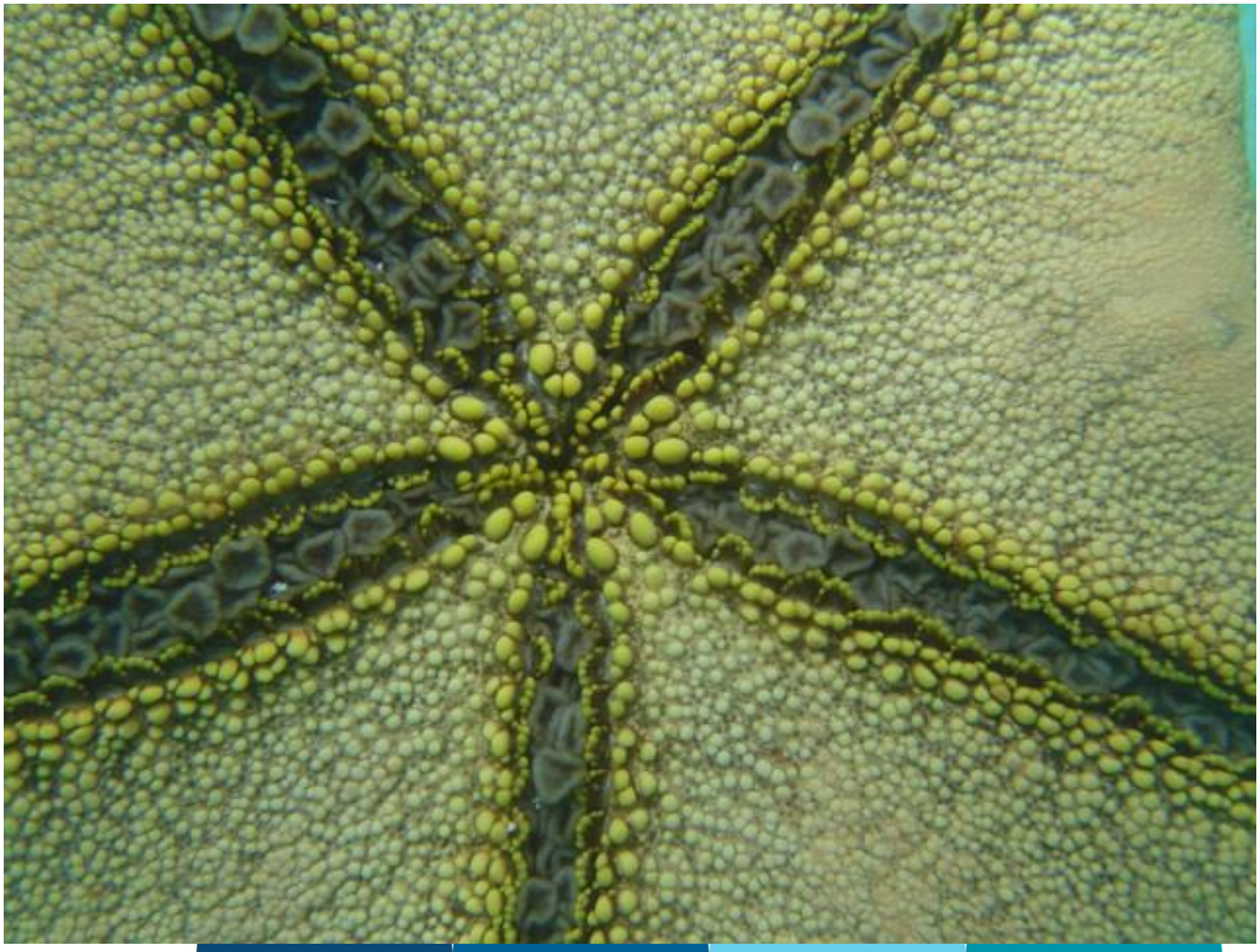
Bunbury Water Resource Recovery Facility Ocean Outlet Monitoring Program

