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Technical Note

Project:	CITIC Pacific Mining Management pit dewatering		
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Date:	9/12/21	**To:**	A Latto
Doc Ref:	1794_001	**CC:**	R DeRoach
Subject:	Groundwater discharge to the Fortescue River		

1 Background

Strategen-JBS&G Pty Ltd are supporting CITIC Pacific Mining Management (CITIC) in an application to increase the volume of groundwater from pit dewatering opperations discharged to the Fortescue River. CITIC aim to increase the annual volume of discharge to the Fortescue River from the existing limit of 12 GL/annum to a limit of 21 GL/annum through referral under Section 38 of the *Environmental Protection Act 1986*. In support of the application, Strategen-JBS&G has sought:

- An assessment of environmental/ecological values and functions of the Fortescue rivermouth and marine outflow in the vicinity of the discharge
- An evaluation of both short, and longer term, extent of impacts of additional loadings of total dissolved solids (TDS) and nutrients (and associated localised increases in concentrations) from the discharge on the environmental values of the Fortescue River and Estuary; taking into account seasonal variability, and providing recommendations in relation to potential changes to operating regime.

1.1 Setting

This area is surrounded by Mardie pastoral station which has been used for pastoral purposes for over 100 years and has Australia's largest mesquite infestation. A frequently used boat ramp is close by and camping area that is heavily utilised during the winter months. CITIC monitoring has shown that during peak periods (May to September) there can in excess of 30 camping groups that stay for extended periods of time (months). There are no ablution facilities.

The Fortescue River outfall is within the estuarine section of the river, approximately 1 km upstream of the mouth. The river is tidally influenced, and the regulatory approval requires discharge on the ebbing tide to maximise dilution and mixing of the discharge. The discharge stream consists of hypersaline groundwater pumped from the mine, potentially containing concentrations of salts, nutrients and metals (boron, copper, nickel and zinc) higher than the rivermouth baseline concentrations.

The salinity of the discharge stream is currently limited at 70 ppt. Baseline TDS in the lower reaches of the Fortescue River varied seasonally between 36,400 mg/L and 52,100 mg/L with an average TDS range of 40,800 to 42,900 mg/L at monitoring locations FR1, FR2 and FR3. Ambient salinity is expected to be lower during floods which will serve to further dilute the discharge.

2 Content of the proposal

The proposed change in process will not modify the concentration of potential analytes in the discharge but will increase the annual volume discharged from 12 GL/annum to 21 GL/annum, scaling up over the life of the mine. The discharge process will remain the same; the water is discharged via a series of diffusers that assist with mixing. The higher discharge volume will be achieved by discharging at the same flow rate (up to 667 L/sec) over a longer period (up to 24 hrs/day). This discharge has the potential to affect marine water quality and dependent organisms in the river and adjacent ocean via the cause/effect pathways described in Table 2-1. Total suspended solids are higher in the receiving environment (up to 315 mg/L) than the discharge (up to 48 mg/L) and metal concentrations in the discharge were typically below the limit of reporting.

Table 2-1 Potential impacts to benthic communities and habitats associated with proposed change to operation

Potential impacts	Context
Osmotic stress	The discharge of high salinity groundwater to the receiving environment may lead to persistent increases in salinity. Elevated salinity may result in osmotic stress. Persistent elevations may exceed the tolerance limits of communities.
Nutrient stress	Additional nutrient loads in the discharge could stimulate algal growth
Toxicity	Elevated ammonia in the discharge could cause short term toxicity near the diffuser. The introduction of toxicants may adversely impact communities near the diffuser.

