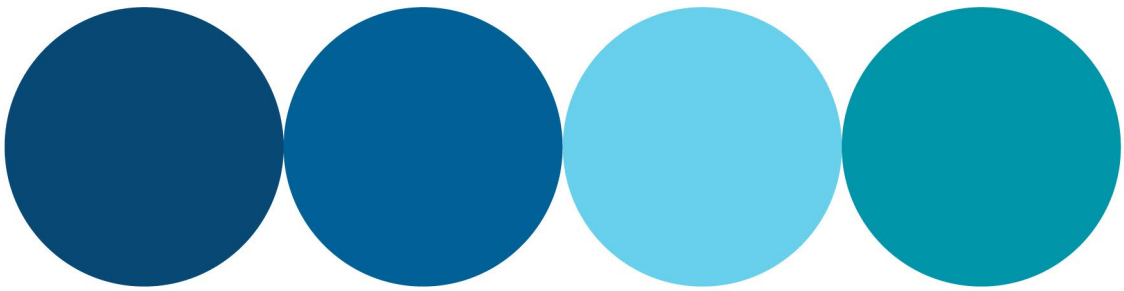
Sepia Depression Ocean Outlet Landline (SDOOL) & Perth Long-Term Ocean Outlet Monitoring Program (PLOOM)

2023–2024 Annual Report



WATER CORPORATION

Document Management

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BMT Commercial Australia Pty Ltd has prepared this report in accordance with our Integrated Management System, in compliance with ISO9001, ISO45001 and ISO14001.

Status

This report is 'Draft' until approved for final release, as indicated below by inclusion of signatures from: (i) the author and (ii) a Director of BMT Commercial Australia Pty Ltd (BMT) or their authorised delegate. A Draft report may be issued for review with intent to generate a 'Final' version, but must not be used for any other purpose.

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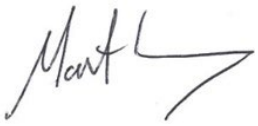


Author
Date: 19/12/2024

Contents

Acronyms

Acronym	Extension
ANZECC & ARMCANZ (2000)	Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand
CFU	Colony forming unit
CTWWC	Comprehensive Treated Wastewater Characterisation
DO	Dissolved oxygen
DoH	Western Australian Department of Health
DPIRD	Western Australia Department of Primary Industries and Regional Development
EPA	Environmental Protection Authority
EQC	Environmental Quality Criteria
EQG	Environmental Quality Guideline
EQMF	Environmental Quality Management Framework
EQO	Environmental Quality Objective
EQS	Environmental Quality Standard
EV	Environmental Value
HEPA	High Ecological Protection Area
LAC	Light attenuation coefficient
LEPA	Low Ecological Protection Area
LoR	Limit of reporting
EMMP	Environmental Monitoring and Management Plan
MMP	Monitoring and Management Plan
MPN	Most probable number
NATA	National Association of Testing Authorities
NOEC	No Observed Effect Concentration
OZI	Observed Zone of Influence
PLOOM	Perth Long-Term Ocean Outlet Monitoring
SDOOL	Sepia Depression Ocean Outlet Landline
SHEZ	Shellfish Harvesting Exclusion Zone
TCM	Trial Compliance Monitoring
TTC	Thermotolerant coliforms
TTM	Total toxicity of the mixture
TWW	Treated wastewater
WASQAP	Western Australian Shellfish Quality Assurance Program
WET	Whole of effluent toxicity
WRRF	Water Resource Recovery Facility
WWTP	Wastewater Treatment Plant

What do the results in this report mean for our community?

Ocean discharge is practiced worldwide and is safe, sustainable and cost effective way to dispose of wastewater. Treated Wastewater from Perth's Water Resource Recovery Facilities (WRRFs) are discharged to the ocean via ocean outlets, and is diluted through a number of physical and chemical processes. It is lighter and lower in density, so it rises and mixes with seawater, diluting wastewater. Ocean outlet activities are regulated by the Department of Water and Environmental Regulation.

Water Corporation discharges treated wastewater from the Woodman Point and East Rockingham WRRFs, the Point Peron Wastewater Treatment Plant, The Kwinana Water Reclamation Plant and industry to the ocean via the Sepia Depression ocean outlet pipeline. The Environmental Protection Authority (EPA); an independent authority appointed by the Governor on the recommendation of the Minister for Environment) has designated an area with a radius of 100 metres as a Low Ecological Protection Area (or LEPA). Within this area, the EPA allows for changes to marine water quality. Outside the LEPA, the EPA has designated the surrounding ocean to be a High Ecological Protection Area (HEPA) and expects there to be no detectable change in marine water quality.

Water Corporation undertakes investigations to test that water quality has returned to within the natural range expected in the HEPA and protect the environment and recreational users (swimmers, boaters and fishers). Water samples are collected within the LEPA, at the boundary of the LEPA and the HEPA, and at reference sites selected to be as similar as possible to the waters around the outlets. Results from the monitoring are compared against nationally agreed criteria. There are two levels of criteria - a simple, conservative early warning trigger (Environmental Quality Guideline or EQG) and a more detailed, complicated assessment of potential impacts (Environmental Quality Standard or EQS). The Perth Long-term Ocean Outlet Monitoring (PLOOM) program and the Sepia Depression Ocean Outlet Landline (SDOOL) Monitoring Program comprises of these investigations.

This annual report documents the findings of the 2023-2024 Sepia Depression monitoring as part of the PLOOM/SDOOL program. The compliance results for 2023-2024 are summarised in Report Card format are summarised in report card format. The report card contains colour-coded results with the individual colours representing the extent to which the Environmental Quality Criteria (EQC) were met.

Summary report card legend

Management response	Colour
Monitor: EQG & EQS met (continue monitoring)	
Investigate: EQG not met (investigate against the EQS)	
Action: EQS not met (management response required)	

Note:

1. The required response following an exceedance of either the Environmental Quality Guideline (EQG) or Environmental Quality Standard (EQS) is shown in parentheses.

Summary of key indicators

Ecosystem integrity

Ecosystem Integrity aims to protect the ecosystem from potential impacts from the discharge and maintain the variety and quantity of marine life at a high level. The top indicators we look at that give us an understanding of this are as follows:

Indicator	Indicator purpose	Result	Commentary
Toxicants in treated wastewater (TWW)			
Bioaccumulating toxicants	Cadmium and mercury are toxicants that can build up in the tissues of marine organisms and contaminate seafood. The concentration of these toxicants are measured in undiluted TWW against national guidelines that are designed to protect marine life.		Concentrations of cadmium and mercury were below the national guideline values.
Non-bioaccumulating toxicants	Some contaminants commonly discharged with domestic wastewater (e.g. detergents, metals and oils) may find their way into treated wastewater and monitoring ensures they are not directly toxic or likely to accumulate in marine life. Wastewater was screened for toxic substances and the concentrations were below the early warning EQG.		Concentrations of toxicants were below the national guideline values.
Total toxicity of the mixture (TTM)	TTM measures the potential for a combined, or cumulative, effect of ammonia, copper and zinc in the TWW after it has been diluted into the ocean. It is used as an additional interpretative tool for estimating the potential toxicity of TWW.		The total toxicity of the mixture was below the national guideline value
Whole of effluent toxicity (WET) testing	WET testing is another tool to test the potential toxicity of the TWW to marine life. WET testing is particularly useful for toxicants that occur in very low concentrations, or for which there are no national guidelines on safe levels. Direct tests on organisms determine the actual toxicity of the wastewater demonstrate that the discharge is not harmful to the ocean environment.		The TWW plume is sufficiently diluted to achieve the No Ecological Effects Concentration at the management boundary.
Nutrient enrichment and phytoplankton blooms			
Chlorophyll-*a*	Phytoplankton are a naturally occurring part of the marine environment, but treated wastewater contains nutrients (ammonia, nitrite, nitrate and orthophosphate) that can stimulate		Chlorophyll–a concentration outside the immediate area around the Sepia Depression outlet met the early warning EQG triggers and was similar to the reference sites. Phytoplankton

Indicator	Indicator purpose	Result	Commentary
	phytoplankton growth. Chlorophyll-*a* (the active constituent in phytoplankton) concentration is used as an indicator for phytoplankton abundance.		were not increased by nutrients in the wastewater.
Light attenuation coefficient	Increased phytoplankton can also block (attenuate) light from reaching the bottom (impacting seagrass and macroalgae).		Light attenuation outside the direct vicinity of the outlet met the early warning EQG. Light transmission to the sea floor was not reduced.
Physical & chemical stressors			
Organic enrichment	Organic matter in treated wastewater is naturally decomposed by bacteria. Oxygen dissolved in water is used by the bacteria during the decomposition process. If the bacteria use more dissolved oxygen (DO) than they produce, the DO levels fall. Low DO levels can be harmful to marine life. We measure the dissolved oxygen concentration against the Environmental Protection Authority (EPA) guidelines.		The amount of DO was high at all times and at all locations near the outlet. DO levels near the outlet were similar to those at the reference sites. There was a very low risk of DO levels falling below critical levels.
Salinity	Salinity refers to the 'saltiness' of water. Treated wastewater is fresh whereas the ocean is saline. When treated wastewater is discharged to the ocean, salinity will be reduced in an area around the outlet until the fresher water is fully mixed with the saline seawater. Low salinity water may cause stress to marine life.		Freshwater was detected at the site nearest the outlet within the HEPA and the early warning EQG was not met. There were no subsequent deaths of marine organisms and the EQS was met

Seafood safe for human consumption

Seafood safe for human consumption aims to ensure that caught or grown seafood remains safe for eating. The top indicators we look at that give us an understanding of this are as follows:

Indicator	Indicator purpose	Result	Commentary
Microbial contaminants			
Thermotolerant coliforms (TTC) near the outlets	The risk from bacteria to seafood safety is assessed using the indicator organism thermotolerant coliforms.		The relevant concentrations of thermotolerant coliforms near the outlet and adjacent the beaches were below the level where they can be detected by the laboratory. The risk to public health from bacteria via seafood in the vicinity of the outfalls was very low.
Shoreline TTC			
Algal biotoxins			
Toxic phytoplankton species	In some cases, phytoplankton can contain species than can taint seafood.		Densities of potentially toxic phytoplankton species were below levels that would pose a risk to seafood.

Primary and secondary contact recreation

Primary and secondary contact recreation aims to ensure that water quality is suitable for primary (e.g. swimming and diving) and secondary (e.g. fishing and boating) recreation contact activities. The top indicators we look at that give us an understanding of this are as follows:

Indicator	Indicator purpose	Result	Commentary
Faecal pathogens			
Enterococci spp. at the outlets	The risk from bacteria to recreation contact (swimming and boating) is assessed using the indicator organism *Enterococci* spp.		*Enterococci* exceeded both the early warning EQG trigger and the more vigorous EQS criteria near the outlet. Concentrations met the EQG near the shoreline.
Shoreline *Enterococci* spp.			
New nationally agreed triggers were introduced in 2013/14. The new triggers are aspirational (i.e. a goal to be achieved as specified in ANZG 2018). The historical discharge footprint from Sepia Depression is unchanged and there has been no increased risk to public health.			
Algal biotoxins			
Phytoplankton cell concentration	In some cases, phytoplankton can reach concentrations that may harm swimmers (called blooms). The level that defines an algal bloom for recreational purposes is a phytoplankton cell count exceeding 10,000 cells/mL.		The chlorophyll-*a* based guidelines for phytoplankton are well below a level that would be visible as an algal bloom. The highest total phytoplankton cell concentration in the HEPA was 457 cells/mL. There were no

			phytoplankton blooms during the monitoring period

Aesthetics

Aesthetics aims to ensure that aesthetic values of the marine environment are protected. The top indicators we look at that give us an understanding of this are as follows:

Indicators	Indicator purpose	Result	Commentary
Aesthetic factors	Perth's coastal waters are aesthetically pleasing, and that aesthetic value needs to be protected. Nuisance organisms (macrophytes, scums, algal mats, blue-green algae and fungus), dead organisms, dirty water, oily films, debris or objectionable odours have the potential to reduce the aesthetic appeal.		Aesthetic values of Perth coastal waters were maintained and protected.

For further results please refer to the full report below.

Executive Summary

This report documents the findings of the 2023–2024 Sepia Depression Ocean Outlet Landline (SDOOL) Monitoring and Management Plan (MMP; BMT Oceanica 2014) within the Perth Long-Term Ocean Outlet Monitoring (PLOOM) Program, fulfilling Commitment no. 4 of the Ministerial Statement 665. The report outlines the findings of three environmental monitoring programs:

- Compliance Monitoring
- Whole of Effluent Toxicity (WET) testing
- Comprehensive Treated Wastewater Characterisation (CTWWC)

Results are reported in the context of the Environmental Quality Management Framework (EQMF) described in EPA (2017). Under the EQMF, Water Corporation should annually to demonstrate achievement against Environmental Quality Objectives (EQOs):

- Maintenance of Ecosystem Integrity
- Maintenance of Seafood Safe for Human Consumption
- Maintenance of Primary and Secondary Recreation
- Maintenance of Aesthetic Values.

The results are summarised in Report Card format (Table ES 1). The report card contains colour-coded results, with the individual colours representing the extent to which the Environmental Quality Criteria (EQC) were met (Table ES 2 to 4)

Table ES 1 Summary report card legend

Management response	Colour
Monitor: EQG & EQS met (continue monitoring)	
Investigate: EQG not met (investigate against the EQS)	
Action: EQS not met (management response required)	

Note:

1. The required response following an exceedance of either the Environmental Quality Guideline (EQG) or Environmental Quality Standard (EQS) is shown in parentheses.

Environmental Quality Objective 'Maintenance of Ecosystem Integrity'

There are several EQC relevant to the 'Environmental Quality Objective (EQO) Maintenance of Ecosystem Integrity': the first are assessed based on in-line measurements of the constituents of the treated wastewater (TWW) stream and its potential toxicity, while the remainder are based on in-situ monitoring (water column nutrients, phytoplankton abundance and physical-chemical stressors) of the receiving environment.

Toxicants in treated wastewater

There are four Environmental Quality Guidelines (EQGs) for TWW toxicants:

- Concentrations of bioaccumulating toxicants (specifically, cadmium and mercury) must be below their respective ANZECC & ARMCANZ (2000) 80% species protection guidelines prior to discharge and dilution with seawater.

Concentrations of bioaccumulating toxicants were below their laboratory limits of reporting and the 80% species protection guidelines in all cases, thus meeting the EQG.

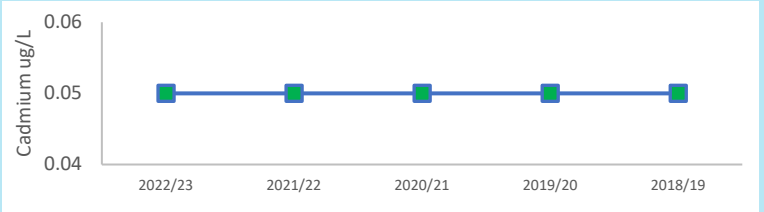
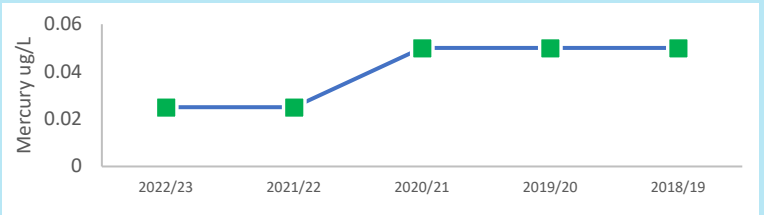
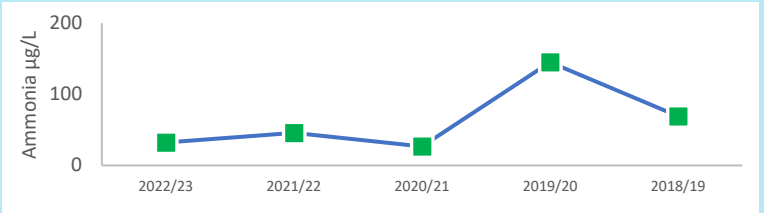
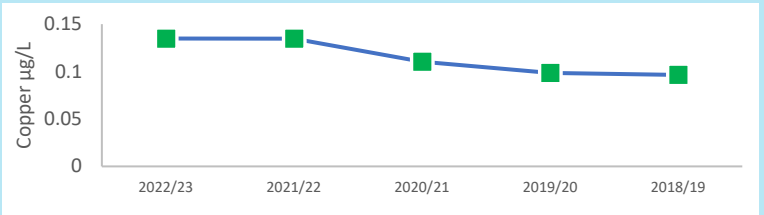
- Concentrations of non-bioaccumulating contaminants must not exceed their ANZECC & ARMCANZ (2000) 99% species protection guideline at the Low Ecological Protection Area (hereafter LEPA) boundary, 100 m radius from the diffuser. Concentrations of non-bioaccumulating toxicants were below their ANZECC & ARMCANZ (2000) criteria scaled based on 5th percentile dilution at the LEPA boundary (as per the EQG BMT Oceanica 2014), thus meeting the EQG (Table ES 2).
- The total toxicity of the mixture (TTM) for the additive effect of ammonia, copper, and zinc in the diluted TWW plume must be less than the guideline of 1.0 (BMT Oceanica 2014; ANZECC & ARMCANZ 2000). The TTM following initial dilution was 0.6, which is lower than the guideline and the EQG was met.
- The highest concentration of TWW at which there is no statistically significant observed effect on fertilisation of sea urchin gametes exposed to different concentrations of TWW (No Observed Effect Concentration [NOEC]) must be greater than 1.0% TWW concentration. The lowest NOEC from tests undertaken in July 2023, October 2023, January 2024 and April 2024 was 3.1% and the EQG was met (Table ES 2).

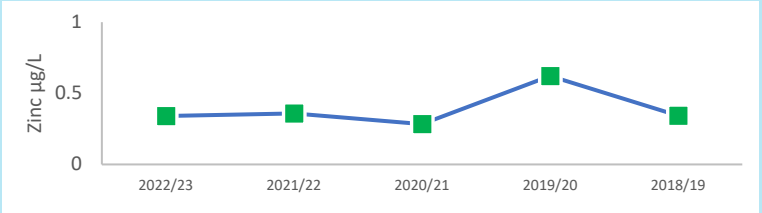
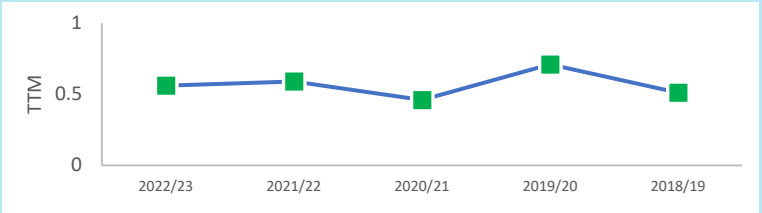
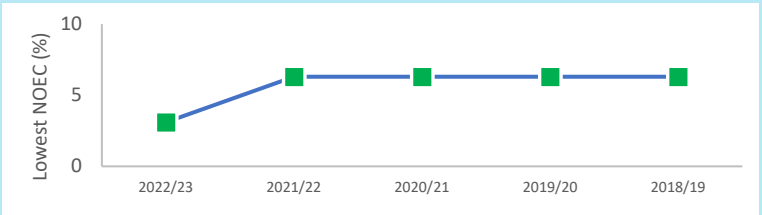
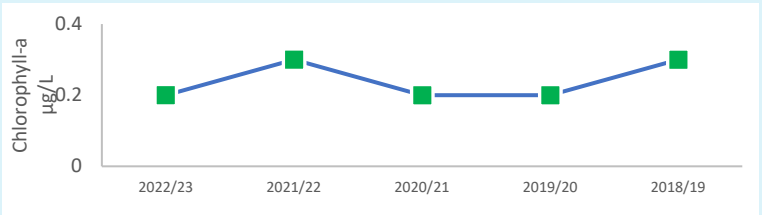
Water quality monitoring – receiving environment

