MARINE ENVIRONMENTAL SERVICES

MARINE PIPELINE PROJECT FOR THE COEGA SPECIAL ECONOMIC ZONE, MARINE ECOLOGICAL ASSESSMENT

PREPARED FOR:

PRDW
Consulting Port and Coastal Engineers

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Contents

1 INTRODUCTION ... 1

2 STUDY AREA ... 1

3 EFFLUENT DISCHARGES AND MODELLING ... 2

3.1 Discharges and Constituents ... 2

3.2 Modelled Scenarios ... 3

3.3 Applicable Water Quality Guidelines and Mixing Zone Dimensions ... 5

3.3.1 Water Quality Guidelines ... 5

3.3.2 Initial Mixing Zone Dimensions ... 6

4 DISCHARGE COMPLIANCE WITH WATER QUALITY GUIDELINES ... 8

4.1 Discharge Scenario 1 ... 9

4.2 Discharge Scenario 2 ... 9

5 WORST CASE TOXICITY RISK ASSESSMENTS ... 10

5.1 Discharge Scenario 1 ... 10

5.2 Discharge Scenario 2 ... 12

6 SUMMARY ... 13

7 REFERENCES ... 15

Figures

Figure 2.1: Algoa Bay showing the respective locations of the Ports of Ngqura and Port Elizabeth (PE) and the Addo Elephant Park MPA. ... 2

Figure 3.1: Schematic showing discharge scenario 1 within the Coega Industrial Development Zone. ... 4

Figure 3.2: Schematic showing discharge scenario 2 within the Coega Industrial Development Zone. ... 4

Figure 3.3: Map showing the marine ecosystem threat status in Algoa Bay as well as the Addo Elephant Marine Protected Area Zones (from SANBI 2016. ... 7

Figure 3.4: Map showing the regional marine ecosystem threat status on the southeast coast of South Africa (from SANBI 2016). ... 8

Figure 5.1: Time series of exposures above dilution thresholds required to meet WQG concentrations for E coli, TAN and TSS at the Port of Ngqura entrance (from PRDW 2020). 12

Tables

Table 3.1: Effluent constituents 3

Table 3.2: Effluent constituents and relevant water quality guidelines (WQG). Ambient levels in the receiving water body as employed in the PRDW (2020) modelling are listed as are published effect levels. 6

Table 4.1: Effluent constituent compliance with WQGs at ecologically important sentinel sites for discharge Scenario 1. Green shaded cells indicate predicted levels comply with the water quality guidelines and yellow indicates non-compliance. Numbers within cells refer to discharges as in PRDW (2020)... 9

Table 4.2: Effluent constituent compliance with WQGs at ecologically important sentinel sites for discharge Scenario 2. Green shaded cells indicate predicted levels comply with the water quality guidelines and yellow indicates non-compliance. Numbers within cells refer to discharges as in PRDW (2020)... 10

Table 5.1: Worst case toxicity risks in the receiving environment for effluents discharged under scenario 1. Effects are assessed based on measured lowest observed effect concentrations (LOEC) in the scientific literature. 11

Table 5.2: Worst case toxicity risks in the receiving environment for effluents discharged under scenario 2. Effects are assessed based on measured lowest observed effect concentrations (LOEC) in the scientific literature. 13

1 INTRODUCTION

The Coega Development Corporation (CDC) plans to establish an integrated marine pipeline servitude in the Coega Industrial Development Zone where investors can establish infrastructure for the abstraction of seawater and the discharge of treated effluent as required by industrial processes.

As part of wider assessments on the proposed marine pipeline servitude, PRDW contracted Lwandle Technologies (Pty) Ltd (Lwandle) to conduct an ecological risk assessment of the effects on the receiving environment. This report will:

- Provide the environmental context in which the proposed discharges will operate based on existing survey information and scientific publications,
- Specify receiving water quality guidelines that should apply in the water body,
- Define mixing zone dimensions where effluent constituent chronic toxicity levels may exceed water quality guideline thresholds, and
- Conduct toxicity effects evaluations on predicted effluent constituent distributions in the receiving environment of the discharges.

This report should be read in conjunction with the PRDW (2020) report: Marine Pipeline Project for the Coega Special Economic Zone, Marine Effluent Dispersion Modelling, PRDW Report No. S2001-150-CE-001-R1, which provides the simulation modelling on which the interpretations and findings of the current report are based.

2 STUDY AREA

The integrated marine pipeline servitude will be located in the Coega Industrial Development Zone (IDZ). The Coega IDZ is located in the Port of Ngqura at the mouth of the Coega River approximately 20 km northeast of Port Elizabeth. The port is adjacent to the western border of the Addo Marine Protected Area (MPA) (Figure 2.1).

Algoa Bay is an eastward facing bay situated along the south coast of South Africa. The local regime of the south-east coast is dominated by the presence of the warm Agulhas Current that flows south-westwards along the continental shelf edge and approximately 50 km offshore of Algoa Bay (Schumann, 1987). The current brings warm subtropical surface waters and deeper central water into the region, moderating the climate (Schumann, 1998). Colder waters can be transported into Algoa Bay from shelf edge upwelling upstream of the bay and by wind-driven coastal upwelling (Lutjeharms et al., 2000; Schumann et al., 1982). Consequently, Algoa Bay is biologically productive and supports high biodiversity including reef-associated organisms, colonies of piscivorous seabirds on the islands, whales and dolphins. The bay also hosts four commercial fisheries, small pelagics, line fish, squid and sharks. Algoa Bay supports dense accumulations of the surf zone adapted diatom *Anaulus australis*. Productivity from these is exported to nearshore waters via surf zone rip currents but also by trophic transfer to mysids, which, in turn, are preyed on by juvenile and adult fish. This rich biodiversity is protected by the incorporation of the bay area to the east of the Port of Ngqura in the Addo Elephant Park MPA (Figure 2.1).

