water consumed = 10% (ADWG, 2011)
Volume of water consumed = 2L (ADWG, 2011)

Drinking water guidance value = (0.009 x 70 x 0.1)/2 = 0.03 mg/L

Cancer

No carcinogenicity studies are available on TTPC. Thus, a cancer reference dose was not derived.

K. Human Health Hazard Assessment of Physico-Chemical Properties

TTPC does not exhibit the following physico-chemical properties:

- Explosivity
- Flammability
- Oxidising potential

7 ENVIRONMENTAL EFFECTS SUMMARY

A. Summary

TTPC has a very high acute toxicity concern to aquatic organisms.

B. Aquatic Toxicity

Acute Studies

Table 3 lists the results of acute aquatic toxicity studies conducted on TTPC.

Table 3 Acute Aquatic Toxicity Studies on TTPC

Test Species	Endpoint	Results (µg/L)	Klimisch score	Reference
Bluegill sunfish	96-hour LC_{50}	58.6	2	ECOTOX
Common Carp	96-hour LC_{50}	87	2	ECOTOX
Rainbow trout	96-hour LC_{50}	490	2	ECOTOX
Rainbow trout	96-hour LC_{50}	200	2	ECOTOX
Daphnia magna	48-hour EC_{50}	25.2	2	ECOTOX
Selenastrum capricornutum	72-hour EC_{50}	19	4	BuruEnergy

Chronic Studies

No studies are available.

C. Terrestrial Toxicity

Table 4 lists the avian toxicity studies conducted on TTPC.

Table 4 Avian Toxicity Studies on TTPC

Test Species	Endpoint	Results	Kl. score	Reference
Bobwhite Quail	8-day dietary	LC_{50}: 4,215 ppm NOEL: 1,980 ppm	2	ECOTOX
Mallard Duck	8-day dietary	LC_{50}: 3,663 ppm NOEL: 1,780 ppm	2	ECOTOX
Mallard Duck	14-day oral gavage	LD_{50}: 232 mg/kg NOEL: <178 mg/kg	2	ECOTOX

D. Calculation of PNEC

The PNEC calculations for TTPC follow the methodology discussed in DEWHA (2009).

PNEC water

Experimental results are available for three trophic levels. Acute EC_{50} values are available for fish (58.6 µg/L), *Daphnia* (25 µg/L) and algae (19 µg/L). No chronic toxicity studies are available on TTPC. On the basis that the data consists of short-term results from three trophic levels, an assessment factor of 1,000 has been applied to the effect concentration of 19 µg/L for algae. The $PNEC_{water.}$ is calculated to be 0.019 µg/L (1.9×10^{-5} mg/L).

PNEC sediment

There are no toxicity data for sediment-dwelling organisms. Therefore, the $PNEC_{sed}$ was calculated using the equilibrium partitioning method. The $PNEC_{sed}$ is 12,982 µg/kg (13.0 mg/kg) sediment wet weight.

The calculations are as follows:

$PNEC_{sed} = (K_{sed\text{-}water}/BD_{sed}) \times 1000 \times PNEC_{water}$
$= (874{,}561/1280) \times 1000 \times 0.019$
$=$ 12,982 µg/kg

Where:
$K_{sed\text{-}water}$ = suspended matter-water partition coefficient (m^3/m^3)
BD_{sed} = bulk density of sediment (kg/m^3) = 1,280 [default]
$PNEC_{water}$ = predicted no effect concentration in water

$K_{sed\text{-}water}$ = 0.8 + [0.2 x Kp_{sed}/1000 x BD_{solid}]
= 0.8 + [0.2 x 1,822,000/1000 x 2400]
= 874,561 m^3/m^3

Where:
Kp_{sed} = solid-water partition coefficient (L/kg)
BD_{solid} = bulk density of the solid phase (kg/m^3) = 2,400 [default]

Kp_{sed} = K_{oc} x f_{oc}
= 45,550,000 x 0.04
= 1,822,000 L/kg

Where:
K_{oc} = organic carbon normalised distribution coefficient (L/kg). The K_{oc} for TTPC calculated from EPISuite™ using the MCI method is 4.555 x 10^7 L/kg.
f_{oc} = fraction of organic carbon in sediment = 0.04 [default].

PNEC soil

There are no toxicity data for terrestrial or soil organisms. Therefore, the $PNEC_{soil}$ was calculated using the equilibrium partitioning method. The $PNEC_{soil}$ is 11,539 µg/kg (11.5 mg/kg) soil dry weight.