Annual Report 2021/2022



WATER CORPORATION

This report has been prepared for Water Corporation by BMT, October 2022 Report Number R-10976-1

Document history

Distribution

Revision	Author	Recipients	Organisation	No. copies & format	Date
A	G Cummins	M Lourey	BMT	1 x docm	06/10/2022
B	G Cummins	J Phillips	Water Corporation	1 x pdf	07/10/2022
0	G Cummins	J Phillips	Water Corporation	1 x pdf	18/10/2022

Review

Revision	Reviewer	Intent	Date
A	M Lourey	Technical Review	06/10/2022
B	J Phillips	Client Review	13/10/2022

Quality Assurance

WWW.JAS-ANZ.ORG/REGISTER

BMT Commercial Australia Pty Ltd has prepared this report in accordance with our Integrated Management System, in compliance with OHSAS18001, ISO14001 and ISO9001

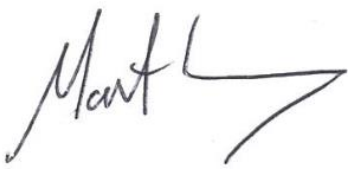
Status

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.

Approved for final release:

Author

Date: 18/10/2022



Director (or delegate)

Date: 18/10/2022

Contents

Acronyms

ANZECC/ARMCANZ	Australian and New Zealand Guidelines for Fresh and Marine Water Quality
CFU	Colony forming unit
DoH	Department of Health
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
MPN	Most probable number
NATA	National Association of Testing Authorities
SHEZ	Shellfish harvesting exclusion zone
TTC	Thermotolerant coliforms
TTM	Total toxicity of the mixture
TWW	Treated wastewater
WASQAP	Western Australian Shellfish Quality Assurance Program
WRRF	Water Resource Recovery Facility

Executive Summary

This report documents the results of 2021–2022 marine environmental monitoring around the Bunbury ocean outlet. The monitoring has been carried out in accordance with the requirements of the Marine Impacts Monitoring and Management Plan (MIMMP; Water Corporation 2012). The monitoring program aims to determine the physical and chemical properties of the treated wastewater plume and establish its effect on the receiving marine environment. Results are reported in the context of the Environmental Quality Management Framework (EQMF) in accordance with the MIMMP (Water Corporation 2012) or EPA (2017). 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– Table ES 4).

Table ES 1 Summary report card legend

Management response	Colour
Monitor: EQG 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.

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

Environmental quality indicator		EQC	Comments	Compliance
Toxicants in treated wastewater (TWW)	Bioaccumulating toxicants	EQG	Concentrations of cadmium and mercury in the undiluted TWW stream were below the analytical limit of reporting and ANZECC/ARMCANZ (2000) 80% species protection guideline	
	Non-bioaccumulating toxicants and initial dilution	EQG	Total ammonia, copper and zinc concentrations exceeded ANZECC/ARMCANZ (2000) guidelines in TWW prior to initial dilution. Initial dilution (of 1:270 expected at the LEPA boundary) was sufficient to reduce contaminant concentrations to below the associated ANZECC/ARMCANZ (2000) 99% species protection guidelines.	
	Total toxicity of the mixture (TTM)	EQG	The TTM for the additive effect of ammonia, copper and zinc after initial dilution was 0.37 and below the ANZECC/ARMCANZ (2000) guideline value of 1.0	
Nutrient enrichment indicators of	Chlorophyll-a	EQG	Median concentration of chlorophyll-a at compliance sites was equal to	

increased nutrients and algal growth potential			(and did not exceed) the 80th percentile of reference site data	
	Phytoplankton biomass (measured as chlorophyll-a)	EQG	Chlorophyll-a concentration did not exceed 3 times the median of chlorophyll-a concentration of reference site data, on any occasion during summer monitoring	■
	Light attenuation coefficient (LAC)	EQG	Median light attenuation measured over the summer period at compliance sites did not exceed the 80th percentile of historical reference site data.	■
	Periphyton chlorophyll-a	EQG	Median concentration of periphyton biomass at compliance sites was below the 80th percentile of reference site data.	■
	Seagrass health	EQS	All nutrient enrichment water quality monitoring EQG were met during the 2022 monitoring and assessment against the seagrass health EQS was not required	NA
Physico-chemical stressor	Dissolved oxygen % saturation	EQG	Dissolved oxygen saturation in bottom waters remained above 90% saturation at all times.	■