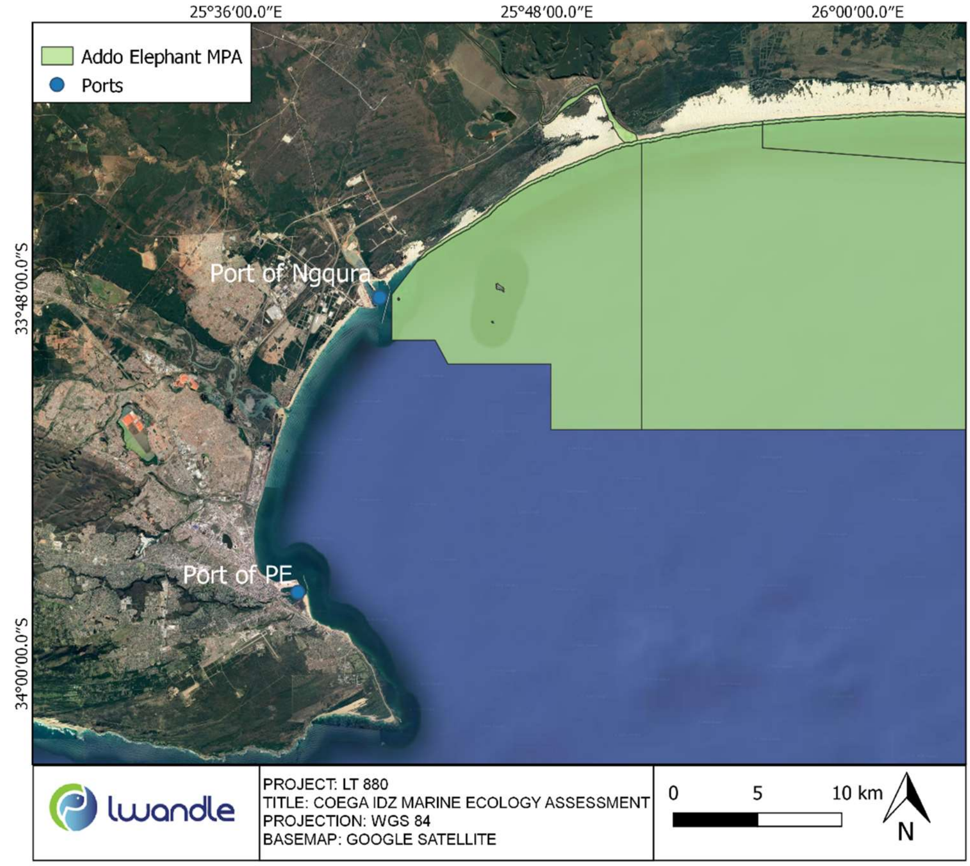

Figure 2.1: Algoa Bay showing the respective locations of the Ports of Ngqura and Port Elizabeth (PE) and the Addo Elephant Park MPA.

3 EFFLUENT DISCHARGES AND MODELLING

3.1 DISCHARGES AND CONSTITUENTS

The effluents and discharge rates specified for this assessment were:

1. Abalone farm effluent (5 m^3/s)
2. Wastewater treatment plant 1 (WW 1, 0.93 m^3/s)
3. Wastewater treatment plant 2 with industrial component (WW 2, 0.46 m^3/s)
4. Brine discharge from a desalination plant (1.22 m^3/s)
5. Recirculating seawater finfish farm effluent (0.94 m^3/s)

6. Cooling water from LNG fuelled power plant, combined with heating water from an LNG regasification process. This covers a number of options specified in Table 6-1 in PRDW (2020). The options assessed here are Cooling water 2 plus Heating water 1 (14.33 m^3/s), and Cooling water 3 plus Heating water 2 (4.54 m^3/s).

The specified constituents of the various effluent discharges are listed in Table 3.1.

Table 3.1: Effluent constituents

Constituent	Discharge	Category
Temperature (Δ)	Power plant and degasification units	System state variable, physiological stressor
Salinity (Δ)	Desalination brines, WWTW 1 & 2	System state variable, physiological stressor
Total suspended solids (TSS)	Abalone farm, WWTW 1 & 2, Finfish	Natural variable, physical stressor
Nitrogen (TKN + NH4 - + NH3)		Plant nutrient, Toxicant (NH3, mainly)
Chemical oxygen demand (COD)		Oxygen demand
Faecal indicator bacteria (E. coli)	WWTW 1 & 2	Human health risk qualifier
Sulphide (HS)	WWTW 2	Toxicant, reducing agent, oxygen demand
Mercury (Hg)	WWTW 2	Toxicant
Cobalt (Co)	WWTW 2	Toxicant
Copper (Cu)	WWTW 2	Toxicant
Cadmium (Cd)	WWTW 2	Toxicant
Zinc, Nickel, Chromium etc.	Not specified but WWTW 2	Toxicant

3.2 MODELLED SCENARIOS

The discharges were modelled by PRDW (2020) in terms of their respective locations, water depths and combinations of flows. Two scenarios were developed for this as shown in the schematics below (Figure 3.1 and Figure 3.2).