The calculations are as follows:

$PNEC_{soil}$ = (Kp_{soil}/BD_{soil}) x 1000 x $PNEC_{water}$
= (911,000/1500) x 1000 x 0.019
= 11,539 µg/kg

Where:
Kp_{soil} = soil-water partition coefficient (m^3/m^3)
BD_{soil} = bulk density of soil (kg/m^3) = 1,500 [default]
$PNEC_{water}$ = predicted no effect concentration in water

Kp_{soil} = K_{oc} x f_{oc}
= 45,550,000 x 0.02
= 911,000 m^3/m^3

Where:
K_{oc} = organic carbon normalised distribution coefficient (L/kg). The K_{oc} for TTPC calculated from EPISuite™ using the MCI method is 4.555 x 10^7 L/kg.
f_{oc} = fraction of organic carbon in soil = 0.02 [default].

8 CATEGORISATION AND OTHER CHARACTERISTICS OF CONCERN

A. PBT Categorisation

The methodology for the Persistent, Bioaccumulative and Toxic (PBT) substances assessment is based on the Australian and EU REACH Criteria methodology (DEWHA, 2009; ECHA, 2017).

TTPC is readily biodegradable; thus, it does not meet the screening criteria for persistence.

The log K_{ow} for TTPC is 2.45. Thus, TTPC does not meet the screening criteria for bioaccumulation.

There are no chronic aquatic toxicity studies available on TTPC. The lowest acute EC_{50} value for TTPC is <1 mg/L in algae. Thus TTPC does meet the screening criteria for toxicity.

Therefore, TTPC is not a PBT substance.

B. Other Characteristics of Concern

No other characteristics of concern were identified for TTPC.

9 SCREENING ASSESSMENT

Chemical Name	CAS No.	Overall PBT Assessment [1]	Chemical Databases of Concern Assessment Step		Persistence Assessment Step		Bioaccumulative Assessment Step	Toxicity Assessment Step			Risk Assessment Actions Required[3]
			Listed as a COC on relevant databases?	Identified as Polymer of Low Concern	P criteria fulfilled?	Other P Concerns	B criteria fulfilled?	T criteria fulfilled?	Acute Toxicity [2]	Chronic Toxicity[2]	
Tributyl tetradecyl phosphonium chloride	81741-28-8	Not a PBT	No	No	No	No	No	Yes	3		3

Footnotes:

1 - PBT Assessment based on PBT Framework.

2 - Acute and chronic aquatic toxicity evaluated consistent with assessment criteria (see Framework).

3 – Tier 3 – Quantitative Risk Assessment: Complete PBT, qualitative and quantitative assessment of risk.

Notes:

NA = not applicable

PBT = Persistent, Bioaccumulative and Toxic

B = bioaccumulative

P = persistent

T = toxic

10 REFERENCES, ABBREVIATIONS AND ACRYNOYMS

A. References

ADWG. (2011). National Water Quality Management Strategy. Australian Drinking Water Guidelines, Section 6, Australian Government, National Health and Medical Research Council, Natural Resource Management Ministerial Council. Updated January 2022. Available: https://www.nhmrc.gov.au/about-us/publications/australian-drinking-water-guidelines

BWA Water Additives. (2011). Material Safety Data Sheet for Bellacide 350, SDS No.: 10794. BWA Water Additives, Report Date: 13/01/2011. Available at: http://biosourceinc.com/images/Bellacide_350_MSDS,_2011.pdf.

BWA Water Additives. (2015). Safety Data Sheet for Bellacide 355, BWA Water Additives, Report Date: 10/03/2009. Available at: http://towerwater.com/wp-content/uploads/2014/08/BELLICIDE-355-Label-SDS.pdf.

BWA Water Additives. (2016). Technical Data Sheet for Bellacide® 355. Available at: http://www.wateradditives.com/files/products/tech_data_sheets/Bellacide%20355_Technical%20Data%20Sheet_Oil%20Gas_8.5x11.pdf.

BuruEnergy. Environmental Properties of Proposed Biocide BE-9.

Cytec. (2012). TSCA Section 8(e) submission letter to U.S. EPA with attachment titled "Acute Inhalation Toxicity Study in Rats – Limit Test", conducted at Product Safety Labs, Laboratory Study #34778. DCN #89130000015. Available at: https://yosemite.epa.gov/oppts/epatscat8.nsf/by+Service/E34D6235E54FA93785257B24006EEF4F/$File/89130000015.pdf.