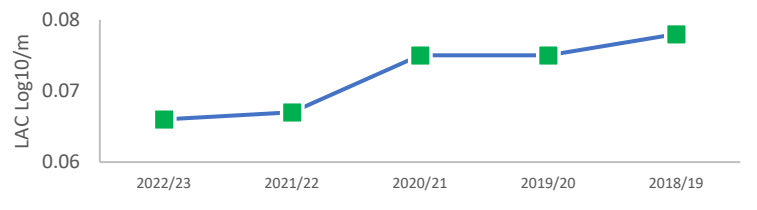
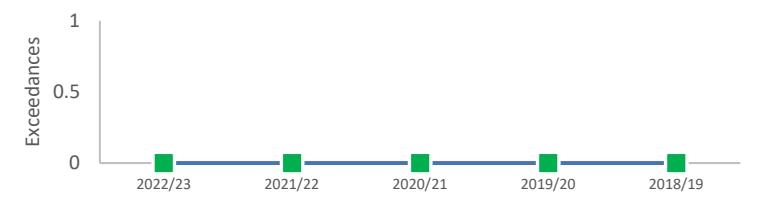
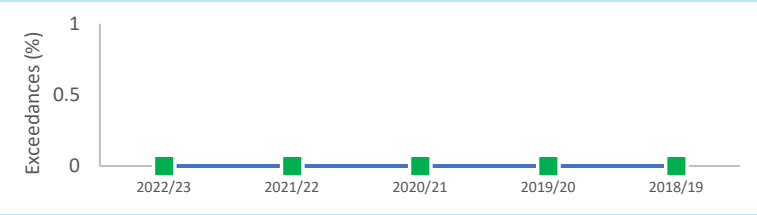
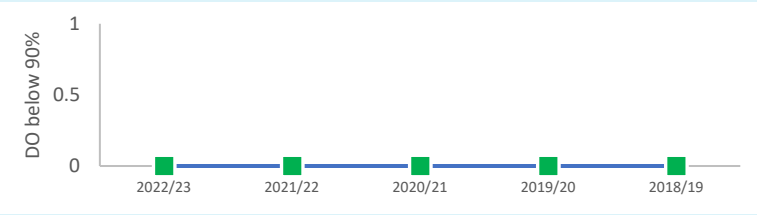
Ocean sampling was conducted fortnightly between December 2023 and March 2024 at fixed distance intervals down-current (determined using a drogue) of the TWW ocean outlet. There are six EQGs based on chlorophyll–a concentration (a measure of phytoplankton biomass), water temperature, salinity, dissolved oxygen and light attenuation coefficient:

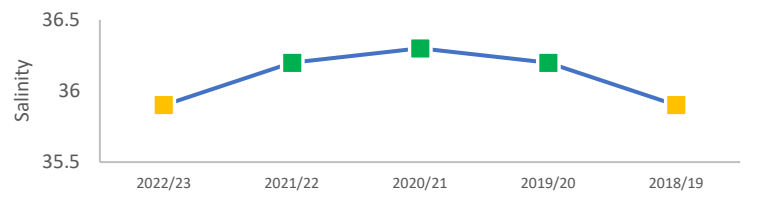
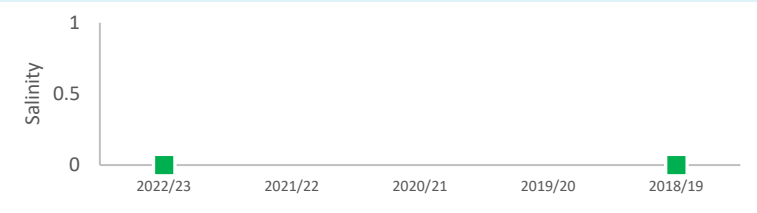
- The median chlorophyll–a concentration in the High Ecological Protection Area (HEPA; i.e. 100 m and greater from the diffuser) during the non-river flow period must not exceed the 80th percentile of historical reference site data. Median chlorophyll–a concentration within the HEPA (0.3 µg/L) was below the 80th percentile of historical reference site concentrations (0.4 µg/L) and the EQG was met.
- The median light attenuation coefficient (LAC) in the HEPA must not exceed the 80th percentile of historical reference site data. Median LAC within the HEPA (0.075 Log_{10}/m) was lower than the 80th percentile of historical reference sites (0.079 Log_{10}/m) and the EQG was met.
- Median phytoplankton biomass, measured as chlorophyll–a must not exceed three times the median chlorophyll-a concentration of historical reference sites, on any occasion. Median chlorophyll–a concentrations did not exceed three times the median of reference sites on any occasion during the summer monitoring period and the EQG was met.
- Phytoplankton biomass measured as chlorophyll–a at any site must not exceed three times the median chlorophyll–a concentration of historical reference sites, on 25% or more occasions. Median phytoplankton biomass measured as chlorophyll–a did not exceed three times the median of reference sites, on any sampling occasion during the summer monitoring period and the EQG was met.
- Median dissolved oxygen in bottom waters (0–0.5 m above the seabed) in the HEPA must be greater than 90% saturation at any site for a defined period of not more than 6 weeks. Dissolved oxygen saturation within the HEPA was above 90% saturation at all times and the EQG was met.
- Median salinity (0.5 m below the water surface) at an individual site over any period is not to deviate beyond the 20th and 80th percentile of natural salinity range over the same period. Median salinity was below the 20th percentile of the natural salinity range at the 100 m site within the HEPA and the EQG was not met, triggering assessment against the EQS.
  - There were no reports of deaths of marine organisms resulting from anthropogenically sourced salinity stress, thus the EQS was met

Table ES 2 Summary report card for the Environmental Quality Objective 'Maintenance of Ecosystem Integrity'

Environmental quality indicator		EQC	Comments	Compliance	Previous five years (2018-2019 to 2022-2023)
Toxicants in treated wastewater (TWW)	Bioaccumulating toxicants	EQG	Concentrations of cadmium and mercury in the undiluted TWW sample were below the ANZECC & ARMCANZ (2000) 80% species protection guideline.		 
	Non-bioaccumulating toxicants and initial dilution	EQG	Contaminant concentrations were lower than the ANZECC & ARMCANZ (2000) 99% species protection guidelines after dilution equivalent to that expected at the Low Ecological Protection Area boundary.		 

Environmental quality indicator		EQC	Comments	Compliance	Previous five years (2018-2019 to 2022-2023)
					
	Total toxicity of the mixture (TTM)	EQG	The TTM for the additive effect of ammonia, copper, and zinc after initial dilution (0.6) was below the ANZECC & ARMCANZ (2000) guideline value of 1.0.		
	Whole of effluent toxicity testing	EQG	The lowest No Observed Effect Concentration from tests undertaken in July 2023, October 2023, January 2024 and April 2024 (3.1%) was >1%.		
Nutrient enrichment	Chlorophyll–a	EQG	The median chlorophyll–a concentration in the Sepia Depression High Ecological Protection Area (HEPA; ≥100 m) was 0.3 µg/L and below the 80th percentile of historical reference site data (0.4 µg/L).		

Environmental quality indicator		EQC	Comments	Compliance	Previous five years (2018-2019 to 2022-2023)
	Light attenuation coefficient (LAC)	EQG	The median LAC in the Sepia Depression HEPA (≥100 m) was 0.075 Log_{10}/m and was lower than the 80th percentile of historical reference site data (0.079 Log_{10}/m).		
Phytoplankton blooms	Phytoplankton biomass (measured as chlorophyll–a)	EQG	Median chlorophyll–a concentration within the HEPA did not exceed three times the median of historical reference sites (0.60 µg/L) on any sampling occasion.		
			Median phytoplankton biomass measured as chlorophyll–a did not exceed three times the median of reference sites, at any site or on any sampling occasion during the summer monitoring period.		
Physical chemical stressors	Organic enrichment	EQG	Bottom water (0–0.5 m) DO saturation in the Sepia Depression HEPA were >90% at all times throughout the summer survey period.		

Environmental quality indicator		EQC	Comments	Compliance	Previous five years (2018-2019 to 2022-2023)
	Salinity	EQG	Median salinity was below the 20th percentile of the natural salinity range at the 100 m site within the HEPA, and the EQG was not met triggering assessment against the EQS.		
		EQS	There were no reports of deaths of marine organisms resulting from anthropogenically sourced salinity stress.		

Notes:

1. Environmental Quality Criteria (EQC): Green (■) symbols indicate the Environmental Quality Guideline (EQG) was met; amber (■) and red (■) symbols represent an exceedance of the EQG or Environmental Quality Standard (EQS), respectively.
2. LEPA = Low Ecological Protection Area; HEPA = High Ecological Protection Area; LAC – light attenuation coefficient; NOEC = no observed effect concentration; the highest concentration of treated wastewater at which there is no statistically significant observed effect on gamete fertilisation.

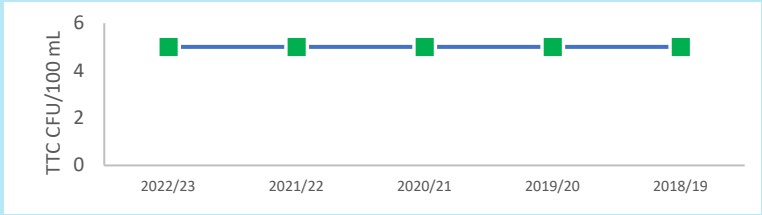
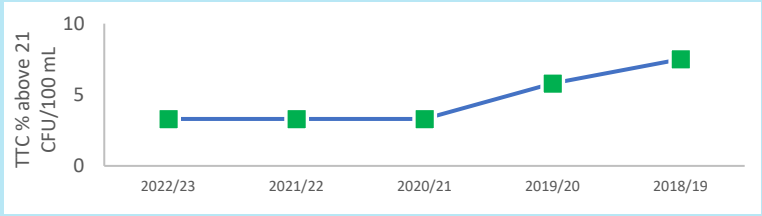
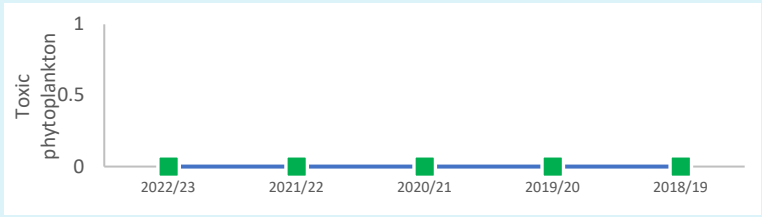
Environmental Quality Objective ‘Maintenance of Seafood Safe for Human Consumption’

There are two EQC for the EQO 'Maintenance of the Seafood for Human Consumption': the first is based on in-water concentrations of thermotolerant coliforms (TTC), and the second is based on in-water concentrations of toxic phytoplankton species (to monitor for algal biotoxins):

- To meet the first EQG, median TTC concentrations at sites at the boundary of the Shellfish Harvesting Exclusion Zone (SHEZ) are not to exceed 14 CFU/100 mL with no more than 10% of the samples exceeding 21 CFU/100 mL. The median TTC concentration pooled from three sampling seasons (2021–22, 2022–23 and 2023–24) required to achieve a suitable sample size (EPA 2005)[1] was at the limit of detection (<10 CFU/100 mL) and below 14 CFU/100 mL. There were 4 instances where TTC exceeded 21 CFU/100 mL, representing 3.3% of samples. The EQG for TTC was met (Table ES 3).
- To meet the second EQG, concentrations of potentially toxic algae at sites at the boundary of the SHEZ must not exceed the Western Australian Shellfish Quality Assurance Program (WASQAP; DoH, DPIRD and Industry 2020) concentrations. Densities of toxic phytoplankton were below relevant WASQP guidelines meeting the EQG for toxic phytoplankton species (Table ES 3).

[1] *NHMRC (2008) guidelines and EPA (2005) suggest that a minimum of 100 samples over the non-river flow period (pooled from multiple years if required) are needed for accurate assessment of microbial water quality EQC.*

Table ES 3 Summary report card for the Environmental Quality Objective 'Maintenance of Seafood for Human Consumption

Environmental quality indicator		EQC	Comments	Compliance	Previous five years (2018-2019 to 2022-2023)
Microbial contaminants	Thermotolerant coliforms (TTC)	EQG	Median TTC concentrations derived from120 samples collected over the 2021–2022, 2022–2023 and 2023–2024 sampling seasons was at the limit of detection (<10 CFU/100 mL) and did not exceed the 14 CFU/100 mL criteria.	■	
		EQG	Less than 10% of the samples exceeded the 21 CFU/100 mL criteria with only 4 samples (3.3%) having exceeded.		
Algal biotoxins	Toxic phytoplankton species	EQG	There were no recorded instances of toxic phytoplankton species exceeding the Western Australian Shellfish Quality Guidelines during the 2023–2024 monitoring period.	■	

Notes:

1. Green (■) symbols indicate the Environmental Quality Guideline (EQG) was met; amber (■) and red (■) symbols represent an EQG or Environmental Quality Standard (EQS), respectively.
2. TTC results below the analytical detection limit (<10 CFU/mL) were halved (=5 CFU/mL) to calculate median concentrations (ANZECC & ARMCANZ 2000).
3. TTC = Thermotolerant coliforms, CFU = colony forming units.

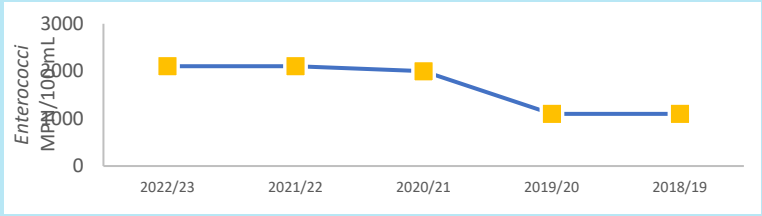
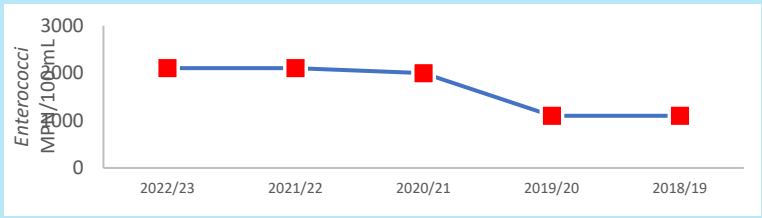
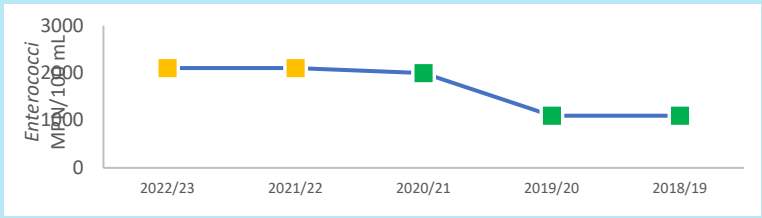
Environmental Quality Objective 'Maintenance of Primary and Secondary Recreation'

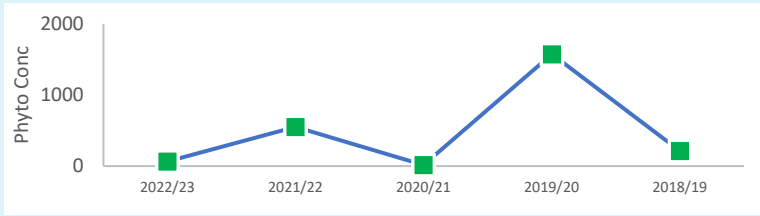
There are two EQC for the EQO 'Maintenance of Primary and Secondary Recreation': the first is based on in-water concentrations of faecal pathogens (*Enterococci* spp.), and the second is based on in-water measures of total phytoplankton cell densities.

- To meet the first EQG, the 95th percentile of faecal pathogens (*Enterococci* spp.) concentrations outside the Recreation Contact Area must not exceed 200 MPN/100 mL and 2000 MPN/100 mL for primary and secondary contact recreation, respectively. The 95th percentile of *Enterococci* spp. concentrations based on pooled data from three sampling seasons (2021–2022, 2022–2023 and 2023–2024) was 1900 MPN/100 mL exceeding the primary contact recreation EQG but meeting the EQG for secondary contact recreation:
  - The 95th percentile of *Enterococci* spp. concentrations based on pooled data from three sampling seasons (2021–2022, 2022–2023 and 2023–2024) (1900 MPN/100 mL) exceeded 500 MPN/100 mL exceeding the primary contact recreation EQS.
- To meet the second EQG, median total phytoplankton cell concentrations for the Recreation Contact Area should not exceed 15 000 cells/mL. The median total phytoplankton cell concentration was 36 cells/mL and the EQG was met.

Prior to 2013/14, primary contact recreation had been managed (albeit informally) against the ANZECC (1992) criteria (median *Enterococci spp*. concentrations <35 MPN/100 mL). Development of the MMP formalised the monitoring regime and updated the approach to the contemporary and best practice EQMF including adopting the EPA (2005) criteria (the 95th percentile *Enterococci* spp. concentration <200 MPN/100 mL). The informal management boundaries that applied historically were not altered accordingly and exceedance of the EPA (2017) recreational contact criteria is an artefact of the change of criteria. The historical discharge footprint is unchanged, and the exceedances are not indicative of an increased risk to EQO. Water Corporation have reported and manage these exceedances on consultation with the Department of Health.

Table ES 4 Summary report card for the Environmental Quality Objective 'Maintenance of Primary and Secondary Contact Recreation'

Environmental Quality Indicator		EQC	Comments	Compliance	Previous five years (2018-2019 to 2022-2023)
Faecal pathogens	*Enterococci* spp.	EQG (primary contact; 200 MPN/100 mL)	The 95th percentile of *Enterococci* spp. concentrations (1900 MPN/100 mL) exceeded the 200 MPN/100 mL EQG criteria.		
		EQS (primary contact; 500 MPN/100 mL)	The 95th percentile of *Enterococci* spp. concentrations (1900 MPN/100 mL) exceeded the 500 MPN/100 mL EQS criteria.		
		EQG (secondary contact; 2000 MPN/100 mL)	The 95th percentile of *Enterococci* spp. concentrations (1900 MPN/100 mL) was lower than the 2000 MPN/100 mL EQG criteria.		

Environmental Quality Indicator		EQC	Comments	Compliance	Previous five years (2018-2019 to 2022-2023)
Algal biotoxins	Phytoplankton (cell concentration)	EQG (15 000 cells/mL)	Median total phytoplankton cell concentration (36 cell/mL) in the area of concern did not exceed 15 000 cells/mL.	■	

Note:

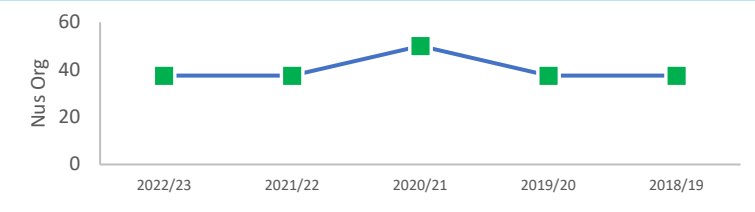
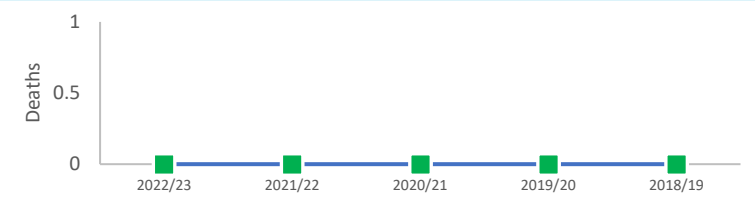
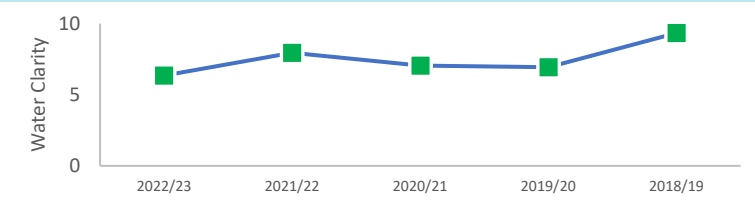
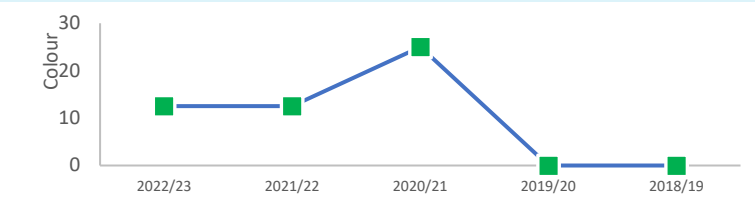
1. Green (■) symbols indicate the Environmental Quality Guideline (EQG) was met; amber (■) and red (■) symbols represent an exceedance of the EQG or Environmental Quality Standard (EQS), respectively.