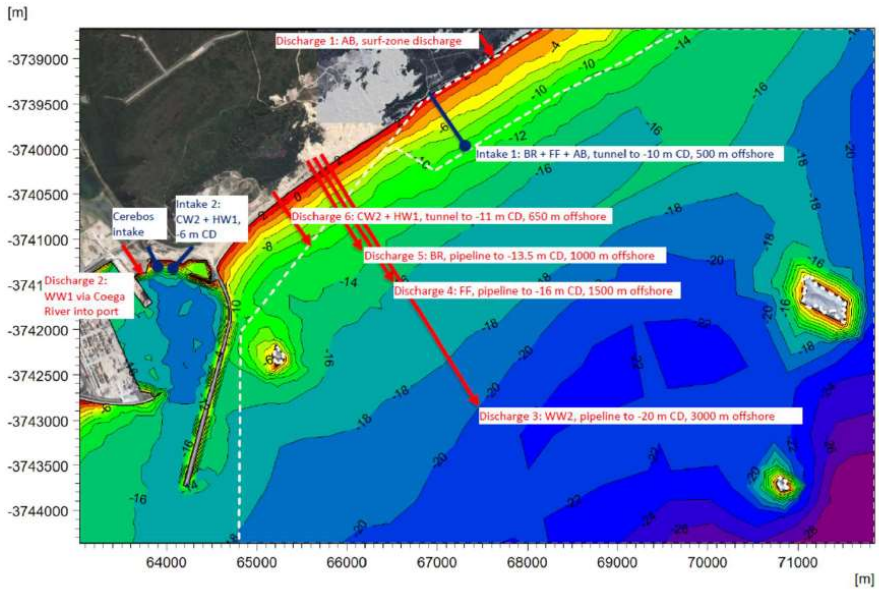

Figure 3.1: Schematic showing discharge scenario 1 within the Coega Industrial Development Zone.

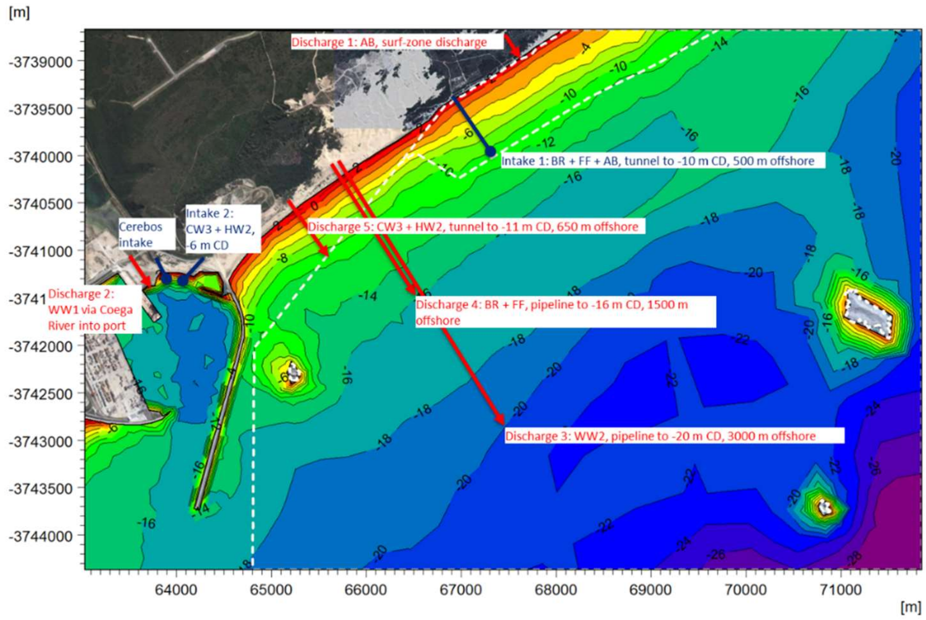

Figure 3.2: Schematic showing discharge scenario 2 within the Coega Industrial Development Zone.

3.3 Applicable Water Quality Guidelines and Mixing Zone Dimensions

The modelling results are presented in PRDW (2020) as simulations of post-discharge plume behaviour and achieved dilutions. Determinations of the associated receiving environmental risks require inputs on the water quality guideline thresholds/concentrations that should be applied and specifications on the appropriate dimensions of initial mixing zones of the discharges where non-compliance with the water quality guidelines may not be achieved.

3.3.1 Water Quality Guidelines

Effluent discharges to receiving marine and freshwater water bodies need to comply with RSA regulations. These require that, in marine and estuarine settings, water quality deterioration as a result of effluent discharges should not compromise beneficial uses of the water body. In freshwater settings, effluent discharges should not compromise the water body such that it may be a risk to human health or to other uses of that water body.

Marine and estuarine effluent discharges are controlled by Coastal Water Discharge Permits (CWDP) in which compliance with water quality guidelines (WQG) outside of specified initial mixing zones is required. Discharges into a freshwater body are generally controlled by conditions within general authorisations for such activities.