Cytec. (2013). TSCA Section 8(e) submission letter to U.S. EPA with attachment titled "Acute Inhalation Toxicity Study in Rats", conducted at Product Safety Labs, Laboratory Study #35656. DCN #89130000015. Available at: https://yosemite.epa.gov/oppts/epatscat8.nsf/by+Service/CA9FA94DCF6D9C7D85257B3D00514E05/$File/89130000257.pdf.

Department of the Environment, Water, Heritage and the Arts (DEWHA). (2009). Environmental risk assessment guidance manual for industrial chemicals, Department of the Environment, Water, Heritage and the Arts, Commonwealth of Australia. Available: http://www.nepc.gov.au/resource/chemical-risk-assessment-guidance-manuals

ECOTOX. U.S. Environmental Protection Agency (USEPA) ECOTOX Database: http://cfpub.epa.gov/ecotox/.

European Chemicals Agency (ECHA). ECHA REACH database: https://echa.europa.eu/information-on-chemicals

ECHA. (2017). Guidance on Information Requirements and Chemical Safety Assessment, Chapter R11: PBT Assessment, European Chemicals Agency, Helsinki, Finland. Available: https://echa.europa.eu/guidance-documents/guidance-on-information-requirements-and-chemical-safety-assessment

enHealth Human Risk Assessment (HHRA). (2012). Environmental Health Risk Assessment, Guidelines for Assessing Human Health Risks from Environmental Hazards. Office of Health Protection of the Australian Government Department of Health. Available: https://www1.health.gov.au/internet/main/publishing.nsf/Content/health-pubhlth-publicat-environ.htm

Health Canada. (2018). Proposed Registration Decision: Tributyl Tetradecyl Phosphonium Chloride and Bellacide 350. PRD2018-11. Health Canada Pest Management Regulatory Agency. 24 July 2018.

Klimisch, H.J., Andreae, M., and Tillmann, U. (1997). A systematic approach for evaluating the quality of experimental and toxicological and ecotoxicological data. Regul. Toxicol. Pharmacol. 25:1-5.

USEPA. (2006). Memorandum: Agency's Response to the Registrant Response for Acute Neurotoxicity and Repeated Exposure Inhalation Study and Determination of Inhalation MOE* and Developmental Toxicity Review for: Belclene 350 [Tri-n-butyl tetradecyl phosphonium chloride]. Office of Prevention, Pesticides and Toxic Substances, United States Environmental Protection Agency, June 27, 2006. Accessed at: http://www3.epa.gov/opp00001/chem_search/cleared_reviews/csr_PC-128824_27-Jun-06_a.pdf.

USEPA. (2017). EPISuite™ v. 4.11, United States Environmental Protection Agency, Office of Pollution Prevention and Toxics and Syracuse Research Corporation. Available at: https://www.epa.gov/tsca-screening-tools/epi-suitetm-estimation-program-interface.

USEPA. (2018). Draft Risk Assessment for Tri-N Butyl Tetradecyl Phosphonium Chloride for Registration Review. Office of Chemical Safety and Pollution Prevention. September 25, 2018.

B. Abbreviations and Acronyms

^{o}C	degrees Celsius
a.i./kg-day	active ingredient per kilogram per day
AICS	Australian Inventory of Chemical Substances
COC	constituent of concern
DEWHA	Department of the Environment, Water, Heritage and the Arts
EC	effective concentration
ECHA	European Chemicals Agency
EU	European Union
GD	gestational day
IUPAC	International Union of Pure and Applied Chemistry
kg	kilogram
kg/m^3	kilograms per cubic metre
Kl	Klimisch scoring system
KOCWIN™	USEPA organic carbon partition coefficient estimation model
kPa	kilopascal
L	litre
L/kg	litres per kilogram
LC	lethal concentration
LD	lethal dose
LOAEL	lowest observed adverse effect level
m^3	cubic metre
MCI	molecular connectivity index
mg/kg	milligrams per kilogram
mg/kg-day	milligrams per kilogram per day
mg/L	milligrams per litre
mm^2/s	square millimetres per second
NICNAS	The National Industrial Chemicals Notification and Assessment Scheme
NOAEL	no observed adverse effect level
NOEL	no observed effect level
OECD	Organisation for Economic Co-operation and Development
PBT	Persistent, Bioaccumulative and Toxic
PNEC	Predicted No Effect Concentration
ppb	parts per billion

ppm	parts per million
REACH	Registration, Evaluation, Authorisation and Restriction of Chemicals
RfD	reference dose
SGG	Synthetic Greenhouse Gases
TTPC	tributyl tetradecyl phosphonium chloride
USEPA	United States Environmental Protection Agency
µg/kg	micrograms per kilogram
µg/L	micrograms per litre
µm	micrometre