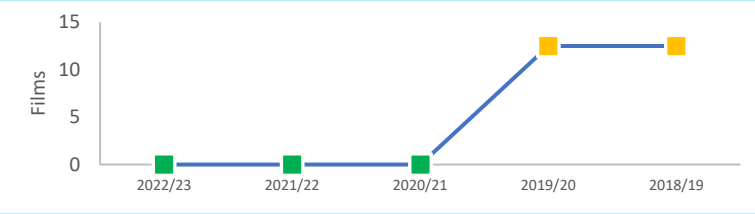
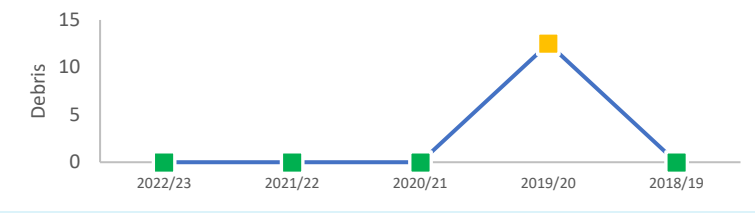
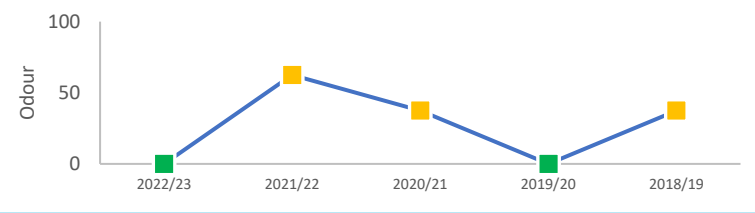
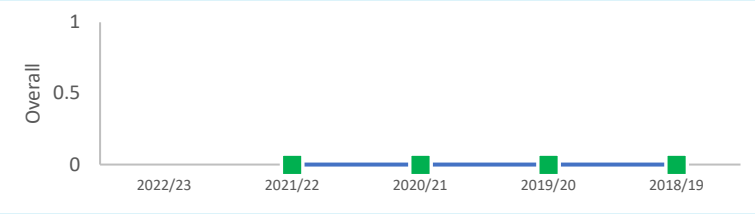
Environmental Quality Objective 'Maintenance of Aesthetic Values'

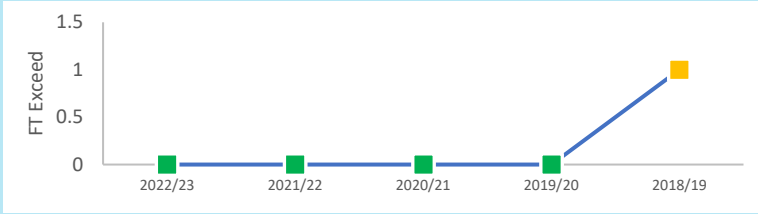
The EQO for the Environmental Value 'Recreation and Aesthetics' is to ensure that the aesthetics of Perth's coastal waters are maintained and that the aesthetic values are protected. There are a series of EQGs that ensure this EQO is met:

- Macrophytes, phytoplankton scums, filamentous algal mats, blue-green algae and sewage fungus should not be present in excessive amounts. Macrophytes were observed during sampling occasions but were not present in excessive amounts and the EQG was met (Table ES 5).
- There should be no reported incidents of large-scale deaths of marine organisms relating from unnatural causes. There were no instances of dead marine organism observed during sampling occasions and the EQG was met (Table ES 5).
- The natural visual clarity of the water should not be reduced by more than 20%. Measurements of light attenuation determined that the natural visual clarity of the water was reduced by ~13.5% (i.e. <20%) and the EQG was met (Table ES 5).
- The natural hue of the water should not be changed by more than ten points on the Munsell scale. There was noticeable colour variation on 1 sampling occasion but overall, not changed by ten points on the Munsell scale over the long-term and the EQG was met (Table ES 5).
- Oil and petrochemicals should not be noticeable as a visible film on the water or detectable by odour. No surface films or oil were recorded on any sampling occasion and the EQG was met (Table ES 5).
- Water surfaces should be free of floating debris, dust and other objectionable matter, including substances that cause foaming. No floating debris or matter was visible on the surface on any sampling occasion and the EQG was met (Table ES 5).
- There should be no objectionable odour. There was a noticeable odour on 37.5% of the sampling occasions and the EQG was not met (Table ES 5).
  - There were no reported complaints of a decrease in the aesthetic water quality values and the EQS was met.
- Fish tainting substances in the comprehensive TWW characterisation sample collected on 15 January 2024 did not exceed the EPA (2017) aesthetic guidelines for fish tainting substances (Table ES 5).

Table ES 5 Summary report card for the Environmental Quality Objective 'Maintenance of Aesthetic Values'

Environmental Quality Indicator	EQC	Comments	Compliance[1]	Previous five years (2018-2019 to 2022-2023)
Nuisance organisms	EQG	Macrophytes were observed but were not present in excessive amounts.		
Faunal deaths	EQG	There were no instances of dead marine organism observed.		
Water clarity	EQG	Measurements of light attenuation determined that the natural visual clarity of the water was reduced by <20% (~13.5%).		
Colour	EQG	There was noticeable colour variation on 1 sampling occasion but overall, not changed by ten points on the Munsell scale over the long-term.		

Environmental Quality Indicator	EQC	Comments	Compliance[1]	Previous five years (2018-2019 to 2022-2023)
Surface films	EQG	No surface films or oil were recorded on any sampling event.		
Surface debris	EQG	No floating debris or matter was visible on the surface on any sampling occasion.		
Odour	EQG	There was a noticeable odour on 37.5% of the sampling occasions.		
Odour	EQS	There were no reported complaints of a decrease in the aesthetic water quality values.		

Environmental Quality Indicator	EQC	Comments	Compliance[1]	Previous five years (2018-2019 to 2022-2023)
Fish tainting substances	EQG	Fish tainting substances in the comprehensive treated wastewater characterisation sample collected on 15 January 2024 did not exceed the EPA (2017) aesthetic guidelines for fish tainting substances.	■	

Note:

1. Green (■) symbols indicate the Environmental Quality Guideline (EQG) was met; amber (■) and red (■) symbols represent an exceedance of the EQG or Environmental Quality Standard (EQS), respectively.

1 Introduction

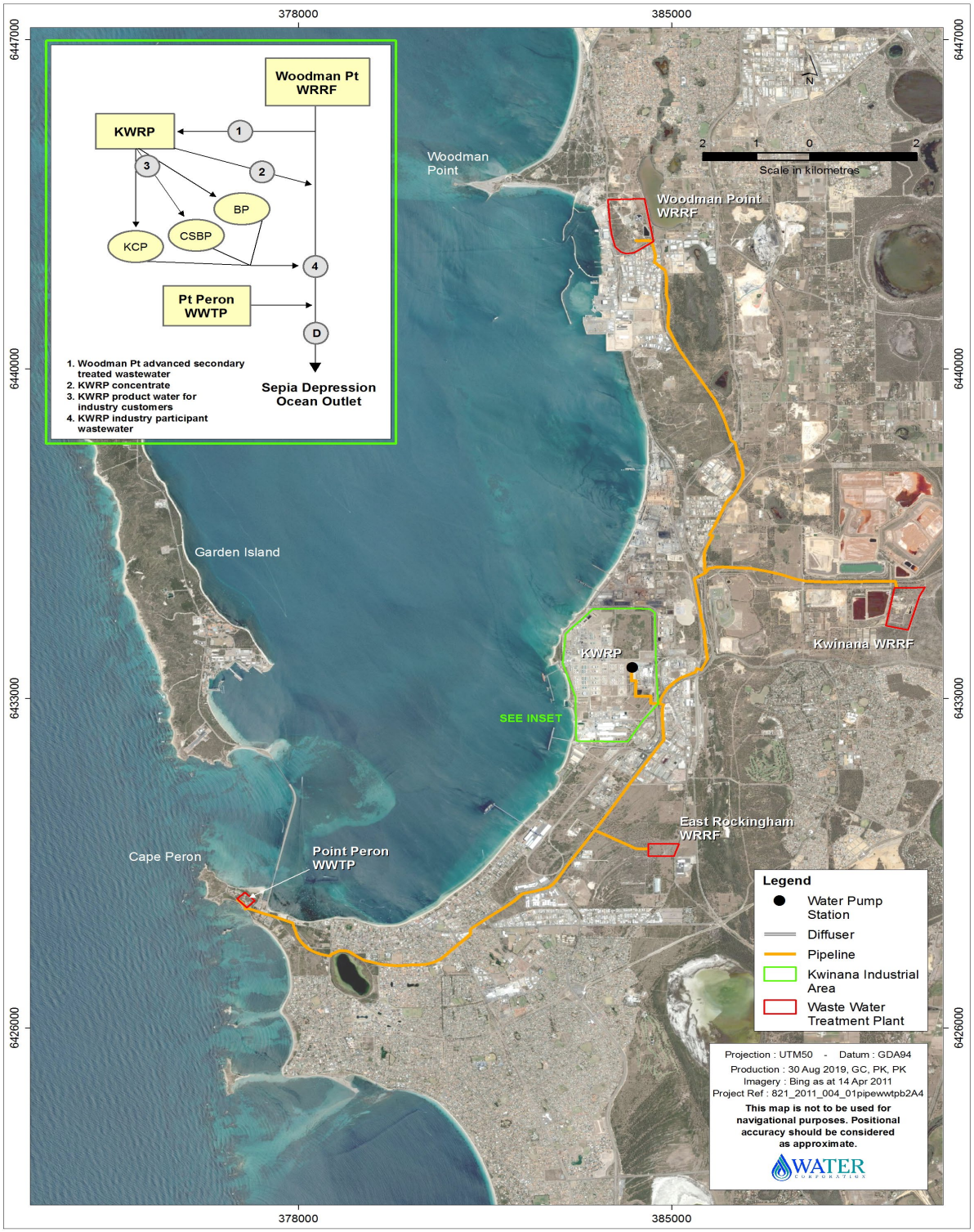
1.1 Document purpose

This annual report documents the findings of the 2023–2024 ocean monitoring around the Sepia Depression ocean outlet. Monitoring was completed according to the Sepia Depression Ocean Outlet Landline (SDOOL) Monitoring and Management Plan (SDOOL MMP; BMT Oceanica 2014).

1.2 Wastewater treatment plant infrastructure and discharge

Treated wastewater (TWW) discharged through the Sepia Depression ocean outlet comes from the Woodman Point Water Resource Recovery Facility (WRRF), East Rockingham WRRF, Kwinana WRRF, Point Peron Wastewater Treatment Plant (WWTP), and the Kwinana Water Reclamation Plant (KWRP) (Figure 1). Most TWW discharged to the Sepia Depression is from the Woodman Point WRRF.

The Woodman Point WRRF services the southern Perth metropolitan area and receives predominantly domestic wastewater (from kitchen, bathroom, toilet and laundry uses), with ~8% received from light industrial wastewater. A small volume of primary TWW is discharged from the Point Peron WWTP, located downstream of the Woodman Point WRRF (Figure 1). The KWRP processes secondary TWW from the Woodman Point WRRF to a quality suitable for use as high-grade industrial processing water by industries in the Kwinana industrial area. This high-grade industrial water is supplied to industry participants to reduce consumption of potable scheme water. The KWRP process concentrate is disposed of via the SDOOL (refer to Figure 1).

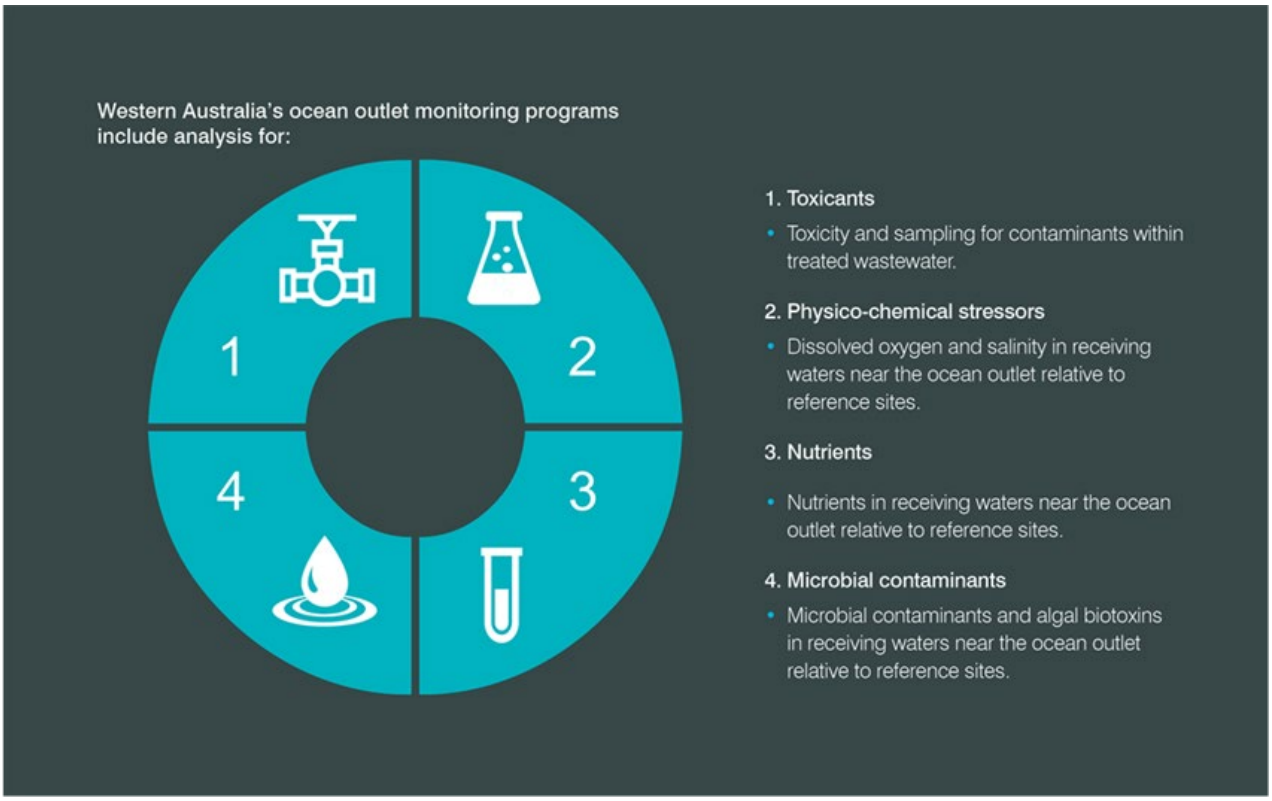


Notes:

1. WWTP = wastewater treatment plant; WRRP = Water Resource Recovery Facility; KWRP = Kwinana Water Reclamation Plant; BP = BP Refinery; KCP = Kwinana Cogeneration Plant; CSBP = CSBP Limited
2. Point D is the composite treated wastewater sample point prior to discharge.

Figure 1 Location of Sepia Depression Ocean Outlet Landline (SDOOL) and contributing waste streams

1.3 Potential stressors in treated wastewater



1.3.1 Toxicants

Metals and persistent organic compounds may be toxic to marine species or accumulate in biota at concentrations sufficient to pose a risk to human health when consumed. TWW is screened for bioaccumulating and non-bioaccumulating toxicants prior to discharge. To account for the synergistic effect of multiple toxicants and toxicants without guidelines, the overall toxicity of the discharge is determined using whole of effluent toxicity (WET) testing (also known as direct toxicity assessment).

1.3.2 Physico-chemical stressors

TWW contains organic matter, the decomposition of which by microorganisms uses oxygen. If more dissolved oxygen (DO) is consumed than is produced, DO levels decline. DO saturation in receiving waters near the outfalls provides an indication of the risk posed by deoxygenation.

Reduced salinity near the outfalls, resulting from freshwater in the TWW plume, may cause osmotic stress in marine biota. Salinity in receiving waters near the outfalls is compared to the salinity at appropriate reference sites to determine whether salinity near the outfalls is within the range of natural variability.

1.3.3 Nutrients

TWW contains elevated concentrations of the biologically available nutrients, ammonia, nitrite, nitrate and orthophosphate. At times, the addition of nutrients may stimulate phytoplankton growth beyond natural levels, which can lead to shading of photosynthetic organisms such as seagrasses and macroalgae. The potential for shading is measured using in-water measures of chlorophyll–a (a measure of phytoplankton biomass) and light attenuation (a measure of water clarity).

Although most algal blooms are harmless, some contain species that produce toxins that may be harmful to swimmers (via ingestion or skin contact) or contaminate seafood. Phytoplankton species composition and cell concentrations are monitored to ensure concentrations are within acceptable limits.

1.3.4 Microbial contaminants

Disease-causing organisms in the TWW pose a risk to humans if exposed during primary and/or secondary contact activities (i.e. swimming and boating). The same organisms, if ingested by marine fauna, may reduce their suitability for human consumption. To assess the risk, concentrations of indicator organisms are routinely compared to the Environmental Protection Authority's (EPA's; EPA 2017) criteria for primary and secondary contact, and the criteria for seafood safe for human consumption.

1.4 Environmental Quality Management Framework (EQMF)

The SDOOL and Perth Long Term Ocean Outlet Monitoring (PLOOM) programs are underpinned by the State Governments Environmental Quality Management Framework (EQMF; EPA 2017).

The EQMF is based on:

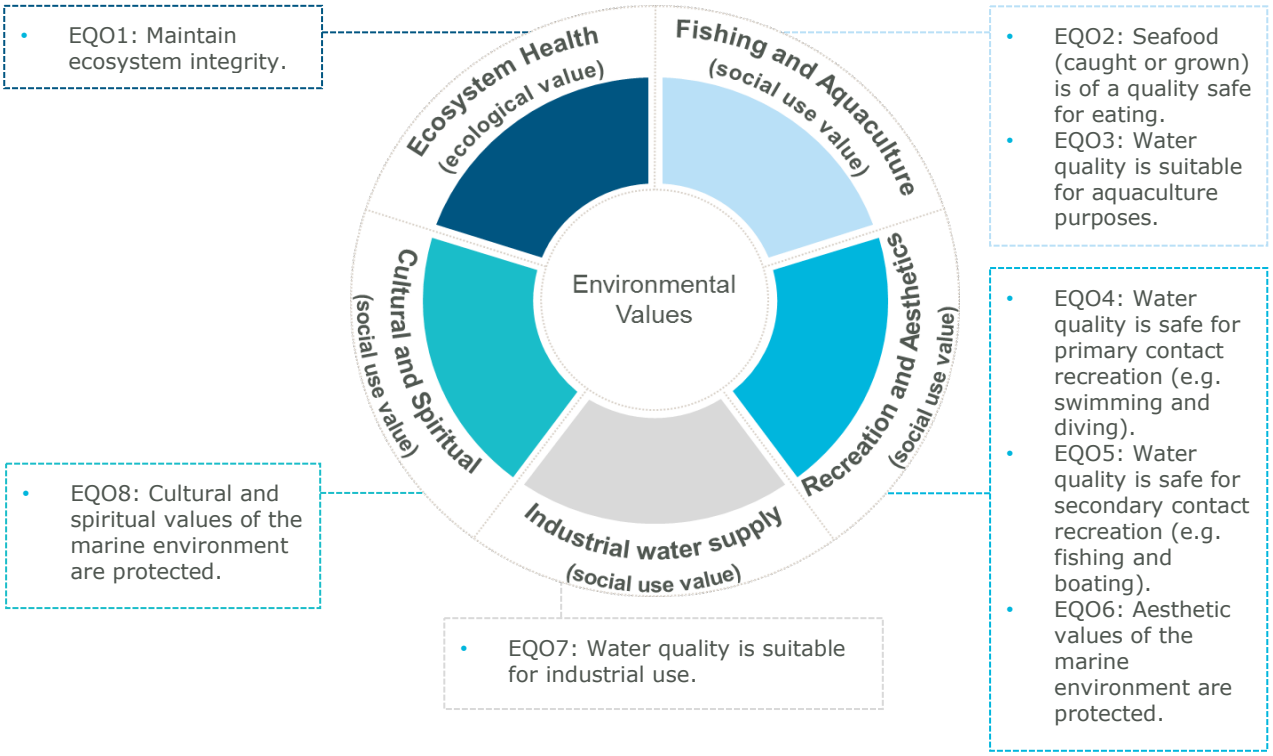
- Identifying Environmental Values (EVs) (Figure 2)
- Establishing and spatially defining Environmental Quality Objectives (EQOs) that need to be maintained to ensure the associated EVs are protected (Figure 2)
- Monitoring and managing to ensure the EQOs are achieved and/or maintained in the long-term in the areas they have been designated
- Establishing Environmental Quality Criteria (EQC), which are quantitative benchmarks or 'trigger values' against which monitoring results can be compared.

There are two levels of EQC:

1. **Environmental Quality Guidelines** (EQGs) are quantitative, investigative triggers, which if met, indicate there is a high degree of certainty that the associated EQO has been achieved. If the guideline is not met a more detailed assessment against the Environmental Quality Standard (EQS) is triggered.
2. **Environmental Quality Standards** (EQSs) are management triggers which, if exceeded, signify that the EQO is at risk of not being met and that a management response may be required.

1.4.1 'Maintenance of Ecosystem Integrity' EQO

The intent of this EQO is to maintain a healthy and diverse ecosystem. There are four levels of ecological protection, with each applied depending on the designated level required: low, moderate, high or maximum (Figure 4). A Low Ecological Protection Area (LEPA) has been established at the Sepia Depression outfall and occupies the area within a 100 m radius of the diffuser (BMT Oceanica 2014). Waters outside the LEPA are maintained to a High Level of Ecological Protection (HEPA; Figure 4).