The marine WQGs currently in force are those defined in DWAFF (1995). These have been reviewed and updated in DEA (2019) but these are still in draft form and are not yet gazetted. Therefore, here the DWAFF (1995) version of the guidelines are followed primarily but are augmented by WQGs from other jurisdictions where required, e.g. ANZECC (2000), IFC (2009), along with peer-reviewed toxicity test data.

In applying WQGs in evaluations of effluent discharges the preferred hierarchy is that:

1. At the initial mixing zone boundary of the discharge in question, generally defined as radius distances from discharge pipeline diffuser banks, constituents of concern comply with DWAFF (1995) guidelines, or
2. Constituents comply with guidelines/limits from other respectable jurisdictions, or
3. Site-specific thresholds are developed to constrain toxicity effects. Note that, in general, this approach should be limited to existing discharges as opposed to those still to be constructed.

Table 3.2 lists the effluent constituents that were specified for this evaluation, the respective concentrations and WQGs for them. Note that the constituent levels/concentrations are representative of the specified worst-case conditions (PRDW 2020).

Table 3.2: Effluent constituents and relevant water quality guidelines (WQG). Ambient levels in the receiving water body as employed in the PRDW (2020) modelling are listed as are published effect levels.

Constituent	Effluent	WQG DWAF 1995	WQG IFC	WQG ANZECC 2000	Ambient PRDW	Site specific Thresholds					
Temperature+	25.91	+1[1]	+3		18.0	<23	DEA 2019 high range		>25	Chronic effects level	
Temperature-	13.00	-1[1]	-3		18.0	>13.5	DEA 2019 low range		30-33	Lethal level zooplankton	
Salinity PSU	53.00	36			35.0	38-40	Smyth et al 2014				
TSS mg/L	200.00	< +10%[2]			10.0	<+5 above background		CCME 2002	<20	Embecon 2004	
COD mg/L	100.00		125		5.0[3]	20.00		Sun et al 2014			
E.coli CFU/100mL	1.00E+05		500		0.0						
TKN/NH_4^- mg/L	81.00	0.6			0.4						
Mercury mg/L	5.00	0.0003		0.0004	*0.0*[4]	0.0390	LOEC 50th %	Ecotox (n=11)	Diatom		
Sulphides mg/L	5.00			0.0010	*0.0*[4]						
Cobalt mg/L	5.00			0.0010	*0.0*[4]	[5]2.5000	LOEC 50th %	Ecotox (n=1)	Diatom		
Copper mg/L	20.00	0.005		0.0013	*0.0*[4]	0.0400	LOEC 50th %	Ecotox (n=14)	Diatom	0.1085	Mysid
Cadmium mg/L	5.00	0.004		0.0055	*0.0*[4]	2.5500	LOEC 50th $CdCl_2$	Ecotox (n=2)	Diatom		
Notes	[1] above/below mean ambient for perioc				[2] above mean ambient for period			[3] estimated from COD/BOD = 1.75			
	[4]assumed		[5]ANZECC NOEC 0.3-23.6 mg/L								

3.3.2 Initial Mixing Zone Dimensions

The initial mixing zone is defined as the area where a discharged effluent undergoes initial dilution, from jet momentum and buoyancy, but can cover secondary mixing in the ambient water body. In this zone, water quality guidelines can be exceeded as long as acutely toxic conditions are prevented. For compliance WQGs as listed in Table 3.2 should be met at the edge of the initial mixing zone. If guidelines are exceeded beyond the mixing zone boundary the probable effects of such are to be evaluated in terms of predicted levels of toxicity for the biological organisms that may be exposed to the offending effluent constituents. These evaluations are then used to determine whether the predicted risks are of such a level that would allow or disallow permissions for discharge to proceed. i.e. WQGs in themselves are not pass/fail entities for exceedances, they simply trigger a further detailed examination of the toxicity risks to the receiving water body ecology. Therefore, as indicated above, the low toxicity risk situation of compliance with the set WQGs is the preferred outcome as it removes requirements for further effluent toxicity assessments that generally have their uncertainties.

Allowed dimensions of initial mixing zones vary across jurisdictions and by sensitivity classification of the receiving water body. For example, the USEPA (2006) and IFC (2009) indicate 100 m in all directions from discharge points, or that calculated by a plume model. Local (DEA 2015) advice is 100 m radius for enclosed water bodies and those classed as being sensitive environments and 300 m radius in open coast settings where water depths exceed 10 m and distance offshore is >500 m.

The proposed discharges in the proposed pipeline servitude will be located in an open coast setting characterised by sometimes vigorous winds, active currents and turbulent sea conditions. The inner continental shelf ecosystem hosting the discharges is rated as 'vulnerable' in terms of conservation threat by SANBI (2016). However, this is in common with large extents of the inner continental shelf between Cape St Francis in the south and East London in the north as shown in Figures 3.3 and Figure 3.4. Consequently, although within a declared MPA this commonality and the open coast setting characterised by vigorous winds and strong wave action indicates that a 300 m radius for the initial dilution zone is appropriate.