Attachment 2 Risk Characterisation Tables

Attachment 2, Table 1
Summary of Exposure Point Concentrations

Chemical	CAS No.	Estimated concentration in pre-injection fluid systems (mg/L)	Half-Life (days)	Estimated Flowback Concentration (mg/L)[1]	Estimated Concentration in Combined Balance Water Feed Pond to WMF (mg/L)[2]		Estimated Concentration in Permeate after 99% treatment efficiency by RO plant (mg/L)[3]		Estimated Concentration in Dawson River (Treated Water Release) (mg/L)[4]		Estimated Concentration in Dawson River Sediment (mg/kg)[5]	
					Temporal Scenario (days)		Temporal Scenario (days)		Temporal Scenario (days)		Temporal Scenario (days)	
					0	30	0	30	0	30	0	30
Tributyl tetradecyl phosphonium chloride	81741-28-8	2.82E-01	1.50E+01	3.76E-02	3.76E-03	9.40E-04	3.76E-05	9.40E-06	1.88E-05	4.70E-06	1.28E+01	3.21E+00

Notes:
mg/L = milligrams per liter
CAS = Chemical Abstracts Service
NA = not applicable
RO = reverse osmosis
WMF = Water Management Facility

1) Estimated flowback concentration in pond influent (150% of injected fluid volume) per coal seam per 20% of mass returned calculated using equation: Pond Influent = FBconcentration (mg/L)/ FB dilution 150% x percent mass returned (mg/L)
2) Estimated flowback concentration was multiplied by a factor of 10% to account for dilution in the water feed pond (90:1) due to the aggregation of produced water from other wells which were not recently hydraulically fractured into the same pond.
3) Concentrations in the water feed pond were further reduced by a factor of 99% to account for efficiencies in the WMF system.
4) A dilution factor of 2 was assumed within the approved mixing zone.
5) $EPC_{sed} = (K_{sed\text{-}water}/BD_{sed}) \times 1000 \times EPC_{water}$
Where:
$K_{sed\text{-}water}$ = suspended matter-water partition coefficient (m^3/m^3)
BD_{sed} = bulk density of sediment (kg/m^3) = 1,280 kg/m^3[default]
$PNEC_{water}$ = treated water EPC
$K_{sed\text{-}water} = 0.8 + [(0.2 \times Kp_{sed})/1000 \times BD_{solid}]$
And:
Kp_{sed} = solid-water partition coefficient (L/kg)
BD_{solid} = bulk density of the solid phase (kg/m^3) = 2,400 kg/m^3[default]
$Kp_{sed} = K_{oc} \times f_{oc}$
Where:
K_{oc} = organic carbon normalised distribution coefficient (L/kg), chemical-specific value found in dossier provided in Attachment 1.
f_{oc} = fraction of organic carbon in sediment = 0.04 [default].

Attachment 2, Table 2
Comparison of Theoretical Concentrations of COPCs to Drinking Water Guidelines

Permeate Pond								
Chemical	CAS No.	Estimated Concentration in Permeate after 99% treatment efficiency by RO plant (mg/L)[1]		Estimated Concentration in Dawson River (Treated Water Release) (mg/L)[1]		Drinking Water Screening Level (mg/L)	Ratio of COPC Concentrations and Screening Criteria (Ratio greater than one = unacceptable potential risk)	
		Temporal Scenario (days)		Temporal Scenario (days)			Temporal Scenario (days)	
		0	30	0	30		0	30
Tributyl tetradecyl phosphonium chloride	81741-28-8	3.76E-05	9.40E-06	1.88E-05	4.70E-06	3.00E-02	6.3E-04	1.6E-04

Notes:
mg/L = milligrams per liter
CAS = Chemical Abstracts Service
NA = not applicable
RO = reverse osmosis
WMF = Water Management Facility

1) Estimated concentrations derived in Table 1.