Source: EPA (2016)

Figure 2 **Environmental Values and Environmental Quality Objectives (EQO) for the marine waters off Western Australia**

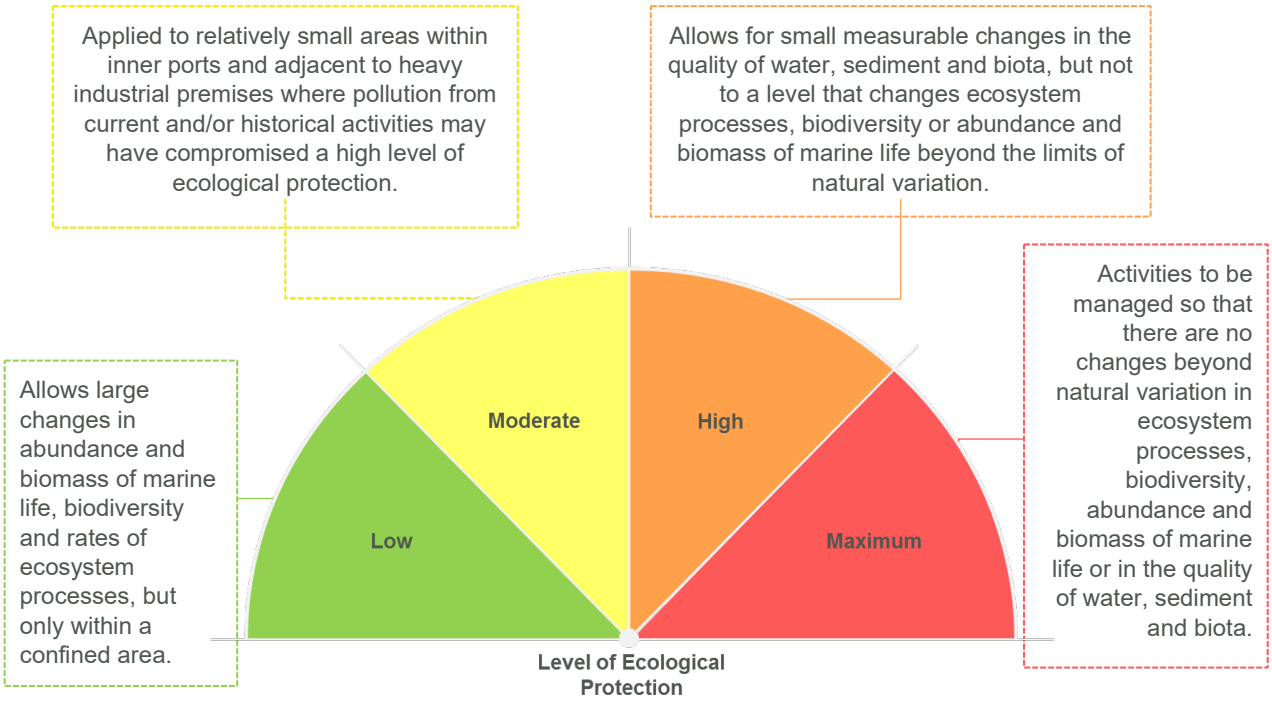


Figure 3 **Levels of Ecological Protection**

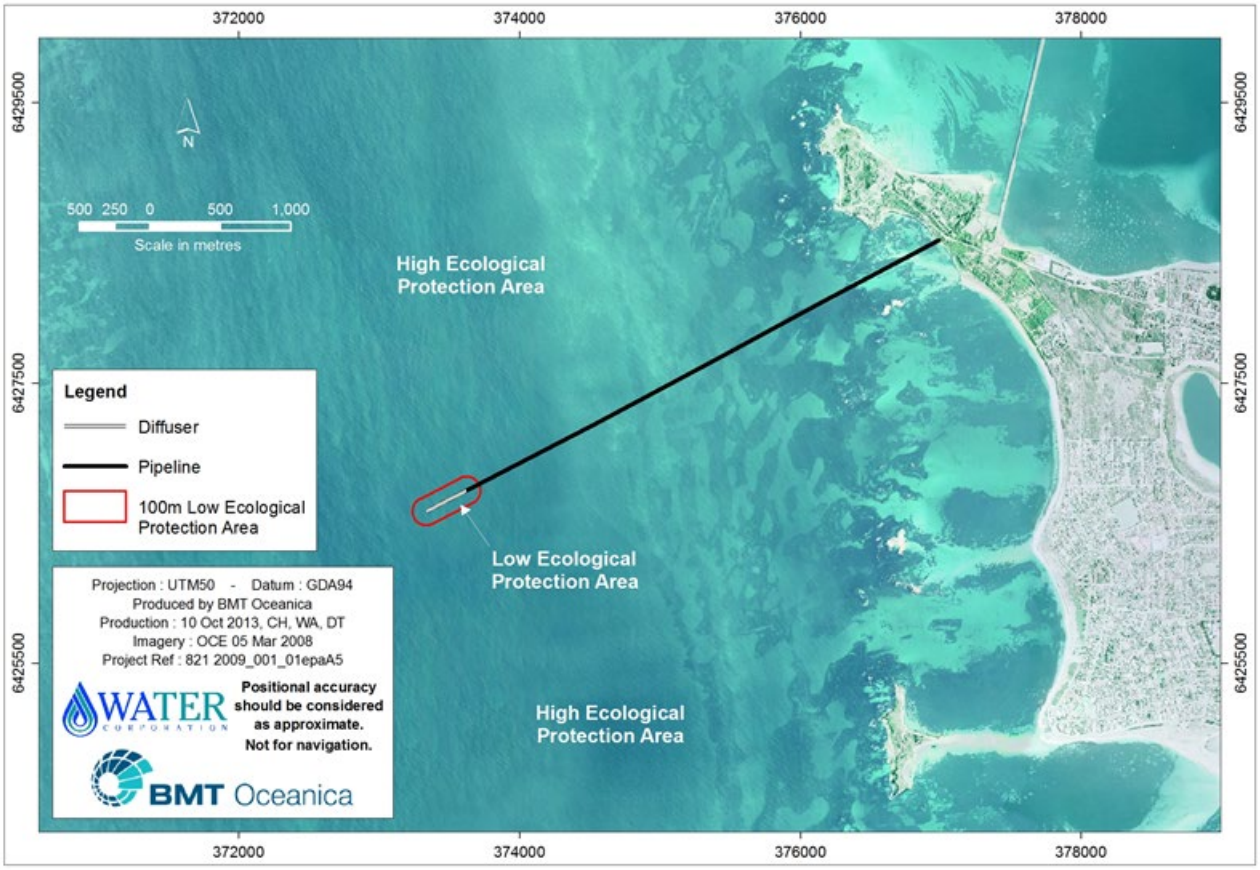


Figure 4 **Sepia Depression ocean outlet, Low and High Ecological Protection Areas**

1.4.2 'Maintenance of Seafood Safe for Human Consumption' EQO

The intent of this EQO is to maintain seafood safe for human consumption (a social value), except for a small area surrounding the ocean outlet where seafood may be unsafe to eat. Formal management zones have been established for the Sepia Depression ocean outlet (Figure 5). Microbiological contaminants and algal biotoxins are monitored at the boundary of the Shellfish Harvesting Exclusion Zone (SHEZ), to ensure the EQO is being met.

1.4.3 'Maintenance of Primary and Secondary Contact Recreation' EQO

The intent of the primary and secondary contact EQOs are to support swimming and boating activities, respectively. The EQOs apply throughout Perth's coastal waters except to areas around ocean outlets, where water quality may not be suitable for swimming. An area where primary contact recreation is not recommended has been established for the Sepia Depression ocean outlet. This is known as the Recreational Contact Exclusion Zone (Figure 5).

1.4.4 'Maintenance of Aesthetic Value' EQO

The objective of this EQO is to ensure that the aesthetic value of Perth's coastal waters is protected. To ensure this EQO is being met, monitoring routinely assesses the quality of the surface water appearance.

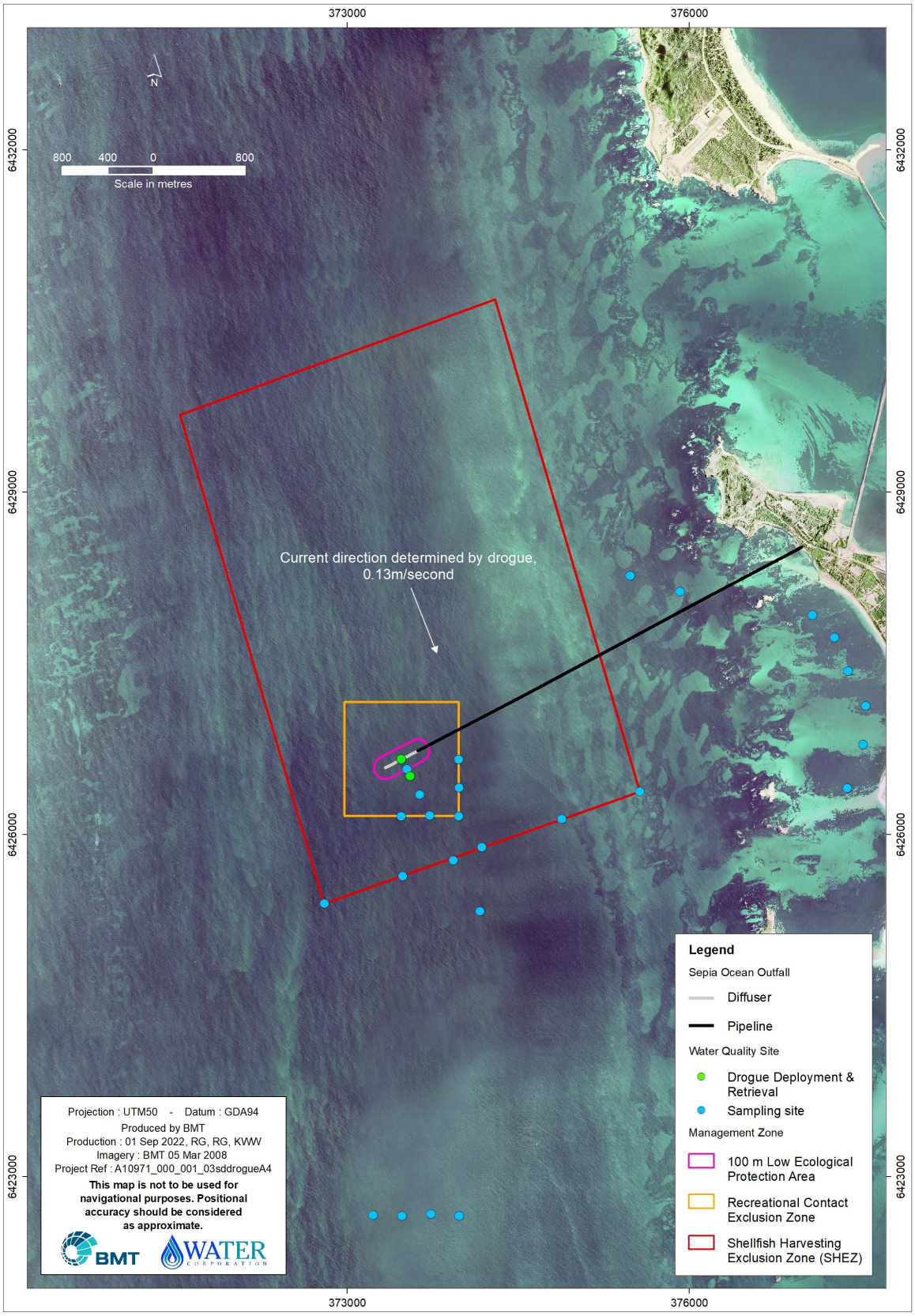


Figure 5 **Sepia Depression ocean outlet, Exclusion Zones, Low Ecological Protection Area and an example of a drogue deployment during a sampling occasion**

2 Toxicants in treated wastewater

2.1 Comprehensive treated wastewater characterisation

TWW (final effluent) from the SDOOL was analysed for a suite of parameters comprising the major contaminants of concern for the Sepia Depression ocean outlet (Figure 6):

- nutrients (total nitrogen, ammonia, nitrate+nitrite (NOx), total phosphorus, orthophosphate)
- microbiological contaminants (thermotolerant coliforms and *Enterococci* spp.)
- bioavailable metals (arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver and zinc)
- pesticides and herbicides (organophosphate pesticides, organochlorine pesticides, triazine herbicides)
- polyaromatic hydrocarbons
- phthalates
- polychlorinated biphenyls
- benzene, toluene, ethylbenzene, and xylenes
- petroleum hydrocarbons
- surfactants
- dissolved organic carbon.

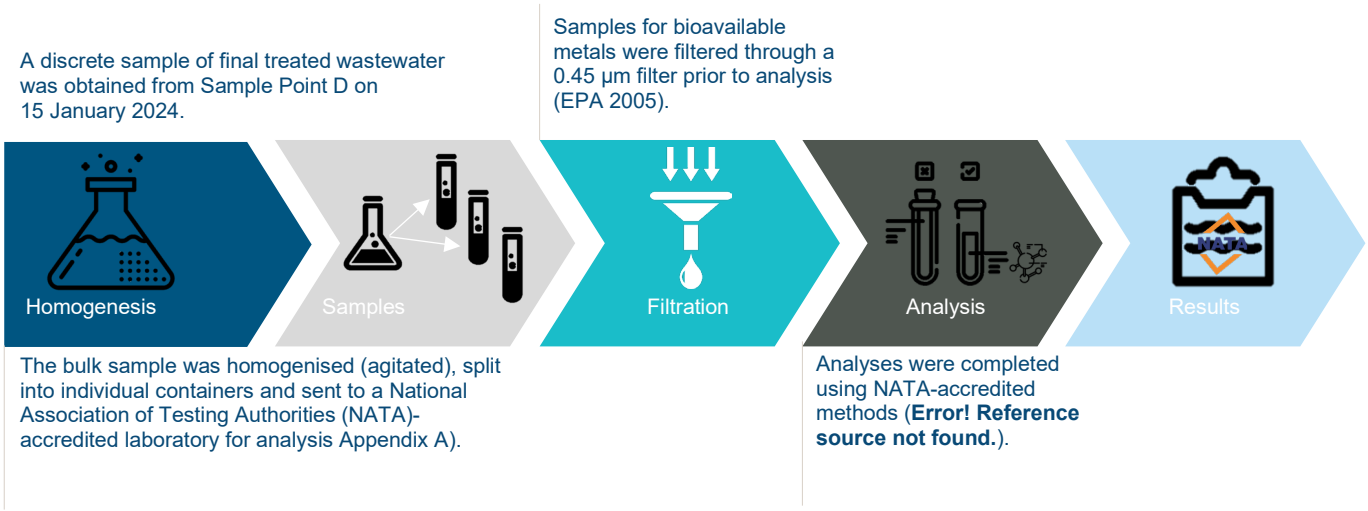


Figure 6 Wastewater sampling and analysis process

2.1.1 Bioaccumulating toxicants

Concentrations of cadmium and mercury (i.e. bioaccumulating toxicants) in the undiluted TWW sample were both below their analytical limit of reporting (LoR; <0.1 µg/L for cadmium and <0.05 µg/L for mercury) and the EQG for cadmium and mercury as bioaccumulating toxicants (36 and 1.4 µg/L, respectively) was met (Table 1; Table 3). Concentrations of bioaccumulating toxicants in the discharge have been consistent over time (Figure 7).

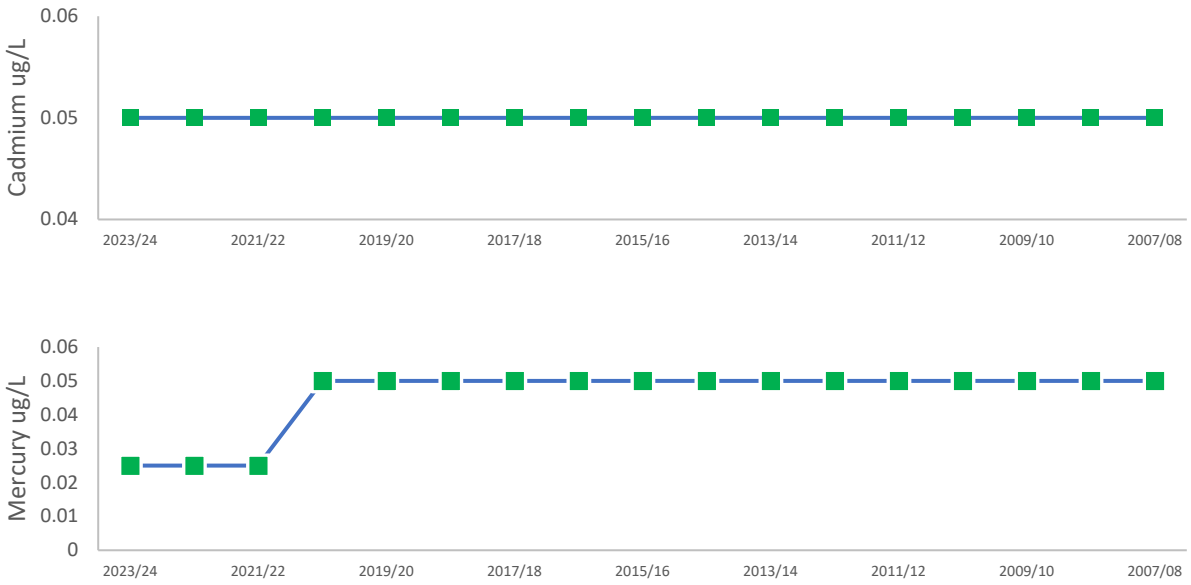
Table 1 Environmental Quality Guideline for bioaccumulating toxicants

EQG	Concentrations of contaminants will not exceed the ANZECC **&** ARMCANZ (2000) 80% species protection guideline trigger levels for bioaccumulating toxicants at the diffuser.

Source: BMT Oceanica 2014

Note:

1. EQG = Environmental Quality Guideline.



Note:

1. Green (■) symbols indicate the Environmental Quality Guideline (EQG) was met; amber (■) and red (■) symbols represent an exceedance of the EQG or Environmental Quality Standard (EQS), respectively.

Figure 7 Historical compliance of concentrations of bioaccumulating toxicants, cadmium and mercury

2.1.2 Non-bioaccumulating toxicants

Contaminant concentrations were below their waste stream triggers based on the ANZECC & ARMCANZ (2000) 99% species protection guidelines scaled for dilution equivalent to that expected at the LEPA boundary (BMT Oceanica 2014; refer to Appendix C). Therefore, the EQG (Table 2) was met (Table 3). Initial dilution (Figure 8) has been sufficient to always reduce the concentration of non-bioaccumulating toxicants to below their EQG concentrations (Figure 9).

Table 2 Environmental Quality Guideline for non-bioaccumulating toxicants

EQG	Wastewater contaminant concentration corrected for minimum dilution at the Low Ecological Protection Area (LEPA) boundary will ensure the ANZECC **&** ARMCANZ (2000) 99% species protection guideline trigger levels for toxicants are being achieved at the boundary of the LEPA (i.e. a high level of protection is met beyond a 100 m radius of the diffuser).