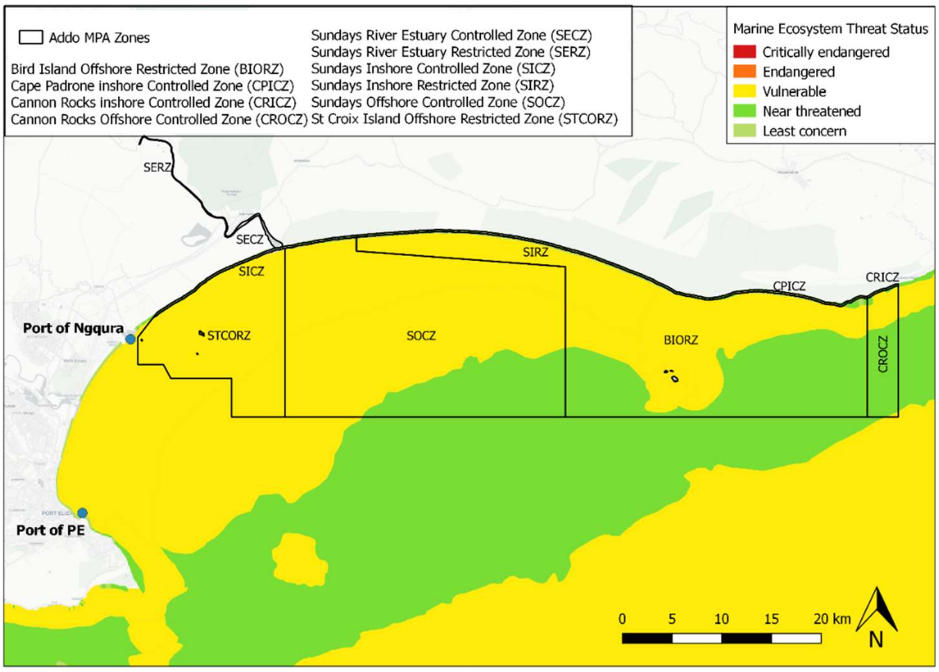

Figure 3.3: Map showing the marine ecosystem threat status in Algoa Bay as well as the Addo Elephant Marine Protected Area Zones (from SANBI 2016.

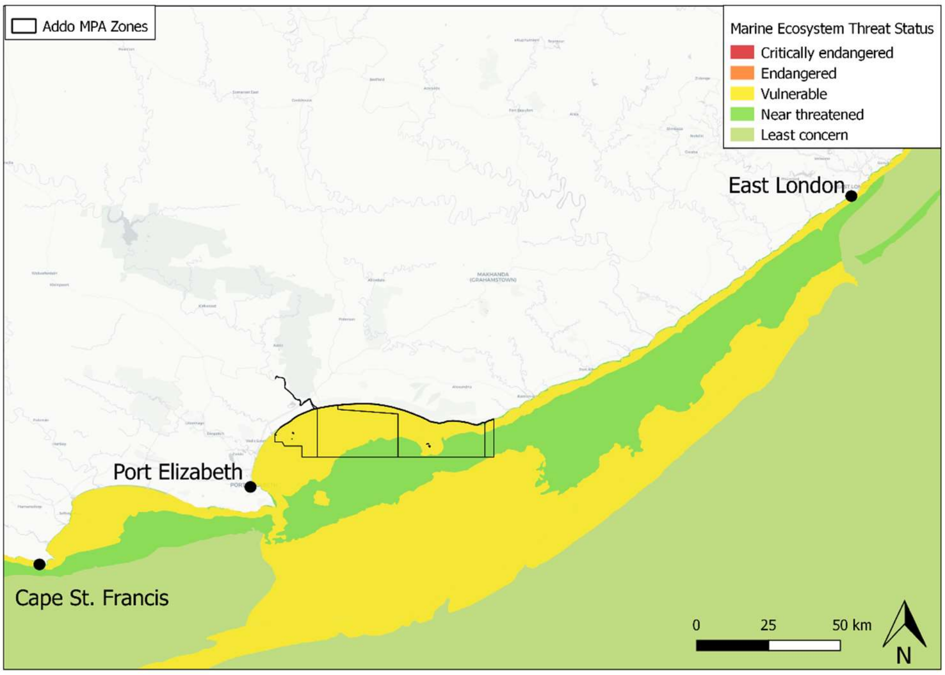

Figure 3.4: Map showing the regional marine ecosystem threat status on the southeast coast of South Africa (from SANBI 2016).

4 DISCHARGE COMPLIANCE WITH WATER QUALITY GUIDELINES

The assessment of ecological effects from predicted effluent behaviour and concentrations in the receiving environment outside of the initial mixing zones of the discharges is based on:

- Ecological characteristics of the receiving environment – identifying receptor organisms and sites,
- Receiving WQGs and published effluent constituent toxicity analyses,
- Modelled dilutions of effluent from the various discharges in the receiving environment. The dilutions provided by PRDW (2020) are 5th percentile values, i.e. dilutions are predicted to be higher than these for 95% of the time, and concentrations of effluent constituents lower than those predicted for 95% of the time, and
- Effluent plume dilution distributions based on the worst (lowest) dilution in each modelled vertical layer, representing the worst-case situation.

The approach is thus inherently conservative and precautionary as befits assessments of anthropogenic effects on the natural environment in general, and specifically the coastal marine environment.

Discharge compliance was examined at 100 m and 300 m boundaries of putative mixing zones for each of the discharges and at sentinel sites which were identified based on their ecological importance, e.g. island rocky shores, surf zones, or for seawater abstraction. The sites were purposefully located outside of the defined nearfield initial mixing zones for the discharges to check their respective degrees of exposure to effluents as they dilute and move into the far-field. The distributions of the sites are shown in PRDW's (2020) Figure 7.3. Risks of deleterious effects are estimated from frequencies of exposures to effluent dilutions below levels required to meet WQG concentrations.