Notes:

1. Green (■) symbols indicate the Environmental Quality Criteria (EQC) were met; amber (■) and red (■) symbols represent an exceedance of the Environmental Quality Guideline or Environmental Quality Standard (EQS), respectively.
2. TWW = treated wastewater, EQC = Environmental Quality Criteria, EQG = Environmental Quality Guidelines, EQS = Environmental Quality Standard, LEPA = Low Ecological Protection Area (100 m from diffuser).

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

Environmental quality indicator		EQC	Comments	Compliance
Microbial contaminants	Thermotolerant coliforms (TTC)	EQG	Median TTC concentrations (<10 CFU/100 mL) did not exceed 14 CFU/100 mL and less than 10% of samples exceeded 21 CFU/100 mL	■
Algal biotoxins	Toxic phytoplankton species	EQG	No toxic phytoplankton species were recorded in numbers greater than WASQAP trigger values (DoF 2007)	■

Notes:

1. Green (■) symbols indicate the Environmental Quality Criteria (EQC) were met; amber (■) and red (■) symbols represent an exceedance of the Environmental Quality Guideline or Environmental Quality Standard (EQS), respectively.
2. WASQAP = Western Australia Shellfish Quality Assurance Program (DoF 2007)

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

Environmental Quality Indicator		EQC	Comments	Compliance
Faecal pathogens	Enterococci spp.	EQG	All sites had Enterococci spp. concentrations between <10 and 10 MPN/100 mL. Therefore, the 95th percentile of pooled Enterococci spp. concentrations was <40 MPN/100 mL	■
Algal biotoxins	Phytoplankton (cell concentration)	EQG	The toxic algal species of concern (*Karenia brevis*, *Lyngbya majuscula* and *Pfiesteria* spp.) were not recorded	■

Note:

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

1 Introduction

1.1 Document purpose

Water Corporation is required to ensure that the discharge of treated wastewater (TWW) from the Bunbury Water Resource Recovery Facility (WRRF) to the marine environment is environmentally sustainable and managed appropriately for the protection of ecosystem and social values. To meet this outcome, Water Corporation undertake their operations in accordance with environmental commitments and Licence Conditions that are outlined in Ministerial Statement (MS) 572.

The Bunbury Operations Environmental Management program and the Marine Impacts Monitoring and Management Plan (MIMMP; Water Corporation 2012) for the Bunbury Ocean Outlet were designed according to Schedule 2 (Proponent's Environmental Management Commitments) of MS 572. The monitoring for the 2021-2022 reporting period was carried out in accordance with the methods and criteria in Water Corporation (2012).

This report describes the results and outcomes of the 2021-2022 Bunbury Ocean Outlet Monitoring (BOOM) program field surveys. The program aims to determine the chemical and physical properties of the TWW plume and to determine the effects of TWW discharge on the receiving marine environment.

1.2 Plant infrastructure

Ocean disposal of TWW from the Bunbury WRRF commenced in July 2002. The Bunbury WRRF primarily services the City of Bunbury. On the 20 January 2022, the flow rate into Bunbury WRRF was 10.85 ML. Prior to disposal, the wastewater is treated using microbial processes to reduce concentrations of nitrogen via an intermittently decanting extended aeration plant. These processes produce secondary TWW and biosolids.

The ocean outlet is located ~7 km south of the Bunbury Central Business District, south-west Western Australia (Figure 1). TWW is discharged via a sub-sea diffuser 1.7 km perpendicular to the shoreline (Water Corporation 2012). The freshwater TWW is less dense than seawater and forms a buoyant plume that rises through the water column and mixes as it ascends.