Attachment 2, Table 3
Comparison of Theoretical Concentrations of COPCs to PNECs (Water and Sediment)

Permeate Pond														
Chemical	CAS No.	Estimated Concentration in Permeate after 99% treatment efficiency by RO plant (mg/L)[1]		Estimated Concentration in Dawson River (Treated Water Release) (mg/L)[1]		PNEC aquatic (mg/L)	Ratio of COPC Concentrations and Screening Criteria (Ratio greater than one = unacceptable potential risk)		Estimated Concentration in Dawson River Sediment (mg/kg)[1]		PNEC sediment (mg/kg)	Ratio of COPC Concentrations and Screening Criteria (Ratio greater than one = unacceptable potential risk)	
		Temporal Scenario (days)		Temporal Scenario (days)			Temporal Scenario (days)		Temporal Scenario (days)			Temporal Scenario (days)	
		0	30	0	30		0	30	0	30		0	30
Tributyl tetradecyl phosphonium chloride	81741-28-8	3.76E-05	9.40E-06	1.88E-05	4.70E-06	1.90E-05	9.9E-01	2.5E-01	1.28E+01	3.21E+00	1.30E+01	9.9E-01	2.5E-01

Notes:
mg/L = milligrams per liter
CAS = Chemical Abstracts Service
NA = not applicable
PNEC = predicted no effects concentration
RO = reverse osmosis
WMF = Water Management Facility

1) Estimated concentrations derived in Table 1.

Attachment 2, Table 4
Risk Estimates for Cattle Egret - Dawson River Release

Constituent Name	CAS No.	Mammal NOAELt	Mammal NOAEL Test Animal		Avian NOAELt [1]	Avian NOAEL Test Animal		Avian Receptor Cattle Egret	
			Animal	Body Weight (kg)		Animal	Body Weight (kg)	Body Weight (kg)	Derived TRV
Tributyl tetradecyl phosphonium chloride	81741-28-8	8.66E+00	Rat	3.50E-01	1.98E+03	Bobwhite Quail	0.178	3.90E-01	1.6E+03

Notes:
NOAELt = No observed adverse effect level test animal
kg = kilogram
NA = not applicable
TRV = toxicity reference value
1/ If an avian NOAEL was not available, the mammal NOAEL was used to derive the TRV for the avian receptor.

$$Derived\ TRV = NOAEL_{test} * \left(\frac{Body\ Weighttest}{Body\ Weightreceptor}\right)^{(1/4)}$$

Exposure Route	Parameter Code	Parameter Definition	Units (a)	Parameter Value	Source (b)
Ingestion	IR	Ingestion rate	l/day	0.03	(c)
	EF	Exposure frequency	day/yr	7	BPJ
	ED	Exposure duration	yr	1	BPJ
	BW	Body weight	kg	0.39	Siegfried, 1969
	AT-NC	Averaging time - noncancer	days	365	BPJ

Notes:
a/ Units:
l/day = litres per day
day/yr = days per year
yr = year
kg = kilogram
b/ References:
BPJ - Best Professional Judgement
W.R. Siegfried (1969) Energy Metabolism of the Cattle Egret, ZoologicaAfricana, 4:2, 265-273, DOI: 10.1080/00445096.1969.11447375
c/ Drinking water ingestion rate (WIR) based on the allometric relationship developed by Calder and Braun (1983), where WIR (L/day) = 0.059 x BW (Kg)$^{0.67}$

Constituent Name	CAS No.	EPC [1] Day 0	EPC [1] Day 30	Toxicity	Total Intake (mg/kg/day)	Hazard Quotient	Total Intake (mg/kg/day)	Hazard Quotient
		CW (mg/l)	CW (mg/l)	TRVs	Day 0	Ingestion	Day 30	Ingestion
Tributyl tetradecyl phosphonium chloride	81741-28-8	1.9E-05	4.7E-06	1.6E+03	2.8E-08	1.7E-11	6.9E-09	4.3E-12

Notes:
CW = concentration in water
EPC = exposure point concentration
mg/kg/day = milligrams per kilograms per day
mg/l = milligrams per liter
NA = not available/applicable
TRV = toxicity reference value
1/ EPC is estimated concentration in Dawson River in Table 1 for Day 0 and Day 30

$$Total\ Intake = \frac{EPC\ \times IR\ \times EF\ \times ED}{BW\ \times ED\ x\ 365^{\ days}/_{year}}$$

$$Hazard\ Quotient = \frac{Total\ Intake\ \left(\frac{mg}{kg-day}\right)}{TRV\ \left(\frac{mg}{kg-day}\right)}$$