4.1 Discharge Scenario 1

As shown in Table 4.1, all constituents except temperature and COD are non-compliant with WQGs at sites and all sites except the aquaculture sites are exposed. The wastewater treatment works are the main sources of noncompliance with finfish and brine discharges exceeding guidelines at the 100 m radius boundary but at no other sites.

Table 4.1: Effluent constituent compliance with WQGs at ecologically important sentinel sites for discharge Scenario 1. Green shaded cells indicate predicted levels comply with the water quality guidelines and yellow indicates non-compliance. Numbers within cells refer to discharges as in PRDW (2020).

Constituent	Site												
	Intake 1	Intake 2	Cerebos 1	Cerebos 2	Jahleel Is.	Brenton Is.	St Croix Is.	Ngqura Entrance	Discharge + 100m	Discharge + 300m	Aqua 7	Aqua 6	Aqua 1
Temperature													
Salinity									2, 5	2			
TSS		2	2					2	2	2			
TAN		2	2					2	2, 4	2			
COD													
FIB		2	2					2	2	2			
Sulphide									3	3			
Mercury	3	3	3	3	3	3	3	3	3	3			
Cobalt									3	3			
Copper									3	3			
Cadmium									3	3			

Key to discharge numbers:

Discharge #	Source
1	Abalone
2	WW 1
3	WW 2
4	Finfish
5	Brine
6	Cooling Water

4.2 Discharge Scenario 2

In this scenario, temperature is the only compliant constituent at all sites and only the distant aquaculture sites 6 and 7 are not exposed to some level of water quality risk (Table 4.2). As in Scenario 1, the main offending discharges are the wastewater treatment works WWTW 1 and WWTW 2.

Table 4.2: Effluent constituent compliance with WQGs at ecologically important sentinel sites for discharge Scenario 2. Green shaded cells indicate predicted levels comply with the water quality guidelines and yellow indicates non-compliance. Numbers within cells refer to discharges as in PRDW (2020).

Constituent	Site												
	Intake 1	Intake 2	Cerebos 1	Cerebos 2	Jahleel Is.	Brenton Is.	St Croix Is.	Ngqura Entrance	Discharge + 100m	Discharge + 300m	Aqua 7	Aqua 6	Aqua 1
Temperature													
Salinity									2	2			
TSS		2	2					2	2, 3	2			
TAN		2						2	2, 4	2, 4			
COD									3	3			
FIB		2	2					2	2, 3	2			
Sulphide									3	3	3		
Mercury	3	3	3	3	3	3	3	3	3	3	3		
Cobalt									3	3	3		
Copper									3	3	3		
Cadmium									3	3			

Key to discharge numbers:

Discharge #	Source
1	Abalone
2	WW 1
3	WW 2
4	Brine + Finfish
5	Cooling Water

It must be noted that, in both Scenarios 1 and 2 the WWTW 2 specified metal concentrations for the effluent are too high to be accommodated in realistically achievable dilutions and need to be modified. Also, metal concentrations exceed acute effects levels indicating marine organism mortality effects within the initial mixing zone. This is counter to the intent of at worst only generating chronic effects in this zone. Using predicted dilutions at the 300 m initial mixing zone boundaries PRDW (2020) have calculated 'end-of-pipe' effluent concentrations for these constituents that will enable compliance with WQG thresholds (their Tables 7.3 and 7.4). The WWTW 2 effluent needs to be managed to achieve these levels.

5 WORST CASE TOXICITY RISK ASSESSMENTS

5.1 Discharge Scenario 1

The probable effects on biological organisms in the receiving environment for the discharges in terms of reported lowest observed effect levels outside of the 300 m radius initial mixing zone for the scenario 1 discharges are summarized in Table 5.1.

Table 5.1: Worst case toxicity risks in the receiving environment for effluents discharged under scenario 1. Effects are assessed based on measured lowest observed effect concentrations (LOEC) in the scientific literature.

Constituent	[300m ZID Boundary]	WQG	LOEC (measured /estimate)	Comment
Salinity PSU	31.11	34-36	33-38	Physiological stress on pelagic organisms entrained in plume
TSS mg/L	76.67	< + 10%	20	Low risk on plankton entrained in plume (20% population chronically affected at 100 mg/L (Smit et al 2008)).
TAN mg/L	9.04	0.6	3.64	20-day exposure for *Sparus auratus* EC50 growth (ANZECC 2000). CCME (2010) does not recommend a guideline for marine waters!.
FIB c/100 ml	11 111.11	500	n/a	No ecological risk, affects recreational use
COD mg/L	33.97	125	n/a	Places oxygen debt on receiving water body, low risk in open coast wave and current active areas
Sulphide mg/L	0.024	0.001	0.01	S^- Active toxicant. In oxic water ½ life ~15 minutes. At 0.2m/s current = 50% decay in 0.2 km distance.
Mercury mg/L	0.024	0.0003	0.04	Below LOEC threshold for diatoms
Cobalt mg/L	0.024	0.001	2.5	Below LOEC threshold for diatoms
Copper mg/L	0.097	0.005	0.04	Can affect diatoms, but below LOEC threshold for mysids (zooplankton) of 0.1065 mg/L
Cadmium mg/l	0.024	0.004	2.55	Below LOEC threshold for diatoms