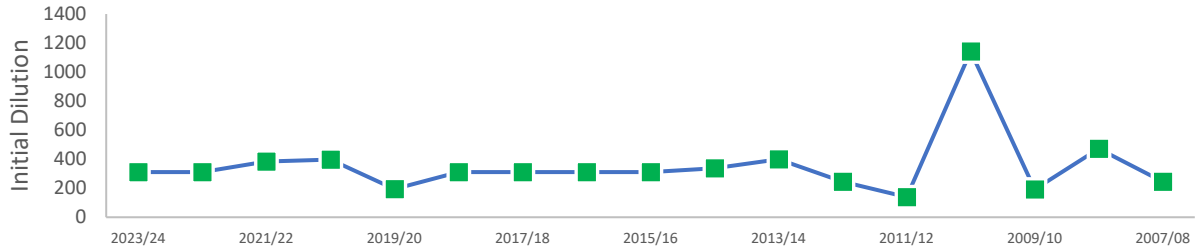
Source: BMT Oceanica 2014

Table 3 Toxicants in the Sepia Depression treated wastewater stream compared with relevant trigger levels

Toxicant	Sepia Depression TWW concentration (µg/L)	Waste stream trigger (µg/L)[1,2]
Ammonia-N	15,000	154,537
Cadmium[5,6]	<0.1	36
Chromium[6]	1.7	43
Copper[6]	17	68
Lead[6]	<1	679
Mercury[5,6]	<0.05	1.4
Nickel[6]	4.5	2016
Silver[6]	<0.8	248
Zinc[6]	65	2124
Chlorpyrifos[6]	<0.1	0.16
Endrin	<0.001	1.24
Endosulfan sulfate[7]	<0.001	1.55
Benzene	<1	110 890
Naphthalene	<0.01	15 485
Benzo(g,h,i)perylene	<0.01	15 485

Notes:

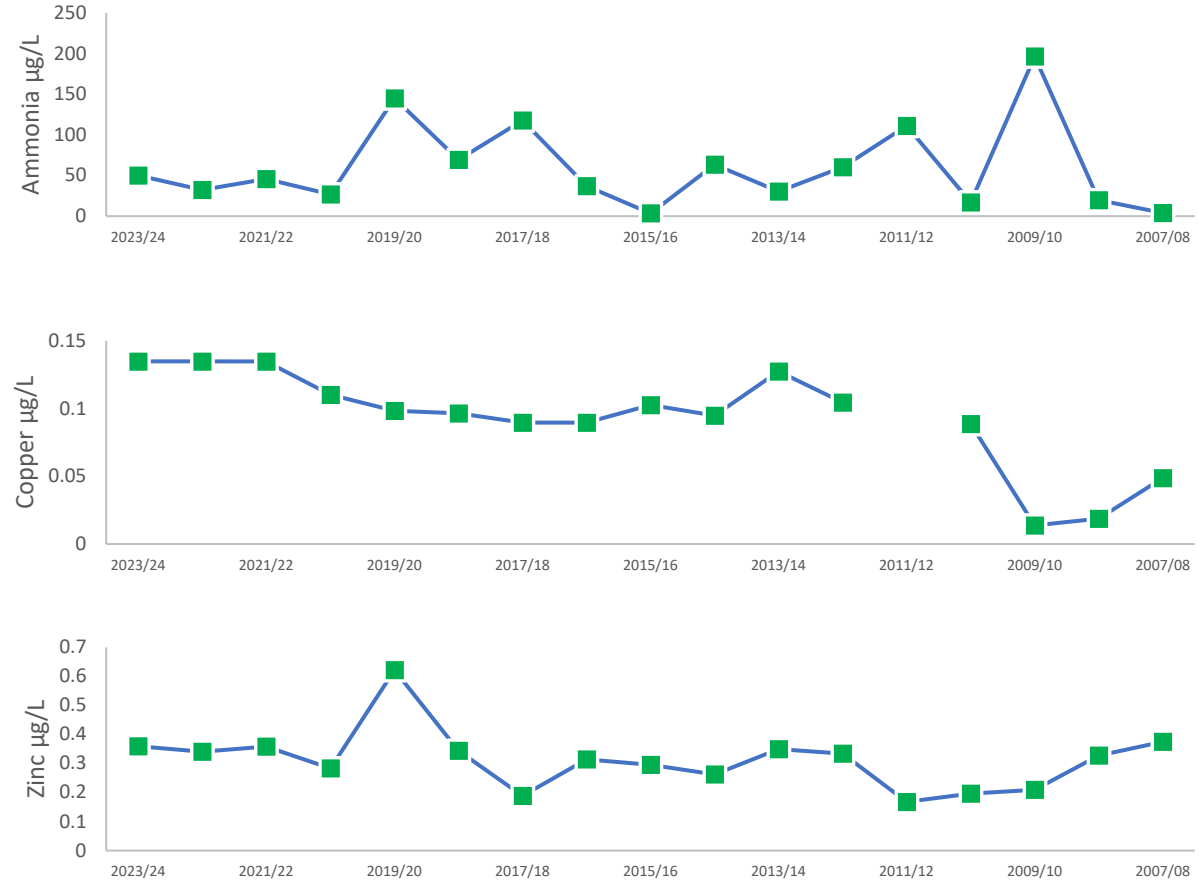
1. ANZECC & ARMCANZ (2000) guidelines used as per SDOOL MMP (BMT Oceanica 2014).
2. ANZECC & ARMCANZ (2000) scaled based on 5th percentile dilution at the Low Ecological Protection Area boundary.
3. TWW = treated wastewater.
4. The EPA has provided advice that in WA waters where a high level of protection applies, 99% species protection levels should be used.
5. The bioaccumulating toxicants cadmium and mercury must meet the 80% species protection guidelines at the diffuser (i.e. prior to initial dilution), and therefore a diluted concentration was not calculated.
6. Dissolved metals 0.45 µm filtered.
7. Trigger values are based on endosulfan, not endosulfan sulfate (Table 3.4.1; ANZECC & ARMCANZ [2000]).



Note:

1. Green (■) symbols indicate the Environmental Quality Guideline (EQG) was met; amber (■) and red (■) symbols represent an exceedance of the EQG or Environmental Quality Standard (EQS), respectively.

Figure 8 Historical Compliance of initial dilution



Note:

1. Green (■) symbols indicate the Environmental Quality Guideline (EQG) was met; amber (■) and red (■) symbols represent an exceedance of the EQG or Environmental Quality Standard (EQS), respectively.

Figure 9 Historical compliance of concentrations of non-bioaccumulating toxicants, ammonia, copper and zinc

2.1.3 Total toxicity of the mixture

The total toxicity of the mixture (TTM) is an indicator of the potential for cumulative toxic effects on marine organisms (Table 4). For the combined effect of ammonia, copper and zinc following dilution as per the management plan, the TTM (0.60, Table 5) was less than the ANZECC & ARMCANZ (2000) guideline value of 1.0 and the EQG for TTM (Table 4) was met (Table 5). Total toxicity of the mixture has not exceeded the EQG criteria over time (Figure 10).

Table 4 Environmental Quality Guideline for the total toxicity of the mixture

EQG	The total TTM for the additive effect of ammonia, copper and zinc, calculated as per ANZECC & ARMCANZ (2000), will not exceed the trigger value of 1.0.

Source: BMT Oceanica 2014

Notes:

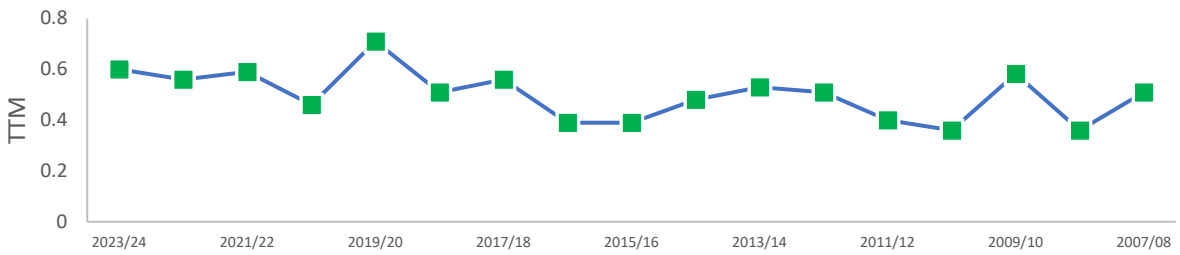
1. EQG = Environmental Quality Guideline; TTM = total toxicity of the mixture.
2. TTM = Σ(Ci/EQGi) where Ci is the concentration of the relevant component (i) in the mixture and its associated EQG for that component.

Table 5 Total toxicity of treated wastewater at the edge of the initial mixing zone associated with the Sepia Depression ocean outlet

Toxicant	TWW concentration (µg/L)	Background concentration (µg/L)[1]	Dilution	Concentration after dilution (µg/L)	Contaminant /guideline (µg/L)	TTM[2]
Ammonia	15,000	1.5	1:310	50	0.10	0.60
Copper	17	0.08		0.14	0.45	
Zinc	65	0.15		0.52	0.05	

Notes:

1. Background concentrations for copper and zinc from McAlpine et al. (2005); Perth marine waters (pp.19). Surface background concentrations for ammonia calculated as median of reference site data from 2003–2024 (BMT; unpublished data).
2. TTM = total toxicity of the mixture = [ammonia]/guideline + [copper]/guideline + [zinc]/guideline, TWW = treated wastewater.



Note:

1. Green (■) symbols indicate the Environmental Quality Guideline (EQG) was met; amber (■) and red (■) symbols represent an exceedance of the EQG or Environmental Quality Standard (EQS), respectively.

Figure 10 Historical compliance of total toxicity of the mixture

2.2 Quarterly treated wastewater characterisation

Water Corporation conducts quarterly sampling of the final SDOOL treated wastewater stream from Sample Point D (Figure 1). Quarterly samples are analysed for a smaller set of the key contaminants of concern that are most likely to be present in the waste stream. Quarterly sampling occurred on 4 July 2023, 3 October 2023, 9 January 2024, 2 April 2024.

On each sample occasion, a composite sample (time-weighted) was obtained from Sample Point D (Figure 1). This sample represents an average of the TWW discharged to the Sepia Depression ocean outlet for the 24-hours prior to and during the sample collection. The bulk sample was homogenised and split into separate sample containers for the various analyte groups. Samples were handled and analysed according to the National Association of Testing Authorities (NATA)-accredited laboratory requirements.

The bioaccumulating toxicants cadmium and mercury were below the LoR on all four dates and met the 80% species protection guidelines (36 µg/L and 1.4 µg/L, respectively) in the TWW stream prior to dilution on each sample (Table 6).

Contaminants measured quarterly in the TWW at Sample Point D were all below their respective BMT Oceanica (2014) waste stream triggers (based on the ANZECC & ARMCANZ (2000) 99% species protection scaled for dilution equivalent to that occurring at the LEPA boundary) (Table 6).

Table 6 **Toxicants measured quarterly in the Sepia Depression treated wastewater compared with relevant guideline trigger levels after initial dilution**

Toxicant[1]	Sepia Depression TWW Sample Point D (µg/L)				Waste Stream Trigger[2] (µg/L)
	July 2023	October 2023	January 2024	April 2024	
Ammonia	5500	4100	4100	1400	154,537
Cadmium[4]	<0.1	<0.1	<0.1	<0.1	36
Chromium	-	<2	<2	<2	43
Cobalt	<1	<1	<1	<1	307
Copper	3	4	4	2	68
Lead	<1	<1	<1	<1	679
Mercury[4]	<0.1	<0.1	<0.1	<0.1	1.4
Nickel	3	4	4	3	2016
Silver	<1	<1	<1	<1	248
Vanadium	<10	<10	<10	<10	14,913
Zinc	50	54	54	49	2124
Phenols	<50	<50	<50[5]	<50	83,685

Notes:

1. Assessment is undertaken only for toxicants with ANZECC & ARMCANZ (2000) guideline values.
2. ANZECC & ARMCANZ (2000) trigger scaled according to the 5th percentile dilution at the Low Ecological Protection Area boundary (BMT Oceanica 2014).
3. TWW = treated wastewater.
4. Bioaccumulating toxicants cadmium and mercury based on the ANZECC & ARMCANZ (2000) 80% species protection guidelines (of 36 and 1.4 respectively) at the diffuser (i.e. prior to dilution).
5. Laboratory report recorded an LoR lower than 50, assumed as a mistake and should be <50.

Table 7 **Total toxicity of the quarterly treated wastewater characterisation for the Sepia Depression treated wastewater**

Quarterly sampling dates	Natural background concentration in Perth's coastal waters (µg/L)[1]			Dilution	Total toxicity of the mixture (TTM)[2]
	Ammonia	Copper	Zinc		
July 2023	1.5	0.08	0.15	1:310	0.38
October 2023					0.39
January 2024					0.39
April 2024					0.34

Notes:

1. Background concentrations for copper and zinc from McAlpine et al (2005); Perth marine waters (p.19). Surface concentrations for ammonia calculated as a median of reference site data from 2003–2024 (BMT; unpublished data).
2. Total toxicity of mixture = [ammonia]/guideline + [copper]/guideline + [zinc]/guideline scaled for dilution and background factored.

2.3 Whole of effluent toxicity (WET) testing

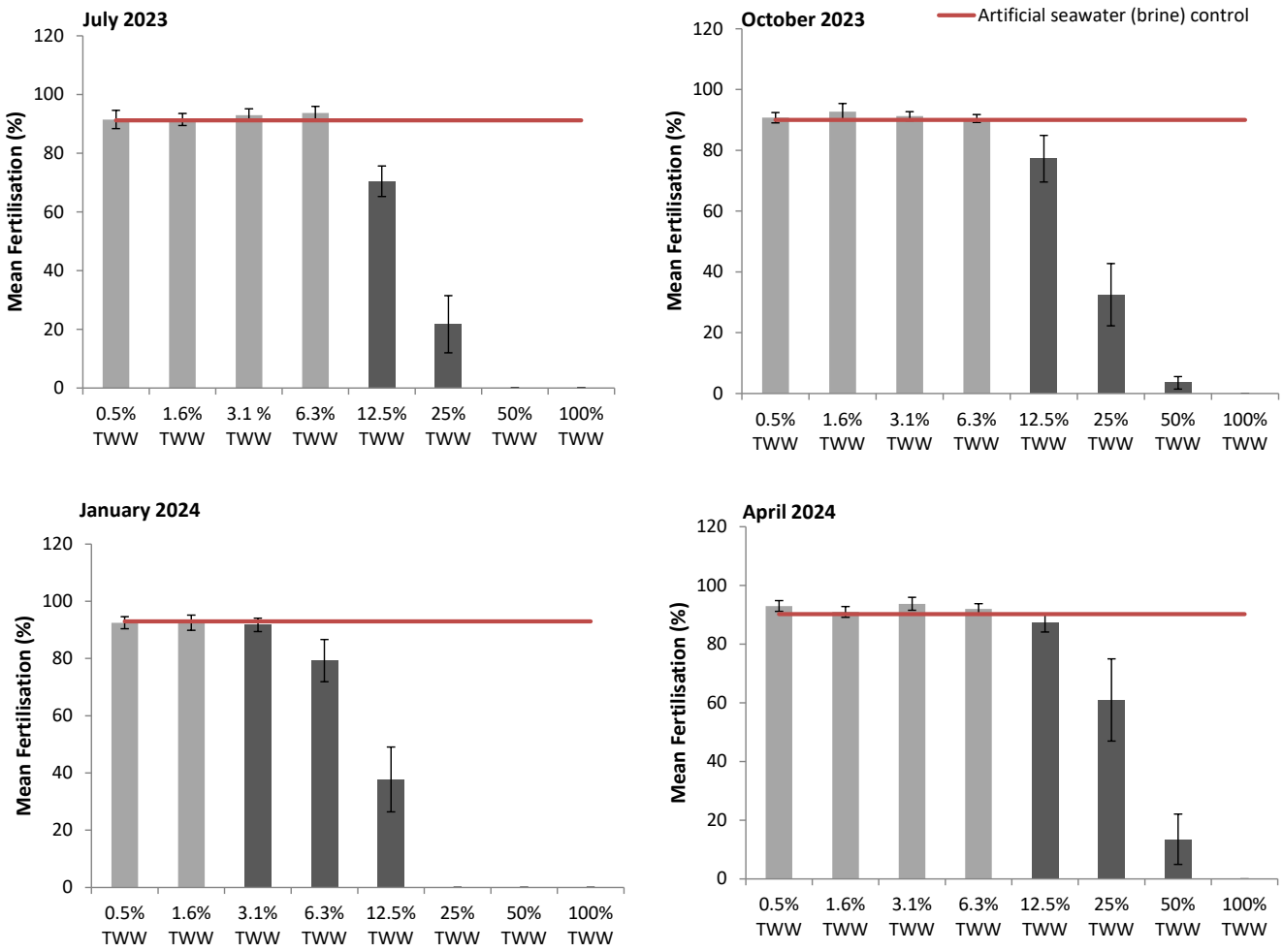
WET testing is useful for assessing the toxicity of potential contaminants without guidelines, or where the effects may be cumulative. Fertilisation success in sea urchins (*Heliocidaris tuberculata*) exposed to salt-adjusted dilutions (0.5, 1.6, 3.1, 6.3, 12.5, 25, 50 and 100%) of TWW was used to calculate a No Observed Effect Concentration (NOEC; the highest concentration where no significant effect is observed; Appendix D).

In January 2024, sea urchin fertilisation was significantly lower in samples exposed to 3.1% TWW dilutions than the artificial seawater control (Figure 11). In July 2023, October 2023 and April 2023, sea urchin fertilisation was significantly lower in samples exposed to 12.5 % TWW dilutions than the artificial seawater control (Figure 11). For all four sampling dates, the equivalent NOEC was greater than 1% TWW (Table 9) and the EQG for WET testing (Table 8) was met. The lowest annual NOEC (and highest apparent toxicity) has been variable over time exceeding the EQG on just one occasion and without an identifiable trend (Figure 12).

Table 8 Environmental Quality Guideline for whole of effluent toxicity testing

EQG	The EQG will be exceeded if following the 1-hour sea urchin test: $\frac{TDA}{DRNOEC} \leq 1.0$ where TDA = Typical Dilutions Achieved (constant based on 200-fold dilution) DRNOEC = number of dilutions required to achieve the no observed effects concentration (NOEC). Breaching the above triggers an investigation against the EQS, which would comprise the full suite of WET tests (minimum of five species from four trophic groups).

Source: BMT Oceanica 2014



Notes:

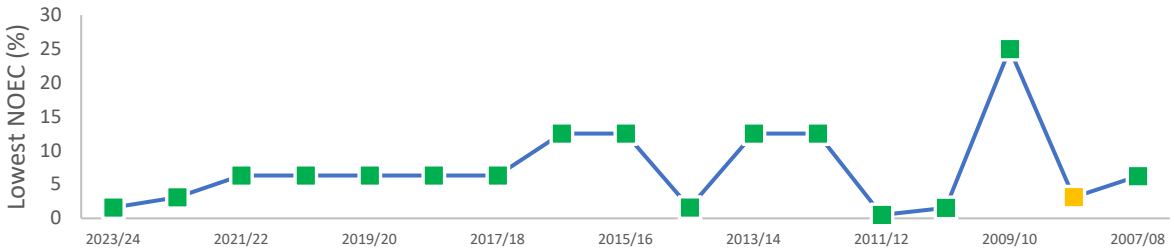
1. Error bars represent ±1 standard deviation; n = 4.
2. TWW = treated wastewater.
3. Light grey bars represent concentrations of TWW at which there is no observed significant effect on fertilisation. Dark grey bars represent concentrations of TWW that acted to significantly reduce the success of sea urchin fertilisation.

Figure 11 Comparison of whole effluent toxicity TWW dilution results to artificial seawater control

Table 9 **Calculated parameters from whole of effluent toxicity tests for Sepia Depression treated wastewater**

Indicator	July 2023	October 2023	January 2024	April 2024
NOEC (%)	6.3%	6.3%	1.6	6.3
Dilutions required to meet the NOEC	15.9	15.9	62.5	15.9
Dilutions required/dilution achieved	0.05	0.05	0.20	0.05
≤1% TWW	Yes	Yes	Yes	Yes

Notes:
1. NOEC = No Observed Effect Concentration.
2. Calculation based on 310 dilutions achieved, which is expected at the Low Ecological Protection Area boundary.



Note:

1. Green (■) symbols indicate the Environmental Quality Guideline (EQG) was met; amber (■) and red (■) symbols represent an exceedance of the EQG or Environmental Quality Standard (EQS), respectively.

Figure 12 **Historical Compliance of No Observed Effect Concentration**

2.4 Diffuser Performance

Diffuser performance was calculated by comparing discharge concentrations from annual TWW sampling with nutrient samples and physical profiling performed at the same time. Salinity, ammonia, orthophosphate, and nitrate+nitrite concentrations were used to assess diffuser performance. Dilution factors were calculated for 0 m (initial dilution), 100 m, 350 m, 1000 m and 1500 m utilising the following formula:

$$Dilution\ Factor = \frac{Effulent\ Concentration}{Plume\ Sampling\ Concentration - Reference\ Concentration}$$

Dilution factors were not calculated where concentrations at the plume sampling site were equal to or lower than the mean reference sites concentration. Dilution estimates ranged from 1:220 to 1:36,785 (Table 10). The large variation suggests that none of the parameters accurately reflect dilution. It is likely that the calculation based on salinity and nitrate+nitrite underestimates dilution due to a relatively small difference between wastewater and background concentrations. It is also likely that the calculation based on ammonia and ortho-phosphate overestimates dilution due to uptake after discharge.

Table 10 Dilution factor calculation results for Sepia Depression treated wastewater

Site	Salinity (psu)	Ammonia (µg/L)	Ortho-P (µg/L)	NOx (µg/L)
Reference	36.38	1.5	4	3
Wastewater	0.69	15,000	9200	35
0 m	36.23	1.5	4	1
100 m	36.22	28	12	34
350 m	36.22	17	9	24
1000 m	36.23	5	6	12
1500 m	36.23	6	7	14
Dilution at 0 m	1:306	–	1:36,785	–
Dilution at 100 m	1:229	1:566	1:1115	1:1
Dilution at 350 m	1:220	1:968	1:1752	1:2
Dilution at 1000 m	1:228	1:4285	1:4087	1:3
Dilution at 1500 m	1:240	1:3333	1:2830	1:3

Notes:
1. NOx = nitrate+nitrite.
2. Ortho-P = orthophosphate.
3. – = Dilutions were not calculated because concentrations at these sites was equal to or less than the mean of reference sites.

3 Water quality monitoring – receiving environment

Nutrients, phytoplankton biomass and physical and chemical stressors were monitored approximately fortnightly from the beginning of December 2023 to the end of March 2024 (coinciding the summer non-river flow period) along a down-current gradient away from the diffuser (Table 11; Appendix E).

Table 11 Water quality monitoring sampling occasions for Sepia Depression ocean outlet between December 2023 and March 2024

Sample day	Date
1	04/12/2023
2	12/12/2023
3	04/01/2024
4	15/01/2024
5	02/02/2024
6	19/02/2024
7	11/03/2024
8	20/03/2024

Wind direction, strength, current grid direction and cloud cover for each sampling occasion are provided in Table 12.