Figure 1 Location of the Bunbury Water Resource Recovery Facility and ocean outlet

1.3 Conditions of operation

The Bunbury WRRF operates in accordance with Conditions outlined in MS 572. Conditions 6.1 and 6.2 of MS 572 include a requirement to ensure the ecological and social health objectives are met in their respective management areas.

1.4 Environmental Quality Management Framework

Monitoring was completed according to Western Australia's Environmental Quality Management Framework (EQMF; EPA 2016). 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 the associated EQO has been achieved. If the guideline is not met a more detailed assessment against the EQS is triggered.
2. Environmental Quality Standards (EQSs) are management triggers which, if exceeded, signify the EQO is at risk of not being met and that a management response may be required.

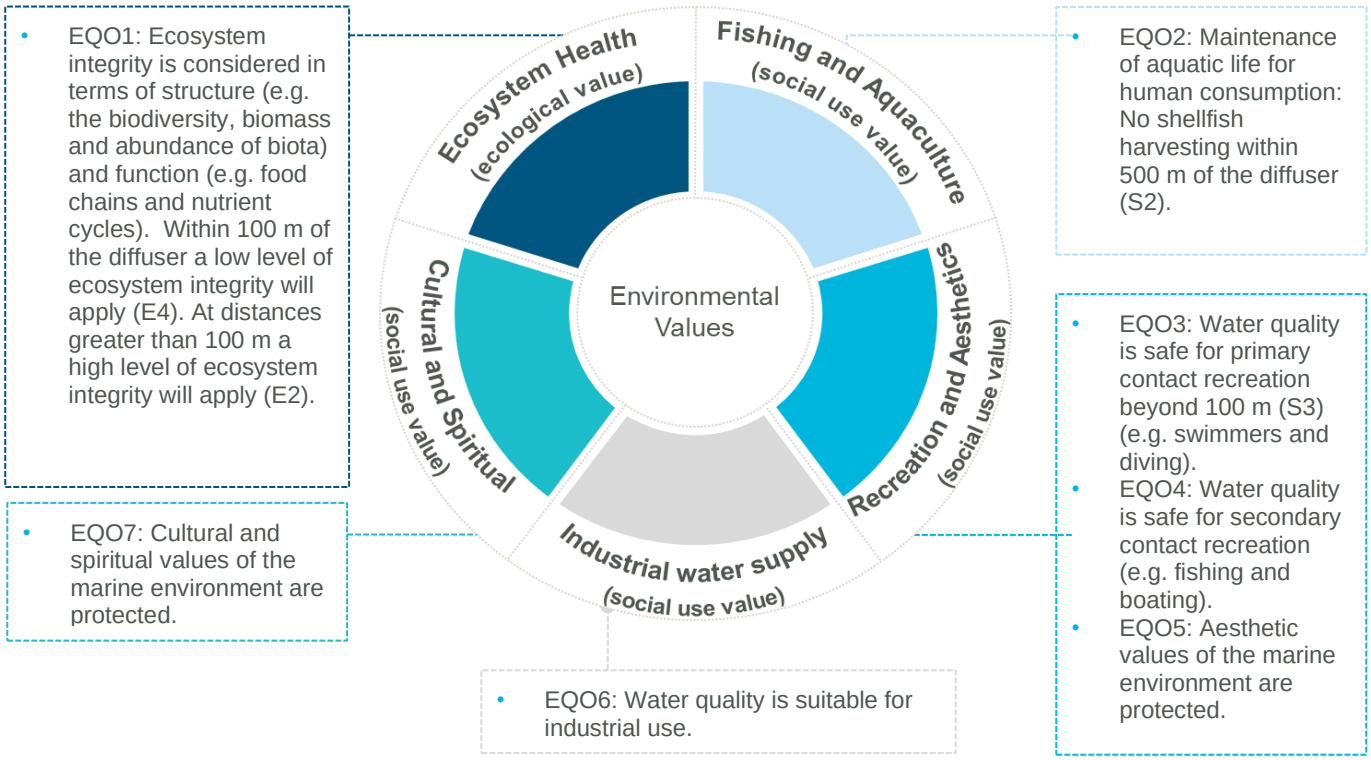


Figure 2 Establishing Values and Environmental Quality Objectives (EQO) for the marine waters of Western Australia