3 Risk assessment approach

3.1 Data sources

The risk assessment considered two data sources:

- Data from routine compliance monitoring at existing discharge rates
- Projections for the expanded discharge based on modelling

3.1.1 Compliance monitoring

Water monitoring has been conducted monthly at FR1 and FR2 (1 km downstream and upstream of discharge point), FR4 and FR5 (18 m upstream and downstream of discharge point) and reported annually in accordance with condition 3.6.1 of Licence No. L8308/2008/2 (DWER 2014). Data were collected for the last 4 years (2017/18, 2018/19, 2019/20 and 2020/21) since discharge commenced. The initial 2017/18 sampling was conducted while approved discharge flow rates were 2 GL/annum, 2018/2019 and 2019/202 sampling while the approved discharge was up to 8 GL/a and 2020/2021 while the approved discharge was up to 12 GL/a.

3.1.2 Model projections

Projected concentrations of contaminants of concern (TDS and ammonia) at sites FR1 and FR3 were determined using modelling (RPS 2020). A time-series of projected 50th percentile TDS and ammonia concentrations at sites FR1 and FR3 were used to derive summary statistics for comparison to the relevant triggers.

3.2 Triggers

TDS has been assessed as a ‘physical and chemical stressor’ using a threshold derived from baseline concentrations prior to construction of the outlet. Baseline data was collected monthly at sites FR1, FR2 and FR3 between April 2014 and November 2016 (prior to commencement of discharge). Projected median TDS is compared to the ANZG (2018) thresholds of 80th and 95th percentile of baseline concentrations prior to construction of the outlet as criteria for slightly to moderately disturbed and highly disturbed systems, respectively.

Ammonia was assessed as a ‘toxicant’ against the relevant ANZG (2018) species protection guidelines. For toxicants, the 95th percentile concentrations are compared to the relevant ANZG (2018) guideline (99% species protection guideline for slightly to moderately disturbed and 90% species protection guideline for highly disturbed systems).

4 Potential environmental impacts

4.1 TDS

TDS in the discharge water was mostly hypersaline (median TDS of 58,400 mg/L) and variable (ranging between 32,200 and 69,200 mg/L) depending on the area being mined within the pit footprint (the eastern and northern flanks being generally more saline than the western and southern flanks) and seasonal influences. Prior to the commencement of discharge, median baseline TDS in the marine environment was 41,050 mg/L (Table 4-1). Surface water monitoring at site FR1 and FR3 found median TDS concentrations were higher than baseline but below the 95th percentile of reference site concentration in each annual survey period (Table 4-1).

Table 4-1 Total dissolved solids concentrations in the marine environment for the current discharge

Median of baseline (FR1, 2 and 3) (mg/L)	95th percentile of baseline (FR1, 2 and 3) (mg/L)	Median concentration at FR1 (mg/L)				Median concentration at FR3 (mg/L)			
		20/21	19/20	18/19	17/18	20/21	19/20	18/19	17/18
41,050	48,035	41,200	42,300	42,450	42,350	43,450	42,500	42,300	42,900

Median TDS concentrations are projected to be elevated over existing concentrations at both sites (Table 4-2). TDS concentrations are expected to exceed the 95th percentile of baseline concentrations (48,035 mg/L) only 2% of the time at FR1 and 6% of the time at FR3 (Figure 4-1). Median TDS for the one month period modelled is projected to remain below the 95th percentile of baseline concentrations at both sites F1 and F3 (Table 4-2).

Table 4-2 Projected stressors in the marine environment for the increased discharge relative to environmental criteria

95th percentile of baseline trigger (mg/L)	Modelled median concentration at FR1 (mg/L)	Modelled median concentration at FR3 (mg/L)
48,035	43,766	45,867