Table 12 Weather conditions and current grid direction for Sepia Depression ocean outlet water quality monitoring sampling occasions

Date	Wind direction	Wind strength (knots)	Cloud cover (%)	Current grid direction
04/12/2023	SW	3 to 14	80	E
12/12/2023	ENE, NNE, N, NNW	0 to 7	0	SW
04/01/2024	E	10 to 18	0 to 5	NW
15/01/2024	NW	10 to 12	0	S
02/02/2024	SSW	2 to 14	0 to 10	N
19/02/2024	E	12 to 16	70 to 90	S
11/03/2024	SE, SSE, S	5 to 10	0	SE
20/03/2024	E, ESE	10 to 18	0	N

Notes:
1. SW = south-west, ENE = east north-east, NNE = north north-east, N = north, NNW = north north-west, E = east, NW = north-west, SSW = south south-west, SSE = south south-east, S = south, ESE = east south-east.
2. Winds are designated by the direction they come from while currents are designated by the direction they flow to.
3. Wind direction and strength are obtained from field observations.

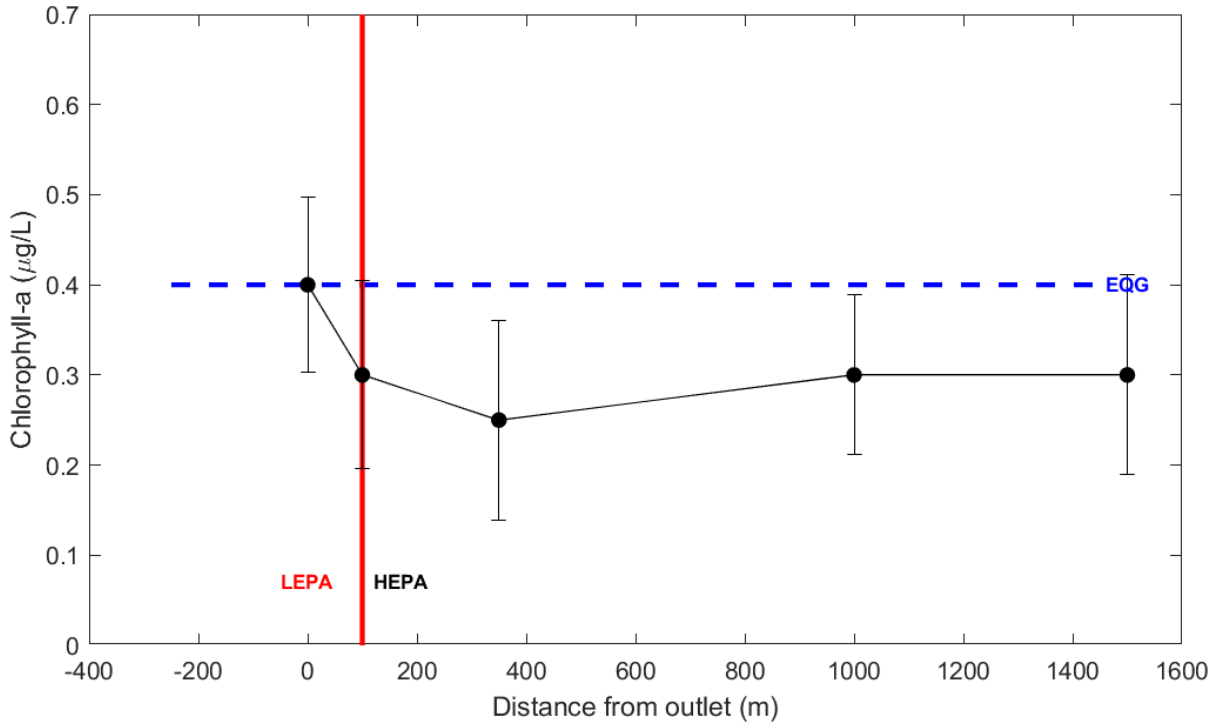
3.1 Nutrient enrichment

The median chlorophyll–a concentration in the Sepia Depression HEPA (≥100 m) was 0.3 µg/L and below the 80th percentile of historical reference site data (0.4 µg/L; Figure 13), meeting the EQG (Table 13, Appendix E). Median chlorophyll–a concentration has been similar over time (Figure 14).

Table 13 Environmental Quality Guidelines for nutrients

EQG	The median chlorophyll–a concentration in the High Ecological Protection Area (HEPA; 100 m or greater from the diffuser) during the non-river flow period is not to exceed the 80th percentile of historical reference site data.
	The median light attenuation coefficient in the HEPA during the non-river flow period is not to exceed the 80th percentile of historical reference site data.

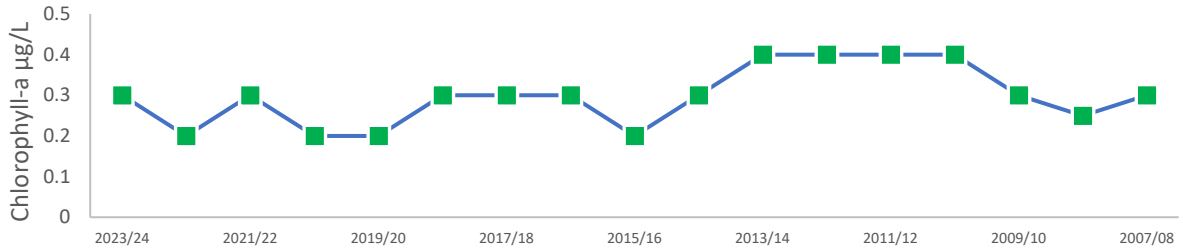
Source: BMT Oceanica 2014



Notes:

1. Error bars represent ±95% confidence intervals; n = 8.
2. Dark blue dashed line = Environmental Quality Guideline (EQG) is the 80th percentile of historical reference site data.
3. LEPA = Low Ecological Protection Area; HEPA = High Ecological Protection Area.
4. Data were pooled across eight sampling days (n=8) over December 2023–March 2024.

Figure 13 Median chlorophyll–a concentration at fixed monitoring sites down-current of the Sepia Depression outlet during the summer monitoring period

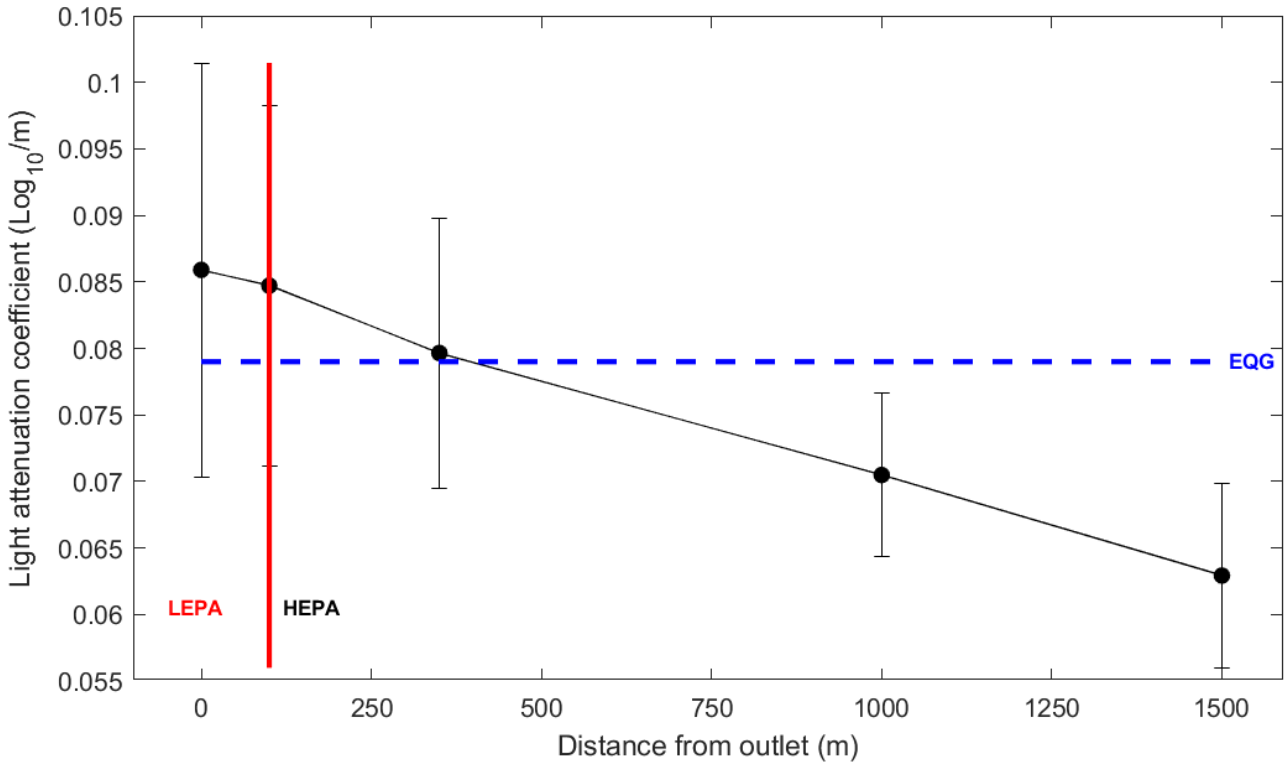


Note:

1. Green (■) symbols indicate the Environmental Quality Guideline (EQG) was met; amber (■) and red (■) symbols represent an exceedance of the EQG or Environmental Quality Standard (EQS), respectively.

Figure 14 Historical compliance of median chlorophyll–a concentration over time

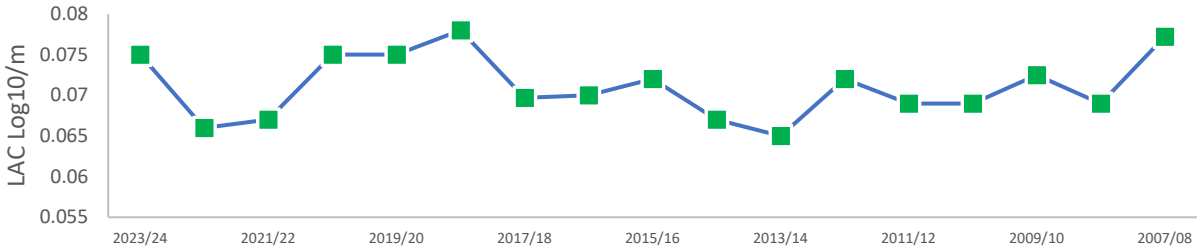
The median light attenuation coefficient (LAC) in the Sepia Depression HEPA (≥100 m) was 0.075 Log_{10}/m and was lower than the 80th percentile of historical reference site data (0.079 Log_{10}/m; Figure 15), meeting the EQG (Table 13). Median light attenuation coefficient has been similar over time (Figure 16).



Notes:

1. Error bars represent ±95% confidence intervals; n = 8.
2. Dark blue dashed line = Environmental Quality Guideline (EQG) is the 80th percentile of historical reference site data.
3. LEPA = Low Ecological Protection Area; HEPA = High Ecological Protection Area.
4. Data were pooled across eight sampling days (n=8) over December 2023–March 2024.

Figure 15 Median light attenuation coefficient at fixed distances down current of the Sepia Depression outlet during the summer monitoring period



Note:

1. Green (■) symbols indicate the Environmental Quality Guideline (EQG) was met; amber (■) and red (■) symbols represent an exceedance of the EQG or Environmental Quality Standard (EQS), respectively.

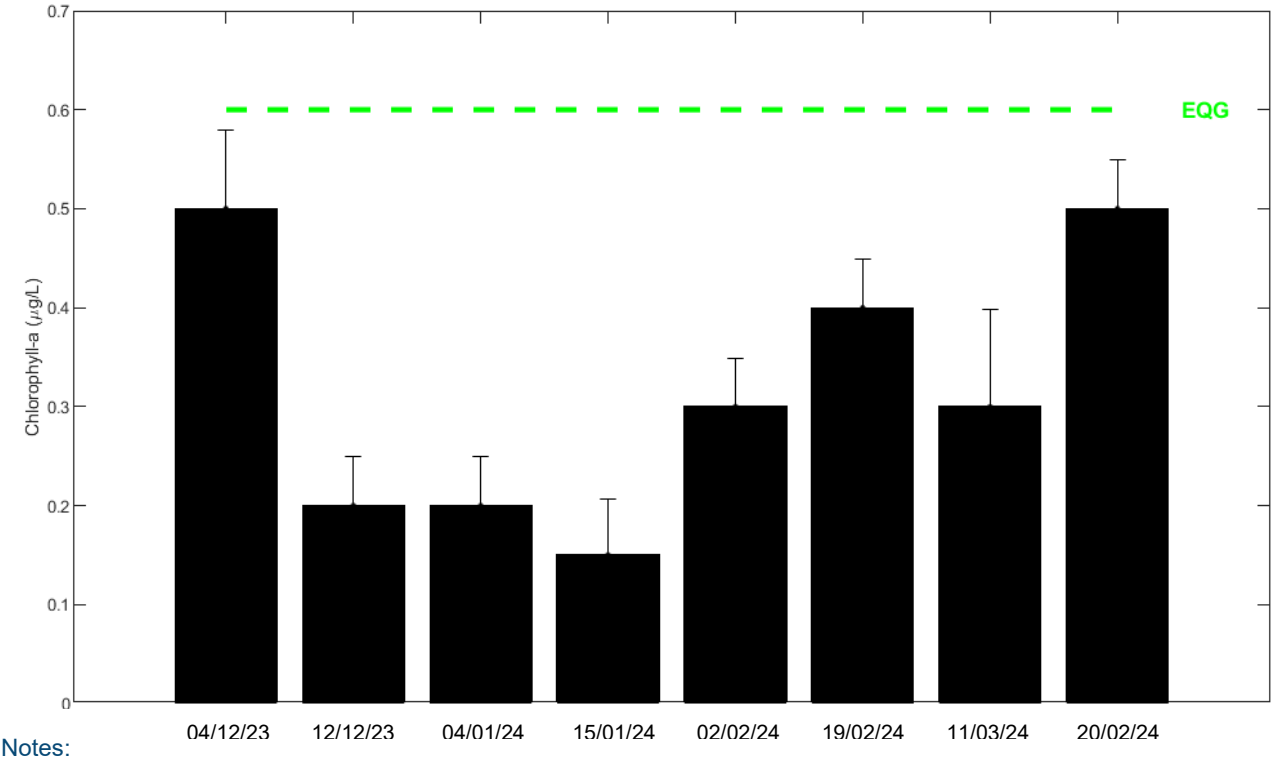
Figure 16 Historical compliance of median light attenuation coefficient over time

3.2 Phytoplankton biomass

Median chlorophyll–a concentration within the HEPA did not exceed three times the median of historical reference sites (0.60 µg/L) on any sampling occasion during the summer monitoring period and EQG1 (Table 14) was met (Figure 17). The EQG has been exceeded 2 times historically but has not been exceeded in two consecutive years and the EQS has always been met (Figure 18).

Table 14 Environmental Quality Guidelines for phytoplankton in receiving waters

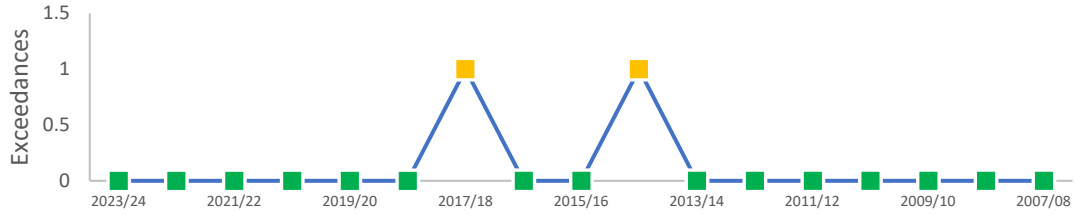
EQG1	Median phytoplankton biomass, measured as chlorophyll–a is not to exceed 3 times the median chlorophyll–a concentration of reference sites, on any occasion during the non-river flow period.
EQG2	Phytoplankton biomass measured as chlorophyll–a at any site does not exceed 3 times the median chlorophyll–a concentration of reference sites, on 25% or more occasions during the non-river flow period.



Notes:

1. Error bars represent ±95% confidence intervals; n = 4.
2. Green dashed line = Environmental Quality Guideline (EQG) is 3-times the median chlorophyll–a concentration of historical reference site data.
3. Measured concentration at 0 m is not displayed or in the EQC assessment, as the 0 m site is situated directly above the outlets within the Low Ecological Protection Area.

Figure 17 **Median phytoplankton biomass at fixed sites ≥100 m down-current of the Sepia Depression outlet during the summer monitoring period**



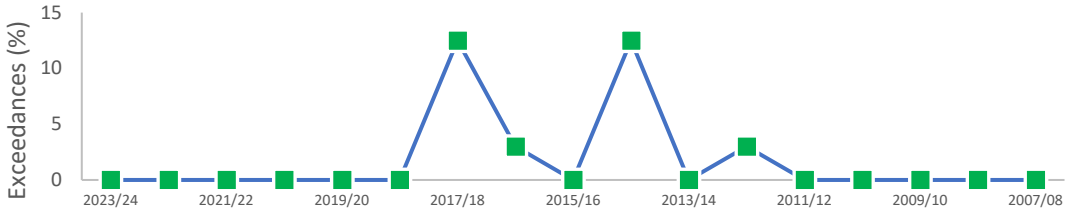
Note:

1. Green (■) symbols indicate the Environmental Quality Guideline (EQG) was met; amber (■) and red (■) symbols represent an exceedance of the EQG or Environmental Quality Standard (EQS), respectively.

Figure 18 **Historical compliance of median chlorophyll–a concentration with exceedances of 3 times reference site concentrations at any site**

Phytoplankton biomass measured as chlorophyll–a did not exceed three times the median of reference sites, at any site or on any sampling occasion during the summer monitoring period (Figure 17), meeting the requirements of

EQG2 (<25% of occasions at any site). Phytoplankton biomass measured as chlorophyll–a has not exceed three times the median of reference sites at any site on 25% or more occasions (Figure 19).



Note:

1. Green (■) symbols indicate the Environmental Quality Guideline (EQG) was met; amber (■) and red (■) symbols represent an exceedance of the EQG or Environmental Quality Standard (EQS), respectively.

Figure 19 **Historical compliance of the percentage of occasions chlorophyll–a concentration exceeded 3 times reference site concentrations at any site**

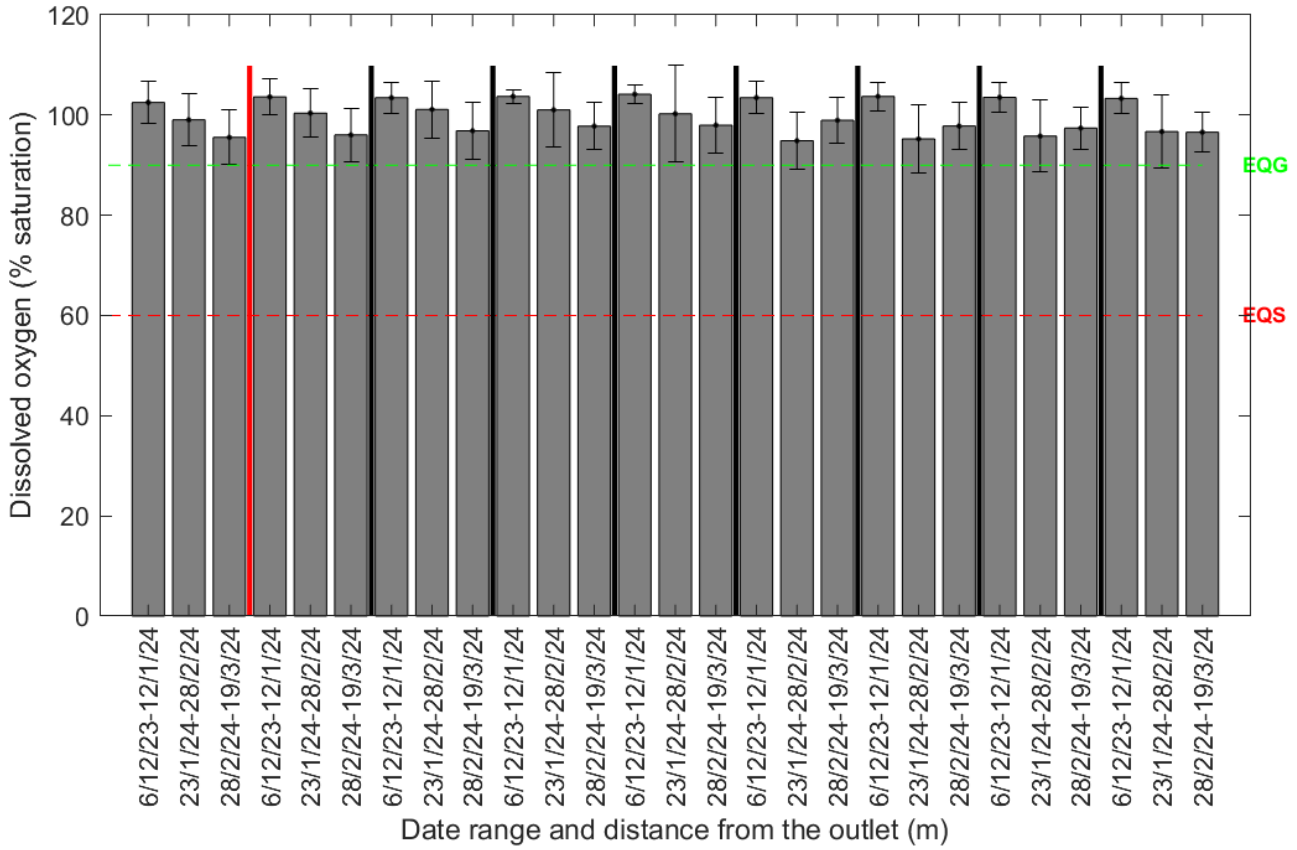
3.3 Physical-chemical stressors

3.3.1 Dissolved oxygen (DO)

Bottom water (0–0.5 m) DO saturation in the Sepia Depression HEPA were >90% at all times throughout the summer monitoring period (Figure 20) and the EQG for dissolved oxygen (Table 15) was met. DO fell below 90% for a single six week period in 2014/15 and a single six week period in 2010/11 (Figure 21). There were no periods where DO fell below the 60% EQS criteria.