1.5 BOOM program framework

MS 572 requires that the EVs Ecosystem Health and Recreation and Aesthetics are maintained and the associated EQOs (EQO1, EQO3, EQO4 and EQO5; Figure 2) are met within 100 m of the Bunbury ocean outlet (Figure 3). MS 572 requires that the EV Fishing and Aquaculture is maintained and the associated EQOs (EQO2 Figure 2) are met within 500 m of the Bunbury ocean outlet (Figure 3).

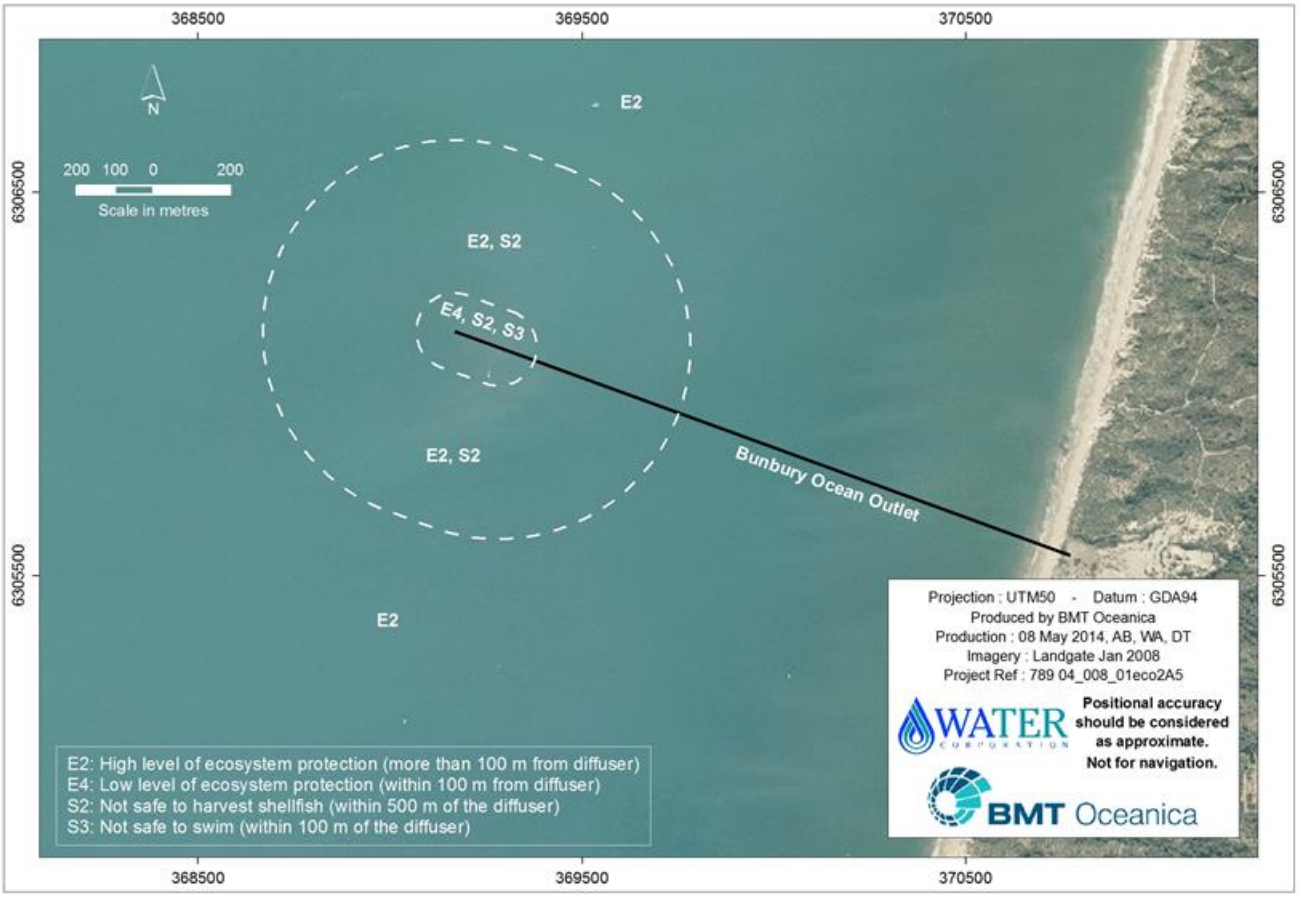


Figure 3 Environmental management areas as defined in Schedule 1 of Ministerial Statement 572

1.5.1 'Maintenance of ecosystem integrity' EQO

The intent of this EQO is to maintain a healthy and diverse ecosystem. The EQO applies a designated level of ecological protection: low, moderate, high, or maximum (Figure 4). A low level of ecological protection applies in the low ecological protection area (LEPA) occupying the area within a 100 m radius of the diffuser at the Bunbury outfall. Waters outside the LEPA are designated as a high ecological protection area (HEPA) and maintained to a high level of ecological protection.

The extent to which the EQO for the Maintenance of Ecosystem Integrity was met during the 2021–2022 reporting period is assessed against the EQC for waste stream characterisation (i.e. toxicants in TWW) and the EQC for receiving waters (i.e. water quality and seagrass health).