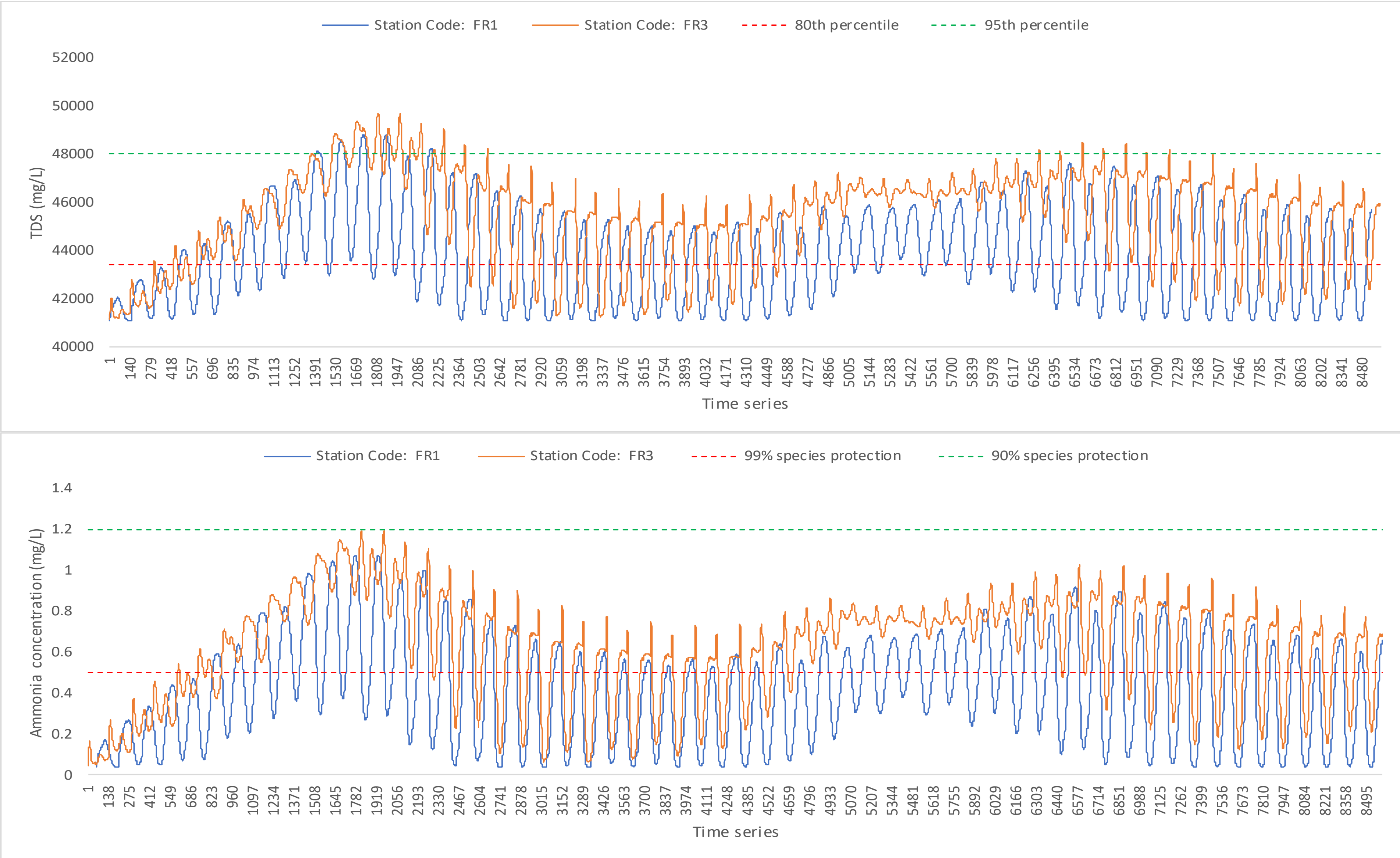

Figure 4-1 Time series of modelled total dissolved solids and ammonia concentrations at FR1 and FR3

4.2 Ammonia

Concentrations of ammonia in the discharge (ranging from 1.23 to 17.9 mg/L) were high relative to the baseline (median of 0.03 mg/L) and as a result the 95th percentile ammonia concentration was an order of magnitude higher at sites FR1 and FR3 than the median baseline concentrations (Table 4-3). Nevertheless, 95th percentile ammonia concentrations were lower than the marine 90% species protection guideline (1.2 mg/L) at each location and on each sampling occasion (Table 4-3).