Table 15 **Environmental Quality Guideline for dissolved oxygen**

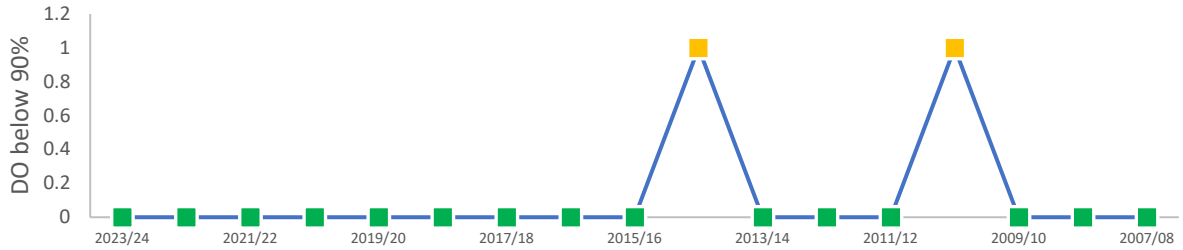
EQG	Median dissolved oxygen in bottom waters (0–0.5 m above the seabed) must be greater than 90% saturation at any site for a defined period of not more than 6 weeks during the non-river flow period.



Notes:

1. Error bars ±95% confidence intervals; n = 3.
2. Dissolved oxygen (DO) measured 0–0.5 m above the seabed.
3. Green dashed line = Environmental Quality Guideline (EQG) = 90% DO saturation.
4. Red dashed line = Environmental Quality Standard (EQS) = 60% DO saturation.
5. LEPA = Low Ecological Protection Area; HEPA = High Ecological Protection Area.
6. Reference site data (SD1–SD4) are compared against EQG for contextual purposes only.

Figure 20 **Median dissolved oxygen for defined periods of ≤6 weeks down-current of the Sepia Depression outlet during the summer monitoring period**



Note:

1. Green (■) symbols indicate the Environmental Quality Guideline (EQG) was met; amber (■) and red (■) symbols represent an exceedance of the EQG or Environmental Quality Standard (EQS), respectively.

Figure 21 Historical compliance of the number of periods where DO was below 90% over time

3.3.2 Salinity

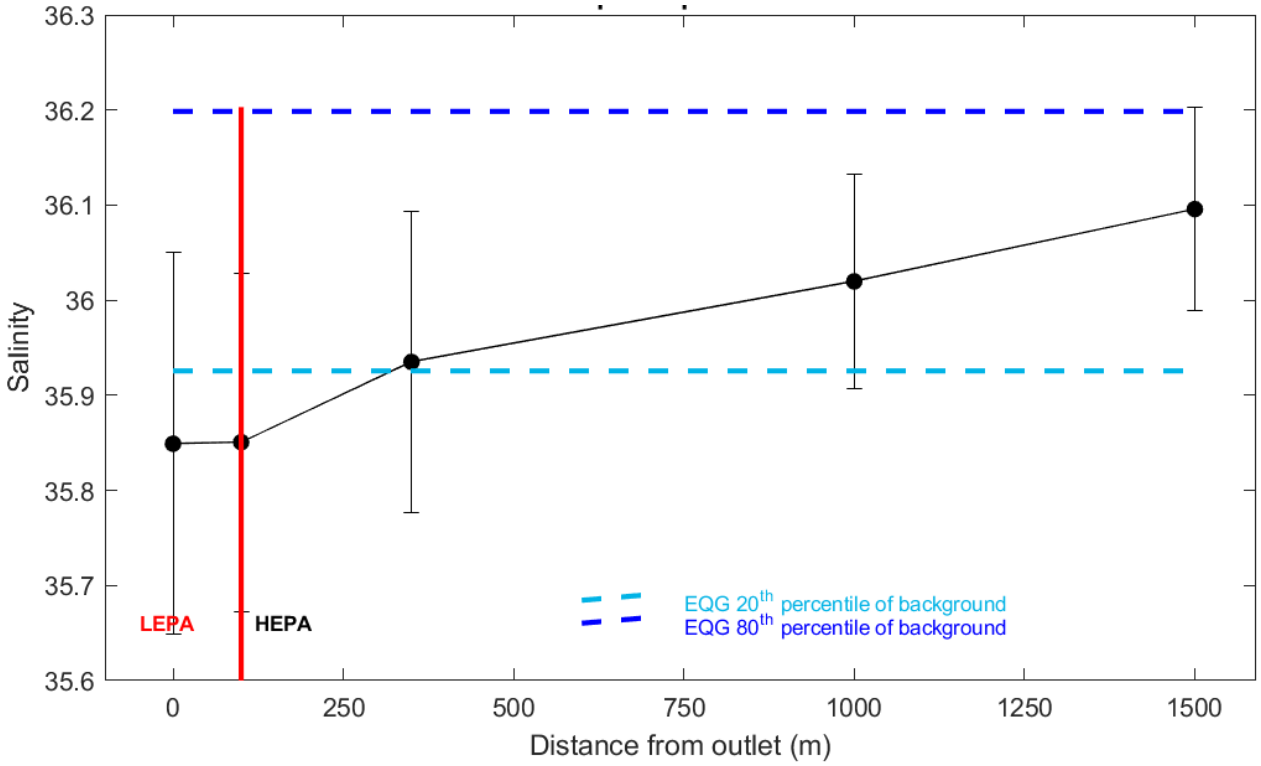
Median salinity was below the 20th percentile of the natural salinity range at the 100 m site within the HEPA and the EQG was not met triggering assessment against the EQS (Table 16 and Figure 22). There were no reports of deaths of marine organisms resulting from anthropogenically sourced salinity stress, thus the EQS was met (Table 16). Historically, median salinity has fallen below the 20th percentile of the natural salinity range at one or more sites within the HEPA on five occasions (Figure 23). The EQS has not been exceeded in any year.

Table 16 Environmental Quality Guideline for salinity

EQG	Median salinity (0.5 m below the water surface) at an individual site over any period is not to deviate beyond the 20th and 80th percentile of natural salinity range over the same period.
EQS	No deaths of marine organisms resulting from anthropogenically sourced salinity stress.

Note:

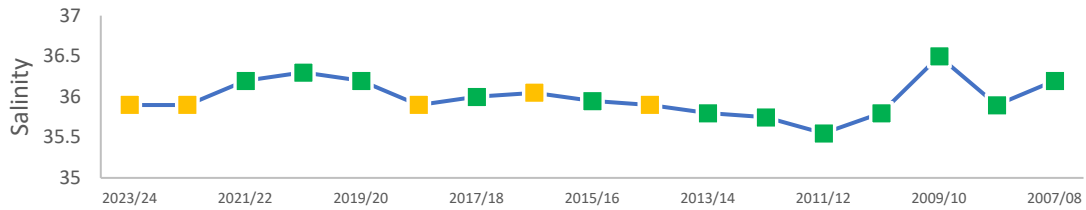
1. EQG = Environmental Quality Guideline; EQS = Environmental Quality Standard



Notes:

1. Error bars represent ±95% confidence intervals; n = 8.
2. Salinity measured in the top 0–0.5 m of the water column.
3. Dark blue line = 80th percentile of historical reference sites; light blue dashed line = 20th percentile of historical reference sites.
4. LEPA = Low Ecological Protection Area; HEPA = High Ecological Protection Area.
5. Data for each distance were pooled across eight sampling occasions (n=8) over December 2023–March 2024.

Figure 22 Median salinity down-current of the Sepia Depression outlet during the summer monitoring period



Note:

1. Green (■) symbols indicate the Environmental Quality Guideline (EQG) was met; amber (■) and red (■) symbols represent an exceedance of the EQG or Environmental Quality Standard (EQS), respectively.

Figure 23 Historical compliance of median salinity over time

4 Microbiological contaminants and algal biotoxins

4.1 Thermotolerant coliforms

TTC were sampled eight times over the 2023–2024 summer monitoring period (n = 40 samples). NHMRC (2008) and EPA (2005) guidelines require a minimum of 100 samples for accurate assessment of the EQC. Data from multiple years can be pooled where there are <100 samples provided local pollution conditions have not changed (NHMRC 2008). Assuming conditions have not changed, data collected over three summer monitoring periods (2021–2022, 2022–2023 and 2023–24) were pooled to yield 120 samples.

The median concentration of TTC derived from three years of pooled samples was equal to the limit of detection meeting the EQG (<10 CFU/100 mL; Table 17 and Table 18). Median concentration of TTC has never exceeded the limit of reporting (Figure 23). Over the three sampling periods, there were 4 instances where TTC exceeded 21 CFU/100 mL, representing 3.3% of samples and thus meeting the EQG (Table 17 and Table 19). The percentage of samples exceeding 21 CFU/100 mL was greater than the 10% EQG criteria on three occasions 2012/13, 2013/14 and 2014/15 (Figure 25). The percentage of samples exceeding 85 CFU/100 mL was greater than the 10% EQS criteria on the first of those occasions (in 2012/13, Figure 26).

Table 17 Environmental Quality Guideline for thermotolerant coliform concentrations

EQG	Median TTC concentrations at sites at the boundary of the SHEZ are not to exceed 14 CFU/100 mL with no more than 10% of the samples exceeding 21 CFU/100 mL as measured using the membrane filtration method

Note:

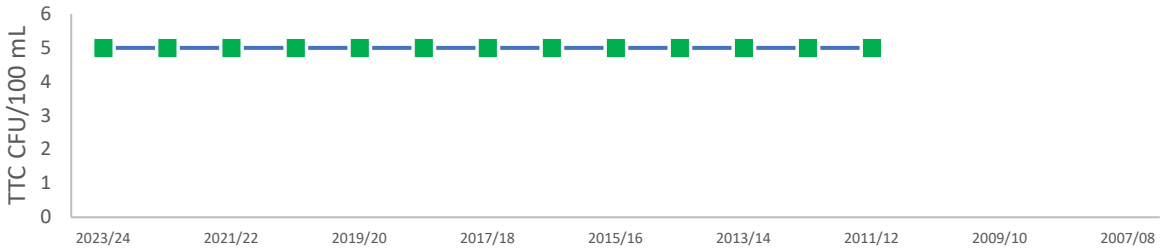
1. TTC = thermotolerant coliforms, SHEZ = Shellfish Harvesting Exclusion Zone, CFU = colony forming units.

Table 18 Median thermotolerant coliform concentration at the boundary of the Shellfish Harvesting Exclusion Zone for the Sepia Depression outlet pooled over 2021–2024 sampling periods

Sampling period	Median (CFU/100 mL)	Compliance
Dec 2021–Mar 2022	<10	■
Dec 2022–Mar 2023		
Dec 2023–Mar 2024		

Note:

1. Green (■) symbols indicate the Environmental Quality Criteria (EQC) were met; amber (■) and red (■) symbols represent an exceedance of the Environmental Quality Guideline (EQG) or Environmental Quality Standard (EQS), respectively.
2. Thermotolerant coliform results below the analytical detection limit (<10 CFU/100 mL) were halved (=5 CFU/100 mL) to calculate the median.
3. CFU = colony forming units.



Note:

1. Green (■) symbols indicate the Environmental Quality Guideline (EQG) was met; amber (■) and red (■) symbols represent an exceedance of the EQG or Environmental Quality Standard (EQS), respectively.

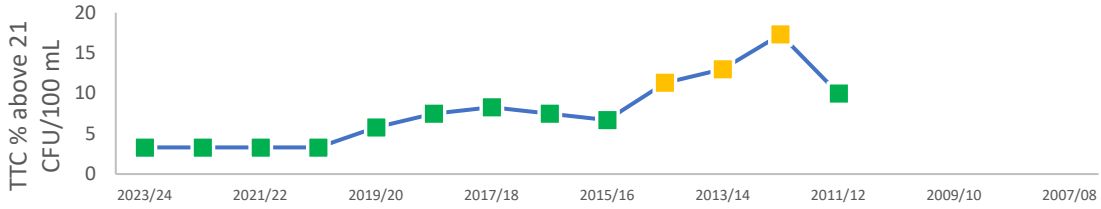
Figure 24 **Historical compliance of median thermotolerant coliforms over time**

Table 19 **Thermotolerant coliforms at sites on the boundary of the Shellfish Harvesting Exclusion Zone for the Sepia Depression ocean outlet pooled over 2021–2024 summer sampling periods that exceed 21 CFU/100 mL**

Sampling period	Date	Site	TTC Concentration (CFU/100 mL)	Compliance
Dec 2021–Mar 2022	14/02/2022	SD24	30	
		SD27	40	
Dec 2022–Mar 2023	24/03/2023	SD28	60	
Dec 2023–Mar 2024	20/03/2023	SD23	50	
% total samples (n = 120) >21 CFU/100 mL = 3.3%				

Notes:

1. Green (■) symbols indicate the Environmental Quality Criteria (EQC) were met; amber (■) and red (■) symbols represent an exceedance of the Environmental Quality Guideline (EQG) or Environmental Quality Standard (EQS), respectively.
2. CFU = colony forming units; EQG = Environmental Quality Guideline; SHEZ = Shellfish Harvesting Exclusion Zone; TTC = thermotolerant coliforms.



Note:

1. Green (■) symbols indicate the Environmental Quality Guideline (EQG) was met; amber (■) and red (■) symbols represent an exceedance of the EQG or Environmental Quality Standard (EQS), respectively.

Figure 25 **Historical compliance of percentage of thermotolerant coliform samples over 21 CFU/100 mL**

Note:

1. Green (■) symbols indicate the Environmental Quality Guideline (EQG) was met; amber (■) and red (■) symbols represent an exceedance of the EQG or Environmental Quality Standard (EQS), respectively.

Figure 26 Historical compliance of the percentage of thermotolerant coliform samples over 85 CFU/100 mL

4.2 Toxic phytoplankton species

There was one instance, on 04 December 2023, where the concentration of the toxic phytoplankton species *Gymnodinium* spp. (1760 cells/L) exceeded the Western Australian Shellfish Quality Assurance Program (WASQAP; DoH, DPIRD, and Industry, 2020) guideline value (1000 cells/L), however; this was at a reference site and the EQG was met (Table 20). There were no other instances where toxic phytoplankton species exceeded the WASQAP guideline values (Table 21, Appendix F).

For technical reasons (beyond the control of Water Corporation), phytoplankton samples are now analysed for the *Gymnodinium-Karenia* genera complex (GK Complex) rather than as individual species (Table 21). The accurate identification of both *Gymnodinium* and *Karenia* genera (also including the *Karlodinium* genus) can be challenging due to subtle taxonomic differences (Daugbjerg et al., 2000; Heimann, 2012). The WASQAP, as outlined in the DoH & DoF (2007), lacks a guideline for the GK Complex. An updated *Gymnodinium-Karenia* guideline has been developed (DoH, DPIRD, and Industry, 2020). The criteria outlined in the most recent WASQAP guidelines (DoH, DPIRD, and Industry, 2020) were met. Toxic phytoplankton exceeding WASQAP concentrations have been present on 2 occasions historically (Figure 27).

Table 20 Environmental Quality Guideline for toxic phytoplankton species

EQG	Cell counts of potentially toxic algae species at sites at the boundary of the SHEZ are not to exceed the WASQAP[1] trigger concentrations for any of the following: • *Alexandrium* spp. (100 cells/L) • *Gymnodinium* spp. (1000 cells/L) • *Karenia* spp. (1000 cells/L) • *Dinophysis* spp. (500 cells/L) • *Dinophysis acuminata* (3000 cells/L) • *Prorocentrum lima* (500 cells/L) • *Pseudo-nitzchia* spp. (250 000 cells/L) • *Gonyaulax cf. spinifera* (100 cells/L) • *Protoceratium reticulatum (Gonyaulax grindleyi)* (500 cells/L)

Notes:

1. Western Australian Shellfish Quality Assurance Program (WASQAP) Operations Manual (DoF 2007), as outlined in the Management Plan (BMT Oceanica 2014).
2. SHEZ = Shellfish Harvesting Exclusion Zone.

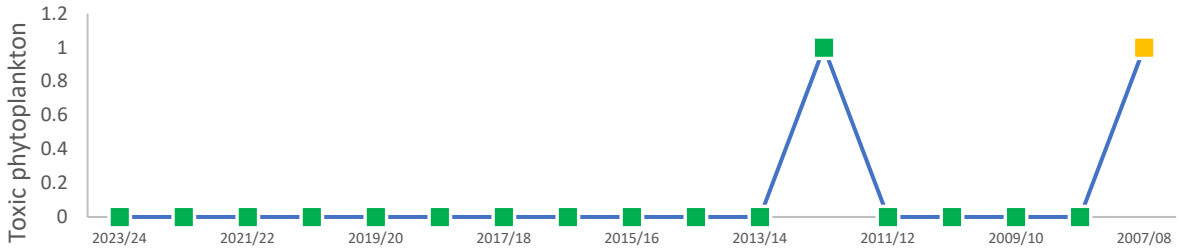
Table 21 **Estimated cell densities of phytoplankton species known to produce toxins at sites on the boundary of the Shellfish Harvesting Exclusion Zone for the Sepia Depression outlet**

Date	Site[1]	Species	Estimated density (cells/L)	WASQAP guideline[2] (cells/L)	Compliance
04/12/2023	SDR2	GK Complex (*Gymnodium-Karenia* Complex)	80	250,000[5]	N/A
		Gymnodium spp.	1760[6]	1000	
		Karenia papilionaceae	80	1000	
		Dinophysis spp.	80	500	
		Pseudo-nitzschia "delicatissima" group	1520	250,000	
		Pseudo-nitzschia "seriata" group	1280	250,000	
	SD19	GK Complex (*Gymnodium-Karenia* Complex)	80	250,000[5]	
		Karenia papilionaceae	80	1000	
		Dinophysis spp	80	500	
		Pseudo-nitzschia "seriata" group	960	250,000	
12/12/2023	SDR3	*Pseudo-nitzschia* "delicatissima" group	960	250,000	N/A
		Pseudo-nitzschia "seriata" group	160	250,000	
		Gonyaulax spinifera	80	100	
		Gymnodinium spp.	160	1000	
	SD32	*Pseudo-nitzschia* "delicatissima" group	2560	250,000	
		Pseudo-nitzschia "seriata" group	640	250,000	
		Gymnodinium spp.	400	1000	
4/01/2024	SDR1	*Pseudo-nitzschia* "delicatissima" group	4800	250,000	N/A
		Gymnodinium spp.	80	1000	
	SD27	*Pseudo-nitzschia* "delicatissima" group	2400	250,000	
15/01/2024	SDR3	*Pseudo-nitzschia* "delicatissima" group	25,280	250,000	N/A
		Gymnodinium spp.	80	1000	
		Dinophysis spp	80	500	

Date	Site[1]	Species	Estimated density (cells/L)	WASQAP guideline[2] (cells/L)	Compliance
	SD30	*Pseudo-nitzschia* “delicatissima” group	11,440	250,000	
		Gymnodinium spp.	80	1000	
02/02/2024	SDR4	*Pseudo-nitzschia* “delicatissima” group	16,480	250,000	N/A
		Pseudo-nitzschia “seriata” group	320	250,000	
	SD23	*Pseudo-nitzschia* “delicatissima” group	17,120	250,000	
		Pseudo-nitzschia “seriata” group	720	250,000	
19/02/2024	SDR3	*Pseudo-nitzschia* “delicatissima” group	640	250,000	N/A
		Gymnodinium spp.	80	1000	
	SD30	*Pseudo-nitzschia* “delicatissima” group	1920	250,000	
		Pseudo-nitzschia “seriata” group	80	250,000	
2/03/2024	SDR1	*Pseudo-nitzschia* “delicatissima” group	5920	250,000	N/A
		Pseudo-nitzschia “seriata” group	720	250,000	
	SD31	Nil	–	–	
19/03/2024	SDR2	*Pseudo-nitzschia* “delicatissima” group	160	250,000	N/A
		Pseudo-nitzschia “seriata” group	800	250,000	
		Gymnodinium spp.	160	1000	
	SD22	GK Complex (*Gymnodium-Karenia* Complex	80	250,000	
		Pseudo-nitzschia “delicatissima” group	80	250,000	
		Gymnodinium spp.	80	1000	

Notes:

1. Samples were analysed for one monitoring site and one reference site per sampling occasion.
2. Western Australian Shellfish Quality Assurance Program (WASQAP) (DoH & DoF 2007).
3. – = no toxic species detected, NA = not applicable.
4. Green (■) symbols indicate the Environmental Quality Criteria (EQC) were met; amber (■) and red (■) symbols represent an exceedance of the Environmental Quality Guideline (EQG) or Environmental Quality Standard (EQS), respectively.
5. Karenia/Karlodinium/Gymnodinium group trigger from DoH, DPIRD and Industry (2020).
6. Not an EQG exceedance as the sample was from the reference site.
7. If the EQG is exceeded, assessment will proceed against the EQS for sentinel mussel tissues.