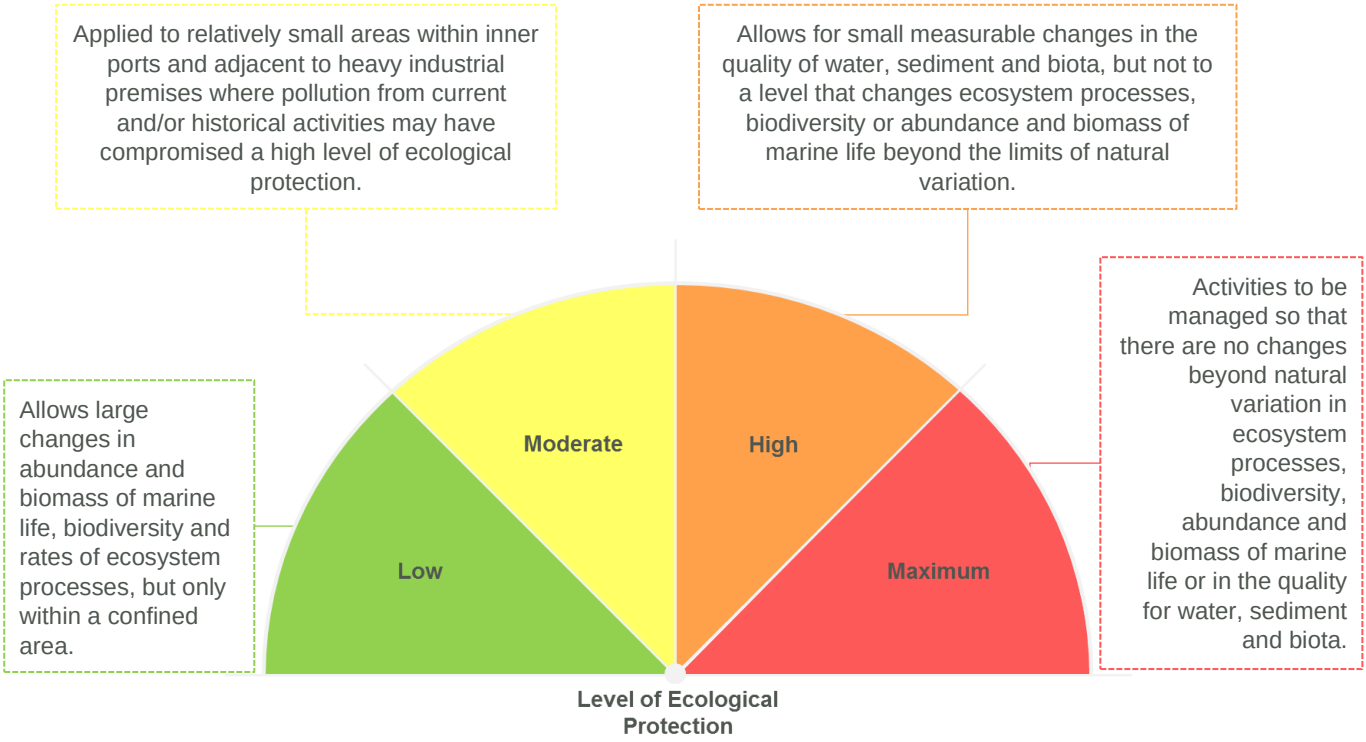


Figure 4 Level of Ecological Protection

1.5.2 'Maintenance of aquatic life for human consumption' EQO

The intent of this EQO is to maintain aquatic life safe for human consumption (a social value) except for a small area surrounding the ocean outlet within 500 m of the diffuser (S2; Figure 3), where shellfish may be unsafe to eat.

1.5.3 'Maintenance of primary and secondary contact recreation' EQO

Primary contact recreation will be maintained outside 100 m of the diffuser (S3; Figure 3). Secondary contact recreation is not to be affected by the presence of the Bunbury ocean outlet. As the EQO for maintenance of primary contact recreation uses a higher water quality standard than secondary contact recreation, it is assumed that if the primary contact criteria are met, then the secondary contact criteria are also met by default.

2 Waste stream monitoring

Monitoring of TWW prior to discharge consisted of:

- monthly TWW characterisation
- annual comprehensive TWW characterisation
- initial dilution monitoring.

2.1 Monthly treated wastewater characterisation

TWW from Pond 2 Discharge Weir was sampled on the second Tuesday of each month by Water Corporation and analysed for:

- total ammonium
- filtered biochemical oxygen demand (BOD)
- conductivity at 25 C
- total nitrogen (TN)
- total phosphorus (TP)