Table 4-3 Ammonia in the marine environment for the current discharge

90% species protection guideline (mg/L)	95th percentile concentration at FR1 (mg/L)				95th percentile concentration at FR3 (mg/L)			
	20/21	19/20	18/19	17/18	20/21	19/20	18/19	17/18
1.2	0.18	0.12	0.34	0.37	0.25	0.17	0.30	0.35

As mining has progressed and regional groundwater has increased, ammonia concentrations in the discharge have fallen over time from median concentration of 14.4 mg/L in 2017/18, 5.38 mg/L in 2018/2019, 3.91 mg/L in 2019/2020 and 3.04 mg/L in 2020/2021 with this increase in mine depth and westward progression. Mining will continue to progress deeper and further to the west and CITIC considers the ongoing groundwater discharge composition will be consistent with that encountered in 2019/2020 (median ammonia concentration of 3.91 mg/L) rather than 2017/18 (median ammonia concentration of 14.4 mg/L).

The 95th percentile concentrations of ammonia are projected to be elevated over existing concentrations at both sites FR1 and FR2 (Table 4-4). For a discharge with a median ammonia concentration of 3.91 mg/L, 95th percentile concentrations at FR1 (0.86 mg/L) and FR3 (0.98 mg/L) are expected to be below the ANZG (2018) 90% species protection guideline at all times (Figure 4-1 and Table 4-4).

Table 4-4 Projected ammonia in the marine environment for the increased discharge relative to environmental criteria

90% species protection guideline (mg/L)	Modelled 95th percentile concentration at FR1 (mg/L)	Modelled 95th percentile concentration at FR3 (mg/L)
1.2	0.86	0.98

4.3 Nutrient loads

Total nitrogen concentrations (median of 9.8 mg/L) and nitrate (median of 4.5 mg/L) were elevated in the discharge compared to baseline. For nutrients, it is the load to the environment (up to 0.56, 0.26 and 0.0017 t/day for total nitrogen, nitrate and phosphorus, respectively) rather than final concentration that determines risk (Table 4-5). The phosphorus load was all bioavailable (Table 4-3). No issues associated with the existing nutrient load (e.g. algal blooms) have been reported.

Total nitrogen loads are projected to increase by 0.24 tonnes/day (from 0.32 to 0.56 tonnes/day). Nitrate loads are expected to increase by 0.1 tonnes/day (from 0.16 to 0.26 tonnes/day) (Table 4-5). Phosphorus loads are expected to increase by 0.001 tonnes/day (from 0.00066 to 0.0017 tonnes/day) (Table 4-5). There are no formal assessment guidelines for nutrient loads, but projected nutrient loads (average total nitrogen load of 560 kg/day) are small compared to sustainable discharges elsewhere (e.g. nitrogen load of up to 4900 kg/day from Perth's Sepia Depression Ocean Outlet) and likely sustainable.

Table 4-5 Nutrient loads to the marine environment for the current discharge and projected for the increased discharge

Parameter	Date	Median groundwater concentration (mg/L)	Discharge volume (up to GL/year)	Load (t/day)
TN	2017/18	27.05	2	0.15
	2018/19	9.4	8	0.21
	2019/20	9.8	8	0.21
	2020/21	9.8	12	0.32
	Projected	9.8	21	0.56
Nitrate	2017/18	12.5	2	0.069
	2018/19	3.5	8	0.076
	2019/20	4.5	8	0.099
	2020/21	4.7	12	0.16
	Projected	4.5	21	0.26
TP or bioavailable phosphorus[1]	2017/18	0.12	2	0.00066
	2018/19	0.025	8	0.00056
	2019/20	0.03	8	0.00066
	2020/21	0.02	12	0.00066
	Projected	0.03	21	0.0017

Notes:
1. All the phosphorus is bioavailable

5 Significance of the additional or different detrimental environment effects

An assessment of potential key environmental factors against the EPA's *Statement of Environmental Principles, Factors and Objectives* (EPA 2018) has identified key environmental factors that are to be considered within an environmental assessment.