Note:

1. Green (■) symbols indicate the Environmental Quality Guideline (EQG) was met; amber (■) and red (■) symbols represent an exceedance of the EQG or Environmental Quality Standard (EQS), respectively.

Figure 27 Historical compliance of exceedances of toxic phytoplankton criteria over time

4.3 Faecal pathogens (*Enterococci* spp.)

Samples were collected eight times over the 2023–2024 summer monitoring period (yielding a total of 40 samples) for faecal pathogen analyses. NHMRC (2008) guidelines and EPA (2005) require a minimum of 100 samples over the monitoring period for accurate assessment of the EQC. Data from multiple years can be pooled where there are less than 100 samples provided local pollution conditions have not changed (NHMRC 2008). Assuming conditions have not changed, data from the past three summers (2021–2024) were pooled to yield 120 samples. The EQG for primary and secondary contact recreation are outlined in Table 22.

The 95th percentile of *Enterococci* spp. concentrations based on 120 samples was 1900 MPN/100 mL (Table 23), exceeding the EQG (Table 22) for primary contact recreation (200 MPN/100 mL) and triggering assessment against the EQS. The 95th percentile of *Enterococci* spp. (1900 MPN/100 mL) also exceeded the EQS for primary contact recreation (500 MPN/100 mL) (Table 23). Worst case (95th percentile) concentrations appear to have increased gradually over time. The 95th percentile concentrations have always exceeded both the primary contact EQG (Figure 28) and EQS (Figure 29). The 95th percentile concentrations exceeded the secondary contact EQG in two recent years (Figure 30) but the EQS has always been met (Figure 31).

Table 22 Environmental Quality Criteria for contact recreation

Primary	EQG	The 95th percentile of bacterial contact of marine waters should not exceed 200 *Enterococci*/100 mL
Primary	EQS	The 95th percentile of bacterial contact of marine waters should not exceed 500 *Enterococci*/100 mL
Secondary	EQG	The 95th percentile of bacterial contact of marine waters should not exceed 2000 *Enterococci*/100 mL
Secondary	EQS	The 95th percentile of bacterial contact of marine waters should not exceed 5000 *Enterococci*/100 mL

Until 2013/14, primary contact recreation had been managed (albeit informally) against the ANZECC (1992) criteria (median *Enterococci spp*. concentrations <35 MPN/100 mL). Development of the MMP formalised the monitoring regime and updated the approach to the contemporary and best practice EQMF including adopting the EPA (2005) criteria (the 95th percentile *Enterococci* spp. concentration <200 MPN/100 mL). The informal management boundaries that applied historically were not altered accordingly and exceedance of the EPA's recreational contact criteria is an artefact of the change of criteria. Median *Enterococci spp*. concentration for the 2023/2024 monitoring season (63 MPN/100 mL) exceeded the previous ANZECC (1992) criteria for the first time since the 2017/2018 monitoring period but were still within the historical median range (up to 69 MPN/100 mL). Although not unprecedented, the recent exceedance of the previous criteria along with the gradual increase in the range of values, suggest that further investigation will be warranted in the event of an exceedance of the median criteria next year.

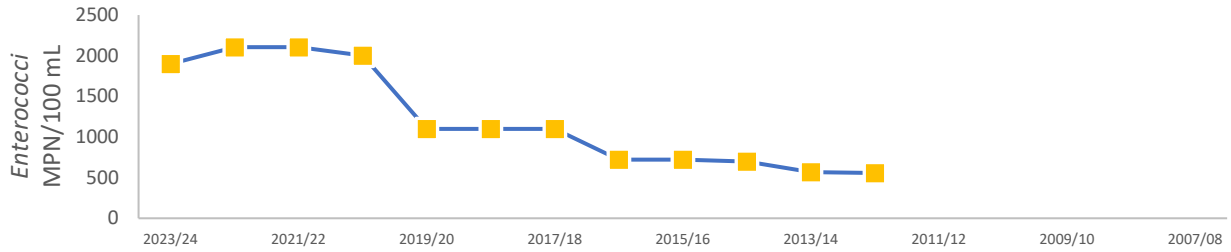
Exceedance of the EQG and EQS for primary contact recreation was reported to Department of Health and Department of Water and Environmental Regulation as per the SDOOL MMP (BMT Oceanica 2014).

Table 23 **The 95th percentile of *Enterococci* spp. concentrations at the boundary Recreational Contact Exclusion Zone for the Sepia Depression ocean outlet**

Sampling period	95th percentile (MPN/100 mL)	Environmental Quality Criteria		Compliance
Dec 2021–Mar 2022 Dec 2022–Mar 2023 Dec 2023–Mar 2024	1900	EQG (primary contact)	95th percentile <200 MPN/100 mL	
		EQS (primary contact)	95th percentile <500 MPN/100 mL	
		EQG (secondary contact)	95th percentile <2000 MPN/100 mL	

Notes:

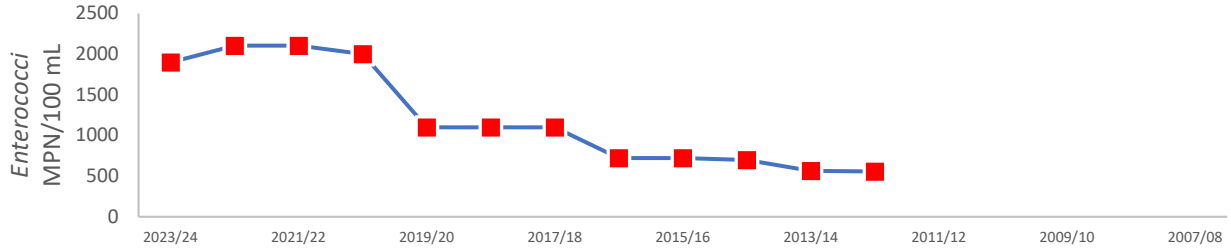
1. Green symbols (■) indicate Environmental Quality Guideline (EQG) were met, amber (■) and red (■) symbols represent an exceedance of the EQG and Environmental Quality Standard (EQS) respectively.
2. *Enterococci* spp. concentrations below the analytical detection limit (<10 *Enterococci* spp. MPN/100 mL) were halved (=5 MPN/100 mL) to calculate the 95th percentile.
3. MPN = most probably number of *Enterococci* spp.



Note:

1. Green (■) symbols indicate the Environmental Quality Guideline (EQG) was met; amber (■) and red (■) symbols represent an exceedance of the EQG or Environmental Quality Standard (EQS), respectively.

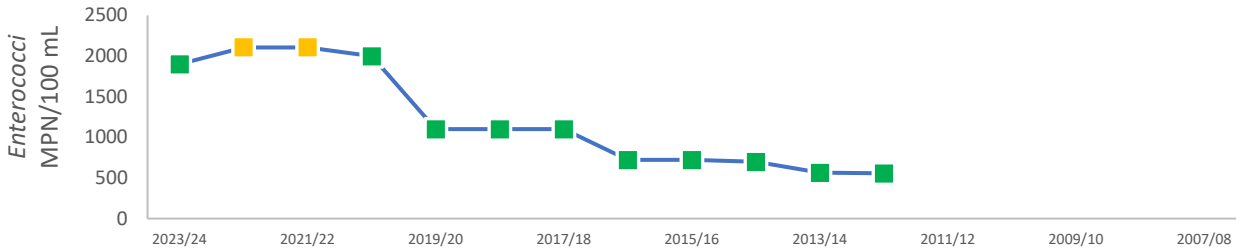
Figure 28 **Historical compliance of the 95th percentile Enterococci spp. over time (with assessment against the primary contact EQG)**



Note:

1. Green (■) symbols indicate the Environmental Quality Guideline (EQG) was met; amber (■) and red (■) symbols represent an exceedance of the EQG or Environmental Quality Standard (EQS), respectively.

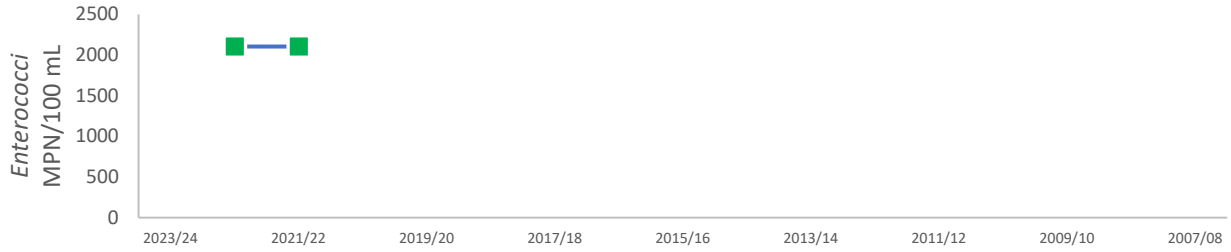
Figure 29 **Historical compliance of the 95th percentile Enterococci spp. over time (with assessment against the primary contact EQS)**



Note:

1. Green (■) symbols indicate the Environmental Quality Guideline (EQG) was met; amber (■) and red (■) symbols represent an exceedance of the EQG or Environmental Quality Standard (EQS), respectively.

Figure 30 Historical compliance of the 95th percentile Enterococci spp. over time (with assessment against the secondary contact EQG)



Note:

1. Green (■) symbols indicate the Environmental Quality Guideline (EQG) was met; amber (■) and red (■) symbols represent an exceedance of the EQG or Environmental Quality Standard (EQS), respectively.

Figure 31 Historical compliance of 95th percentile Enterococci spp. over time (with assessment against the secondary contact EQS)

4.4 Phytoplankton cell concentrations

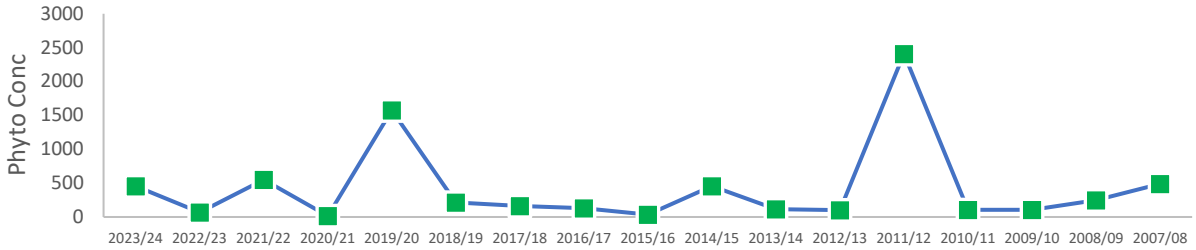
The highest phytoplankton cell concentration in any sample was 457 cells/mL and the median total phytoplankton cell concentration was 36 cells/mL (Table 24) and the EQG was met (Table 25). The highest phytoplankton cell concentration in any sample over time has never exceeded the 15,000 cell/mL criteria (EPA 2000).

Table 24 Environmental Quality Guideline for phytoplankton cell count

EQG	**Median total phytoplankton cell concentration for the area of concern should not exceed 15 000 cells/mL**

Table 25 **Estimated phytoplankton total cell densities collected at fixed monitoring sites down-current of the Sepia Depression outlet for contact recreation**

Date	Site	Total density (cells/mL)	Compliance
04/12/2023	SD3	457	
12/12/2023	SD13	197	
04/01/2024	SD8	104	
15/01/2024	SD3	7	
02/02/2024	SD5	61	
19/02/2024	SD14	11	
11/03/2024	SD2	4	
20/02/2024	SD8	4	
Median (all data)		**36**	



Note:

1. Green (■) symbols indicate the Environmental Quality Guideline (EQG) was met; amber (■) and red (■) symbols represent an exceedance of the EQG or Environmental Quality Standard (EQS), respectively.

Figure 32 **Historical compliance of the highest algal density in any sample over time**

5 Aesthetics

Aesthetic quality was assessed fortnightly via a questionnaire completed by field personnel on eight occasions during the non-river flow period (Table 26). On each occasion, the questionnaire was completed at one location on the post upgrade boundary down-current of the diffuser. Water clarity around the outlet (mean LAC 350 m from the diffuser, pooled from all days) was compared against water clarity at a greater distance from the outlet (mean LAC at 1500 m from the diffuser from all days pooled). Water Corporation also maintains a complaints register for the SDOOL program.

Table 26 Environmental Quality Criteria for Recreation and Aesthetics

Indicator	Environmental Quality Criteria	
	EQG	EQS
Nuisance organisms	Macrophytes, phytoplankton scums, filamentous algal mats, blue-green algae and sewage fungus should not be present in excessive amounts	There should be no overall decrease in the aesthetic water quality values of Cockburn Sound using direct measures of the community's perception of aesthetic value.
Faunal deaths	There should be no reported incidents of large-scale deaths of marine organisms relating from unnatural causes.	
Water clarity	The natural visual clarity of the water should not be reduced by more than 20%	
Colour	The natural hue of the water should not be changed by more than ten points on the Munsell scale.	
Surface films	Oil and petrochemicals should not be noticeable as a visible film on the water or detectable by odour.	
Surface debris	Water surfaces should be free of floating debris, dust and other objectionable matter, including substances that cause foaming.	
Odour	There should be no objectionable odour.	
Fish tainting substances	Concentrations of contaminants will not exceed the aesthetics guidelines for fish tainting substances at the Shellfish Harvesting Exclusion Zone.	There should be no detectable tainting of edible fish harvested outside the Shellfish Harvesting Exclusion Zone.

The field surveys observed algae/plant material visible on the surface on 37.5% of occasions (Table 27). No dead marine organisms were visible on any occasion (Table 27). There was noticeable colour variation on 12.5% of occasions (Table 27). There were no films or oil on the surface or floating debris on any sampling occasion (Table 27). There was a noticeable odour associated on 37.5% of the

sampling occasions (Table 27). There was no overall decrease in the aesthetic water quality values of Cockburn Sound using direct measures of the community's perception of aesthetic value.

Mean LAC at 350 m from the ocean outlet (0.0770 Log_{10}/m) was slightly higher than at 1500 m distance from the outlet (0.0666 Log_{10}/m) suggesting that light was more quickly attenuated at 350 m than 1500 m (Table 28). Overall water clarity was reduced by ~13.5% and therefore the EQG that the natural visual clarity of the water should not be reduced by more than 20% was met.

Fish tainting substances in the comprehensive TWW characterisation sample collected on 15 January 2024 did not exceed the EPA (2005) aesthetic guidelines for fish tainting substances (Table 29). Hexachlorocyclopentadiene and 2,4 – Dichlorophenol concentrations in the TWW sample were below the limit of reporting, but the LoR was greater than the aesthetic guideline for fish tainting substances (Table 34). Any potential exceedance would be considered negligible after initial dilution.

Table 27 **Aesthetic observations and measurements at selected sites on the post upgrade boundary down-current of the Sepia Depression ocean outlet**

Date	Site	Algae/ plant material?	Dead marine organisms?	Secchi depth (m)	Colour variation?	Oil or other films?	Floating debris?	Odour?	Cotton Buds?
04/12/2023	SD3	No	No	11.5	No	No	No	No	No
12/12/2023	SD1	No	No	13	No	No	No	No	No
4/01/2024	SD9	Yes	No	9.5	No	No	No	Yes	No
15/01/2024	SD1	Yes	No	15	No	No	No	No	No
02/02/2024	SD7	No	No	9	No	No	No	Yes	No
19/02/2024	SD16	No	No	11.6	No	No	No	Yes	No
11/03/2024	SD4	No	No	8.5	No	No	No	No	No
20/02/2024	SD8	Yes	No	10	Yes	No	No	No	No

Table 28 **Light attenuation coefficient at sites 350 m and 1500 m from the Sepia Depression ocean outlet from December 2023 to March 2024**

Date	Light attenuation coefficient (Log^{10}/m)	
	350 m (site SDT-350 m)	1500 m (site SDT – 1500 m)
04/12/2023	0.0901	0.0795
12/12/2023	0.0534	0.0559
4/01/2024	0.0692	0.0592

Date	Light attenuation coefficient (Log^{10}/m)	
	350 m (site SDT-350 m)	1500 m (site SDT – 1500 m)
15/01/2024	0.0623	0.0627
02/02/2024	0.0909	0.0631
19/02/2024	0.0906	0.0775
11/03/2024	0.0776	0.0572
20/02/2024	0.0817	0.0780
Mean	**0.0770**	**0.0666**

Table 29 **Toxicants in the Sepia Depression treated wastewater on 15 January 2024 and guidelines for fish tainting substances**

Toxicants	Aesthetics guidelines (fish tainting) (µg/L)	Sepia Depression TWW concentration (µg/L)
Copper	1000	17
Zinc	5000	65
Phenol	300	<1
2,4 – Dichlorophenol	0.3	<1
2,4,6 – Trichlorophenol	2	<2
Pentachlorophenol	30	<2
Hexachlorocyclopentadiene	1	<20
Nitrobenzene	30	<20
Toluene	250	<1
Ethylbenzene	250	<1
Naphthalene	1000	<0.01
Acenaphthene	20	<0.01

Notes:
1. Bold numbers are where the limit of reporting is greater than the guideline.
2. Guideline values obtained from EPA (2017)

6 Shoreline monitoring

6.1 Thermotolerant coliforms

TTC were sampled at eight shoreline monitoring sites eight times over the 2023–2024 summer period (yielding a total of 64 samples). NHMRC (2008) guidelines and EPA (2005) recommend that a minimum of 100 samples is needed for accurate assessment of the EQG. Data from multiple years can be pooled where there are <100 samples provided local pollution conditions have not changed (NHRMC 2008). Assuming conditions have not changed, data collected over two summers were pooled to yield 128 samples.

The shoreline sites are not formally assessed against the EQC but the median and 90th percentile TTC concentrations derived from the 128 samples were less than the limit of detection (<10 CFU/100 mL; Table 30, Appendix G) and less than the 14 and 21 CFU/100 mL criteria, respectively meeting the EQG (Table 17).

Table 30 Median and 90th percentile of thermotolerant coliform concentrations at the shoreline monitoring sites for the Sepia Depression outlet pooled over for 2022–2024 sampling periods

Sampling period	Median (CFU/100 mL)	90th percentile (CFU/100 mL)	Compliance (EQG)
Dec 2022–Mar 2023 Dec 2023–Mar 2024	<10	<10	■

Notes:
1. Green symbols (■) indicate the Environmental Quality Criteria (EQC) were met, amber (■) and red (■) symbols represent an exceedance of the Environmental Quality Guideline (EQG) and Environmental Quality Standard (EQS), respectively.
2. Thermotolerant coliform results below the analytical detection limit (<10 CFU/100 mL) were halved (=5 CFU/100 mL) to calculate the median and 90th percentile.
3. CFU = Colony forming unit.

6.2 Faecal pathogens (*Enterococci* spp.)

Samples were collected eight times at eight shoreline monitoring sites over the 2023–2024 summer monitoring period (yielding a total of 64 samples) for faecal pathogens analyses. NHMRC (2008) and EPA (2005) recommend a minimum of 100 samples over the monitoring period are required for accurate assessment of the EQC. Data from multiple years can be pooled where there are less than 100 samples provided local pollution conditions have not changed (NHMRC 2008). Assuming conditions have not changed, data collected over two summers were pooled to yield 128 samples.

Shoreline sites are not formally assessed against the EQC against the EQC but the 95th percentile of *Enterococci* spp. derived from the 128 samples at the shoreline monitoring sites for the Sepia Depression ocean outlets was <10 MPN/100 mL (Table 31), and met both the primary (<200 MPN/100 mL) and secondary (<2000 MPN/100 mL) contact recreation EQGs (Table 22) .

Table 31 **The 95th percentile of *Enterococci* spp. concentrations at the shoreline monitoring sites for the Sepia Depression ocean outlet pooled over the 2022–2024 sampling periods**

Sampling period	95th percentile (MPN/100 mL)	Compliance	
		Primary contact	Secondary contact
Dec 2022–Mar 2023 Dec 2023–Mar 2024	<10	■	■

Notes:

1. Green symbols (■) indicate the Environmental Quality Criteria (EQC) were met; amber (■) and red (■) symbols represent an exceedance of the Environmental Quality Guideline (EQG) and Environmental Quality Standard (EQS), respectively.
2. *Enterococci* spp. concentrations below the analytical detection limit (<10 *Enterococci* spp. MPN/100 mL) were halved (=5 MPN/100 mL) to calculate the 95th percentile.
3. MPN = most probable number of *Enterococci* spp.

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