Effluent constituent toxicity effect risks outside of the 300 m radius mixing zone are negligible for all but TAN, and trace metals discharged from WWTW 2. In this case, effects are expected to be transient due to short exposure durations. Short duration exposures durations are a function of variable current directions and the locations of receptors relative to these. This variability is evident at the Ngqura Port entrance sentinel site as shown in Figure 5.1. Exposure periods greater than three days are rare in the modelled periods. As most toxicity tests are based on three- or four-day exposure durations this implies that shorter exposure periods should have reduced effects on biological receptors. In this regard note that the TAN LOEC toxicity is based on a 20-day exposure and it is unlikely that elevated concentrations of TAN would be maintained in the natural environment for such a period, even without variations in currents. Shorter-term toxicity tests for fish show LOECs ranging from 8.8-44.9 mg/L, for crustaceans 18.7-264 mg/L, molluscs 7.72-42.8 mg/L and marine rotifers 101 mg/L (ANZECC 2000). These indicate that TAN toxicity if it occurs at all, should be limited to the immediate vicinity of the discharges and probably quiescent periods. In terms of trace metals, however, effects can cover larger geographic scales and compromise aquaculture precincts in Algoa Bay unless effluent concentrations are reduced.

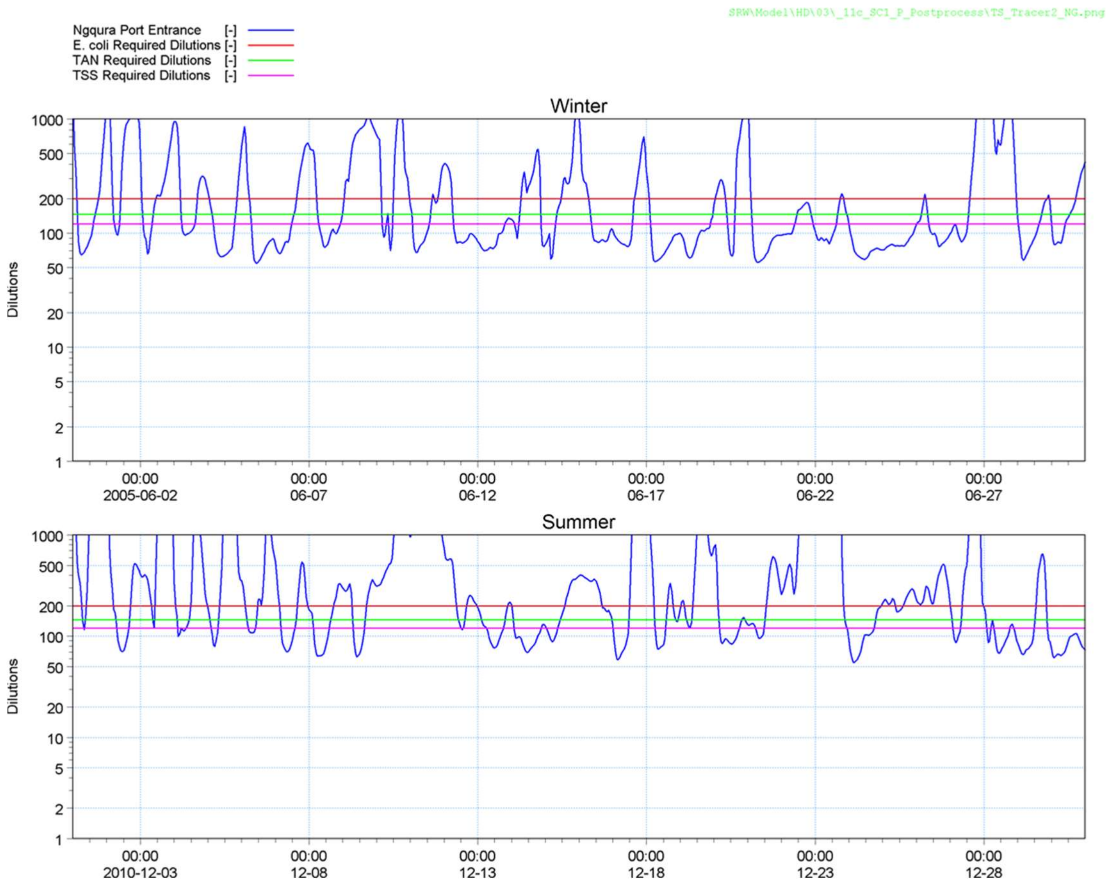

Figure 5.1: Time series of exposures above dilution thresholds required to meet WQG concentrations for E coli*, TAN and TSS at the Port of Ngqura entrance (from PRDW 2020).*

The WWTW 1 wastewater discharge into the Ngqura port compromises intake water quality for the Cerebos salt works and may give rise to human health risks. However, these will be moderated by the extreme osmotic pressures on bacteria and viruses once they are transferred into the salt works' evaporation ponds. Further, salt itself is hygroscopic and will draw water out of bacteria effectively killing them, hence its use as a food preservative. Given that upset conditions under which the modelling by PRDW (2020) was conducted should be short-term (days), it should be possible for Cerebos to reduce exposure risks by either stopping seawater withdrawal entirely during wastewater treatment plant breakdowns or only drawing feedwater from the C2 intake (Figure 6.3, PRDW 2020) into the saltworks over the breakdown period.