Attachment 2, Table 5
Risk Estimates for Kangaroo - Dawson River Release

Constituent Name	CAS No.	Mammal NOAELt	Mammal NOAEL Test Animal		Mammal Kangaroo	
			Animal	Body Weight (kg)	Body Weight (kg)	Derived TRV
Tributyl tetradecyl phosphonium chloride	81741-28-8	8.66E+00	Rat	3.50E-01	2.50E+01	2.98E+00

Notes:
NOAELt = No observed adverse effect level test animal
kg = kilogram
NA = not applicable
TRV = toxicity reference value
1/ If an avian NOAEL was not available, the mammal NOAEL was used to derive the TRV for the avian receptor.

$$Derived\ TRV = NOAEL_{test} * \left(\frac{Body\ Weighttest}{Body\ Weightreceptor}\right)^{(1/4)}$$

Exposure Route	Parameter Code	Parameter Definition	Units (a)	Parameter Value	Source (b)
Ingestion	IR	Ingestion rate	l/day	3	Fleming, 2001
	EF	Exposure frequency	day/yr	7	BPJ
	ED	Exposure duration	yr	1	BPJ
	BW	Body weight	kg	25	Fleming, 2001
	AT-NC	Averaging time - noncancer	days	365	BPJ

Notes:
a/ Units:
l/day = litres per day
day/yr = days per year
yr = year
kg = kilogram
b/ References:
BPJ - Best Professional Judgement
Fleming, 2001
Fleming, Peter; Laurie Corbett, Robert Harden, Peter Thomson (2001). Managing the Impacts of Dingoes and Other Wild Dogs. Commonwealth of Australia: Bureau of Rural Sciences.

Constituent Name	CAS No.	EPC[1] Day 0	EPC[1] Day 30	Toxicity	Total Intake (mg/kg/day)	Hazard Quotient	Total Intake (mg/kg/day)	Hazard Quotient
		CW (mg/l)	CW (mg/l)	TRVs	Day 0	Ingestion	Day 30	Ingestion
Tributyl tetradecyl phosphonium chloride	81741-28-8	1.9E-05	4.7E-06	3.0E+00	4.3E-08	1.5E-08	1.1E-08	3.6E-09

Notes:
CW = concentration in water
EPC = exposure point concentration
mg/kg/day = milligrams per kilograms per day
mg/l = milligrams per liter
NA = not available/applicable
TRV = toxicity reference value
1/ EPC is estimated concentration in Dawson River in Table 1 for Day 0 and Day 30

$$Total\ Intake = \frac{EPC\ \times IR\ \times EF\ \times ED}{BW\ \times ED\ x\ 365\ ^{days}/_{year}}$$

$$Hazard\ Quotient = \frac{Total\ Intake\ \left(\frac{mg}{kg-day}\right)}{TRV\ \left(\frac{mg}{kg-day}\right)}$$

Attachment 2, Table 6
Risk Estimates for Dingo - Dawson River Release

Constituent Name	CAS No.	Mammal NOAELt	Mammal NOAEL		Mammal	
			Test Animal		Dingo	
			Animal	Body Weight (kg)	Body Weight (kg)	Derived TRV
Tributyl tetradecyl phosphonium chloride	81741-28-8	8.66E+00	Rat	3.50E-01	1.30E+01	3.51E+00

Notes:
NOAELt = No observed adverse effect level test animal
kg = kilogram
NA = not applicable
TRV = toxicity reference value
1/ If an avian NOAEL was not available, the mammal NOAEL was used to derive the TRV for the avian receptor.

$$Derived\ TRV = NOAEL_{test} * \left(\frac{Body\ Weighttest}{Body\ Weightreceptor}\right)^{(1/4)}$$

Exposure Route	Parameter Code	Parameter Definition	Units (a)	Parameter Value	Source (b)
Ingestion	IR	Ingestion rate	l/day	0.75	Dawson, 1995
	EF	Exposure frequency	day/yr	7	BPJ
	ED	Exposure duration	yr	1	BPJ
	BW	Body weight	kg	13	Dawson, 1995
	AT-NC	Averaging time - noncancer	days	365	BPJ

Notes:
a/ Units:
l/day = litres per day
day/yr = days per year
yr = year
kg = kilogram
b/ References:
BPJ - Best Professional Judgement
Dawson, 1995
Dawson, Terence J. (1995). Kangaroos: Biology of the Largest Marsupials. Cornell University Press, Ithaca, New York. Second printing: 1998. ISBN 0-8014-8262-3.