5.1 Benthic communities and habitats

The EPA's environmental objective for benthic communities and habitats is "*To protect benthic communities and habitats so that biological diversity and ecological integrity are maintained*" (EPA 2018).

5.1.1 Mangroves

Mangroves along the Pilbara coastline are the largest single unit of relatively undisturbed tropical arid zone habitats in the world. The EPA recognises the intrinsic value of these tropical arid zone mangroves and the need to protect distribution and function along the Pilbara coastline. Mangroves constitute a small but important area of benthic habitat in the Fortescue Estuary (EPA 2001). The Fortescue River was mapped in 2001 and the following areas were calculated. Intertidal flats covered 8.3 km^2, mangroves covered 1.2 km^2 (Oz Estuaries 2020). Mangroves provide critical ecosystem functions and services and are habitat for adult fish, refuge for juveniles and a source of nutrients and carbon. Mangroves respond to changes in environmental conditions and therefore could potentially be impacted by changes in water quality associated with increased discharge volumes (Semeniuk and Cresswell 2018; EPA 2001).

Mangroves are considered salt tolerant, but salinity is an important factor limiting propagule germination, seedling growth and reproduction. Optimal growth varies from 10% to 50% seawater. Salinity tolerance in mangroves depends on a range of adaptations, including ion compartmentation, osmoregulation, selective transport and uptake of ions, maintenance of a balance between the supply of ions to the shoot, and capacity to accommodate the salt influx but because of the extreme water and salinity stresses in the Pilbara intertidal zone mangroves are of relatively lower productivity than the mangrove communities of the wet tropics (EPA 2001).

The tolerance of mangroves to a high saline environment is also tightly linked to population genetics. Western Australian species are known to tolerate high TDS concentrations up to 85,000 mg/L (Table 5-1). Baseline salinity was as high as 52,100 mg/L suggesting local species may be similarly adapted to locally high salinity.

Table 5-1 Salinity tolerances of mangroves

Species	Optimal TDS (mg/L)	Maximum TDS tolerance (mg/L)
Avicennia marina	15 - 30,000	85,000
Ceriops australis	40 - 50,000	72,000
Rhizophora stylosa	8 - 26,000	74,000

Source: Stantec (2018)

5.1.2 Intertidal flats/saltmarsh/salt flats.

The Fortescue River was mapped in 2001 and intertidal flats covered 8.3 km^2 and saltmarsh/salt flats covered 13.8 km^2 (Oz Estuaries 2020). Intertidal habitats provide essential food, refuge and nursery habitat for healthy fisheries. They protect coastlines and communities (Boorman 1999).

Salt marshes and flats are subject to rapid wetting periods during high water followed by a slow drying period as the water progressively evaporates. As a result, the salinity of the surface water varies over time and becomes progressively more saline as it evaporates. Salt marshes and flats are therefore salt tolerant and unlikely to be impacted by changes in salinity associated with potential increased discharge volumes (Boorman 1999).

Intertidal flats are subject to wetting and drying on a tidal cycle. Tolerance can be achieved through behavioural, ecological and/or physiological mechanisms (Drouin et al. 1985; Helmuth 1998; Zardi et al. 2006; Michalec et al. 2010). For example, the response of sessile molluscs to low tides involves closure of shell valves (bivalves) or operculum (gastropods) isolating them from the environment for a period of hours (Hoyaux et al. 1976; Davenport & Wong 1986; Berger & Kharazova 1997; HRS-Brenko 2006). The close correlation between periods of high salinity and the tidal cycle suggests that the short timescale of periods of elevated TDS may be tolerable by intertidal species.