5.2 Discharge Scenario 2

The probable effects on biological organisms in the receiving environment for the discharges in terms of reported lowest observed effect levels outside of the 300 m radius initial mixing zone for the Scenario 2 discharges are summarized in Table 5.2. Given different combinations of effluents, constituent concentrations at the 300 m mixing zone boundary differ from those in Table 5.2.

Table 5.2: Worst case toxicity risks in the receiving environment for effluents discharged under scenario 2. Effects are assessed based on measured lowest observed effect concentrations (LOEC) in the scientific literature.

Constituent	[300m ZID Boundary]	WQG	LOEC (measured /estimate)	Comment
Salinity PSU	30.63	34-36	33-38	Physiological stress on pelagic organisms entrained in plume
TSS mg/L	85.00	< + 10%	20	Low risk on plankton entrained in plume (20% population chronically affected at 100 mg/L (Smit et al 2008)).
TAN mg/L	10.16	0.6	3.64	20-day exposure for *Sparus auratus* EC50 growth (ANZECC 2000). CCME (2010) does not recommend a guideline for marine waters!
FIB c/100 ml	12 500	500	n/a	No ecological risk, affects recreational use
COD mg/L	33.01	125	n/a	Places oxygen debt on receiving water body, low risk in open coast wave and current active areas
Sulphide mg/L	0.020	0.001	0.01	S^- Active toxicant. In oxic water ½ life ~15 minutes. At 0.2m/s current = 50% decay in 0.2 km distance.
Mercury mg/L	0.020	0.0003	0.04	Below LOEC threshold for diatoms
Cobalt mg/L	0.020	0.001	2.5	Below LOEC threshold for diatoms
Copper mg/L	0.090	0.005	0.04	Can affect diatoms, but below LOEC threshold for mysids (zooplankton) of 0.1065 mg/L
Cadmium mg/l	0.020	0.004	2.55	Below LOEC threshold for diatoms

Evaluation of the Scenario 2 discharges yields essentially similar results to those of Scenario 1; i.e. TAN may present limited ecological risk, trace metals from the WWTW 2 discharge may also along with possibly compromising aquaculture at precinct 7, and the WWTW 1 discharge under upset conditions may present some product quality risks for the Cerebos salt works. As noted above the latter risks should be avoidable.

6 SUMMARY

The two modelled discharge scenarios assessed stand-alone and combined effluent discharges. WQG compliance and toxicity risks for these are summarised below.

- For discharge scenarios 1 and 2, the modelled discharge plumes indicate that the DWAFF (1995) receiving environment WQGs will be mostly complied with at realistic mixing zone boundaries for all discharges except for the WWTW 1 and WWTW 2 wastewater treatment effluents. Exceedances of TSS, TAN, salinity, COD and trace metals are predicted to be concentrated in the nearfield of the WWTW 1 discharge but extend into the far-field for WWTW 2 (especially in the case of mercury).
- Scenario 1 brine discharge produces exceedances in salinity at the 100 m mixing zone boundary. The combined brine and finfish discharge in Scenario 2 reduces this effect but is predicted to cause elevated TAN concentrations at this and the 300 m boundary.
- In both scenarios, trace metals show high exceedances above the respective water quality guidelines. The WWTW 2 specified metal concentrations are too high to be accommodated in realistically achievable dilutions and need to be modified. Further, the specified metal and sulphide concentrations in the effluent exceed acute (lethal effect) toxicity thresholds for a wide range of marine organisms (e.g. ANZECC 2000) and can kill biota as they are entrained

into the effluent plume within the initial mixing zone. This is counter to the intent of mixing zones in marine outfalls in that toxicity levels within them should be limited to chronic effects concentrations at worst. If the WWTW 2 effluent as defined is discharged this can have negative consequences for aquaculture in precinct 7 and possibly the more distant precincts 1 and 6.

- Evaluation of predicted chronic toxicity effects from LOEC and other indicators outside of the 300 m mixing zone boundary indicate low-risk levels primarily to planktonic organisms. This is partly due to the expected short duration of exposure to toxicant concentrations above higher risk levels as the effluent plumes dilute and dissipate in far-field mixing.
- The combinations of discharges in the two scenarios show the following features:

  - **Scenario 1 Finfish and Brine** – The separated discharges generate water quality guideline exceedances outside of the 100 m initial mixing zone radius but are constrained to within the 300 m radius initial mixing zone for TAN and salinity respectively, brine less so than TAN.

  - **Scenario 2 combined Finfish and Brine** – Combining the effluents brings the brine component within the water quality guideline for salinity but extends the non-compliance for TAN. Given measured TAN toxicity, effects are predicted to be minor.

  - **Scenario 1 Cooling water 2 + Heating water 1 and Scenario 2 Cooling water 3 and Heating water 2** – Both discharges are compliant with water quality guideline for temperature, even though this is very restrictive, at the 100 m radius initial mixing zone. The Scenario 2 configuration includes brine from power plant cooling and is also compliant for salinity at this boundary. As expected from differences in effluent discharge rates the plume for the Scenario 2 configuration extends over a smaller footprint than that of Scenario 1 and, on that basis, would be the preferred option. As both options are compliant with water quality guidelines this is not justifiable from linked toxicity effects on marine organisms alone.

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