Constituent Name	CAS No.	EPC[1] Day 0	EPC[1] Day 30	Toxicity	Total Intake (mg/kg/day)	Hazard Quotient	Total Intake (mg/kg/day)	Hazard Quotient
		CW (mg/l)	CW (mg/l)	TRVs	Day 0	Ingestion	Day 30	Ingestion
Tributyl tetradecyl phosphonium chloride	81741-28-8	1.9E-05	4.7E-06	3.5E+00	2.1E-08	5.9E-09	5.2E-09	1.5E-09

Notes:
CW = concentration in water
EPC = exposure point concentration
mg/kg/day = milligrams per kilograms per day
mg/l = milligrams per liter
NA = not available/applicable
TRV = toxicity reference value
1/ EPC is estimated concentration in Dawson River in Table 1 for Day 0 and Day 30

$$Total\ Intake = \frac{EPC\ \times IR\ \times EF\ \times ED}{BW\ \times ED\ x\ 365\ ^{days}/_{year}}$$

$$Hazard\ Quotient = \frac{Total\ Intake\ \left(\frac{mg}{kg-day}\right)}{TRV\ \left(\frac{mg}{kg-day}\right)}$$

Attachment 2, Table 7
Risk Estimates for Cattle - Dawson River Release

Constituent Name	CAS No.	Mammal NOAELt	Mammal NOAEL		Mammal	
			Test Animal		Cattle	
			Animal	Body Weight (kg)	Body Weight (kg)	Derived TRV
Tributyl tetradecyl phosphonium chloride	81741-28-8	8.66E+00	Rat	3.50E-01	4.54E+02	1.44E+00

Notes:
NOAELt = No observed adverse effect level test animal
kg = kilogram
NA = not applicable
TRV = toxicity reference value
1/ If an avian NOAEL was not available, the mammal NOAEL was used to derive the TRV for the avian receptor.

$$Derived\ TRV = NOAEL_{test} * \left(\frac{Body\ Weighttest}{Body\ Weightreceptor}\right)^{(1/4)}$$

Exposure Route	Parameter Code	Parameter Definition	Units (a)	Parameter Value	Source (b)
Ingestion	IR	Ingestion rate	l/day	86	API, 2004
	EF	Exposure frequency	day/yr	7	BPJ
	ED	Exposure duration	yr	1	BPJ
	BW	Body weight	kg	454	API, 2004
	AT-NC	Averaging time - noncancer	days	365	BPJ

Notes:
a/ Units:
l/day = litres per day
day/yr = days per year
yr = year
kg = kilogram

b/ References:
BPJ - Best Professional Judgement
API, 2004
API. (2004). Risk-Based Screening Levels for the Protection of Livestock Exposed to Petroleum Hydrocarbons, Regulatory Analysis and Scientific Affairs No. 4733 July 2004.

Constituent Name	CAS No.	EPC[1] Day 0	EPC[1] Day 30	Toxicity	Total Intake (mg/kg/day)	Hazard Quotient	Total Intake (mg/kg/day)	Hazard Quotient
		CW (mg/l)	CW (mg/l)	TRVs	Day 0	Ingestion	Day 30	Ingestion
Tributyl tetradecyl phosphonium chloride	81741-28-8	1.9E-05	4.7E-06	1.4E+00	6.8E-08	4.7E-08	1.7E-08	1.2E-08

Notes:
CW = concentration in water
EPC = exposure point concentration
mg/kg/day = milligrams per kilograms per day
mg/l = milligrams per liter
NA = not available/applicable
TRV = toxicity reference value
1/ EPC is estimated concentration in Dawson River in Table 1 for Day 0 and Day 30

$$Total\ Intake = \frac{EPC\ \times IR\ \times EF\ \times ED}{BW\ \times ED\ x\ 365\ ^{days}/_{year}}$$

$$Hazard\ Quotient = \frac{Total\ Intake\ \left(\frac{mg}{kg-day}\right)}{TRV\ \left(\frac{mg}{kg-day}\right)}$$