- nitrate and nitrite (NO_x)
- *Escherichia coliforms* (E. coli).

This regulatory monthly sampling is carried out in accordance with Bunbury No. 2 WRRF operating licence L5972/1922/14. The operating licence limit for total phosphorus of 10 mg/L was met during the July 2021–June 2022 reporting period (Table 1). All other discharge limits in the Schedule 1 Table of MS 572 (suspended solids, biochemical oxygen demand, total nitrogen and total nitrogen load), are reported separately.

Table 1 Regulatory monthly parameter results from Pond 2 Discharge Weir

Month	Total ammonium	Filtered BOD	TN	TP	pH	NOx	E. coli
Unit	mg/L	mg/L	mg/L	mg/L		mg/L	cells/100mL
LoR	NA	<5	NA	NA	NA	NA	NA
Jul 21	1.7	<5	6.3	4.3	7.8	3.0	3400
Aug 21	1.2	<5	7.4	3.7	7.7	3.8	>24000
Sept 21	3.5	5	10.0	4.6	7.4	3.7	5200
Oct 21	3.0	<5	10.0	4.2	7.8	4.7	>24000
Nov 21	3.7	5	11.0	3.6	7.6	4.8	>24000
Dec 21	2.5	<5	9.6	3.4	7.8	5.0	>24000
Jan 22	2.1	<5	10.0	4.2	7.8	5.6	>24000
Feb 22	2.6	<5	10.0	3.9	7.7	5.2	>24000
Mar 22	2.7	<5	8.7	3.3	7.6	3.5	>24000
Apr 22	2.5	<5	9.0	3.8	7.7	4.1	17000
May 22	3.1	<5	8.0	2.4	7.7	2.4	>24000
Jun 22	4.3	5	10.0	2.1	7.6	4.1	24000
Mean	**2.7**	**5**	**9.2**	**3.6**	**7.7**	**4.2**	**NA**

Note:

1. LoR = Limit of reporting, BOD = biological oxygen demand, TN = total nitrogen, TP = total phosphorus, NOx = nitrate+nitrite, E. coli = Escherichia coli, NA = not applicable.