5.2 Marine Fauna

A wide diversity of marine fauna occur in the river. There is potential for the behaviour of species which are sensitive to salinity to be modified during discharge activities. The EPA's environmental objective for marine fauna is "to protect marine fauna so that biological diversity and ecological integrity are maintained" (EPA 2018). Large barramundi and other estuarine species are present in the river and are important for recreational fishing. Impacts to recreational fisheries may potentially arise as a result of the effluent discharges (EPA 2001).

Environments of variable salinity are inhabited by euryhaline fishes which have wide salinity tolerance ranges. Euryhaline fishes employ mechanisms that control dynamic changes in osmoregulatory strategy. Most euryhaline fishes have an upper salinity tolerance limit of approximately 2× seawater (60,000 mg/L) (Kultz 2015). Native estuarine fish are generally salt tolerant with species such as barramundi farmed in saline groundwater systems with salinities >45,000 mg/L (Partridge 2008). Studies of fish abundance in hypersaline solar salt fields found native estuarine fish frequented the ponds but there was an inverse relationship between salinity and biomass as well as species richness (Molony and Parry 2006). Prawns can withstand a range of temperatures and salinities (Jackson and Burford 2003; O'Brien 1994), but exposure to extreme temperatures (15 and 35 ° C) and salinities (5 ‰ and 55 ‰) results in high mortality rates (O'Brien 1994).

5.3 Marine environmental quality

The Fortescue River is remote and relatively undeveloped. The Fortescue River function is tidally dominated. It has naturally high turbidity and low sediment trapping efficiency. There is some development for recreational (boat ramp and camping) and pastoral use of the catchment, but water and sediment quality are expected to be high. The Proposal has the potential to modify water and sediment quality during operation through the discharge but the 95th percentile ammonia concentrations at sites FR1 (0.86 mg/L) and FR3 (0.98 mg/L) are expected to meet the ANZG (2018) 90% species protection guidelines (1.2 mg/L).

6 Summary

6.1.1 Osmotic stress

The dewatering process will discharge a wastewater stream roughly twice the TDS of seawater (70,000 mg/L). Salinity was assessed as a 'stressor' (ANZG 2018) using the 95th percentile of baseline concentrations prior to construction of the outlet as a threshold. Baseline TDS was high (up to 52,100 mg/L) and the ecosystem is also potentially adapted and tolerant to elevated salinity. Monitoring under existing discharge conditions suggest that median TDS concentrations at sites FR1 and FR3 are presently below the 95th percentile of baseline concentrations. Median salinity for the modelled period is expected to increase at both sites relative to the existing discharge. For the 21 GL/annum discharge, median TDS is expected to remain below the 95th percentile of baseline concentrations at both sites.

6.1.2 Toxicity

Under existing discharge conditions, the annual 95th percentile ammonia concentrations at FR1 and FR3 are below the ANZG (2018) 99% species protection guideline (0.5 mg/L). For an ongoing 21 GL/annum discharge with a wastewater composition consistent with 2019/20 monitoring period, the 95th percentile ammonia concentration at FR1 (0.86 mg/L) and FR3 (0.98 mg/L) are expected to the meet ANZG (2018) 90% species protection guidelines.

6.1.3 Nutrient stress

Total nitrogen loads are projected to increase by 0.24 tonnes/day (from 0.32 to 0.56 tonnes/day). Nitrate loads are expected to increase by 0.1 tonnes/day (from 0.16 to 0.26 tonnes/day). Phosphorus loads are expected to increase by 0.001 tonnes/day (from 0.00066 to 0.0017 tonnes/day). There are no formal assessment guidelines for nutrient loads, but nitrogen loads (average load of 560 kg/day) are small compared to sustainable discharges elsewhere (e.g. nitrogen load of up to 4900 kg/day from Perth's Sepia Depression Ocean Outlet).

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