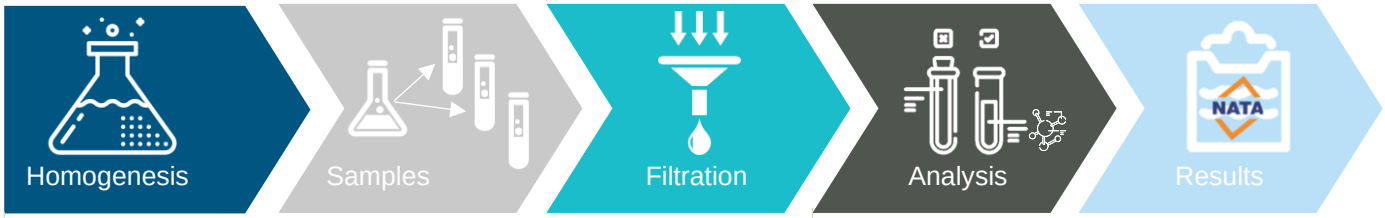
2.2 Comprehensive treated wastewater characterisation

TWW (final effluent) from the Bunbury WRRF was analysed for a suite of potential contaminants of concern:

- ammonium as nitrogen
- NO_x as nitrogen
- TP
- TSS
- BOD (5–day)
- salinity
- metals (Ag, As, Cd, Cr, Cu, Hg, Mo, Ni, Pb, Se, Zn)
- pesticides
- herbicides

A 24-hour flow weighted composite sample was obtained from the Bunbury WRRF on 20 January 2022.

Samples for bioavailable metals were filtered through a 0.45 µm filter prior to analyses.



The bulk sample was homogenised (agitated), split into individual sample containers and sent to a National Association of Testing Authorities (NATA)-accredited laboratory for analysis.

Samples were handled according to the NATA accredited laboratory requirement. Analyses were completed using NATA-accredited methods.

2.2.1 Initial dilution monitoring

The MIMMP requires the initial dilution of TWW to be estimated using two different methods (i) using an internationally recognised mixing model (in the case VPLUMES) simulation of the conditions at the time of sampling and (ii) using the concentrations of nutrients within TWW compared to the in-water estimates at the times of sampling (Water Corporation 2012). The most conservative (lowest) estimate of the two is used in further calculations and comparisons (Water Corporation 2012).

2.2.2 Initial dilution using model simulation

Initial dilution modelling (using plume dispersion model VPLUMES) was used to predict the near field dilution of the wastewater plume around the Bunbury ocean outlet. Initial dilution is the dilution between the point of discharge and the point of maximum rise or fall of the plume (in this case when the buoyant plume reaches the surface).

On 20 January 2022 (concurrent to the first summer water quality survey), ambient data (i.e. temperature and flow) were collected for input into the plume dispersion model. To determine the current velocity and direction at the time of sampling, a surface drogue was released above the outlet diffuser and the location of the drogue recorded at intervals over time using an on-board Global Positioning System. Surface current velocities were used to synthesise a vertical velocity profile based on the gradient determined by current meters deployed at 2 m and 7.5 m above the seabed ~900 m offshore from the diffuser at the Bunbury ocean outlet (WNI 2000).

Modelling using VPLUMES indicated an average initial dilution of 1:270 and a centreline dilution of 1:103 on 20 January 2022 (Figure 5). The full model output is included in Appendix A.

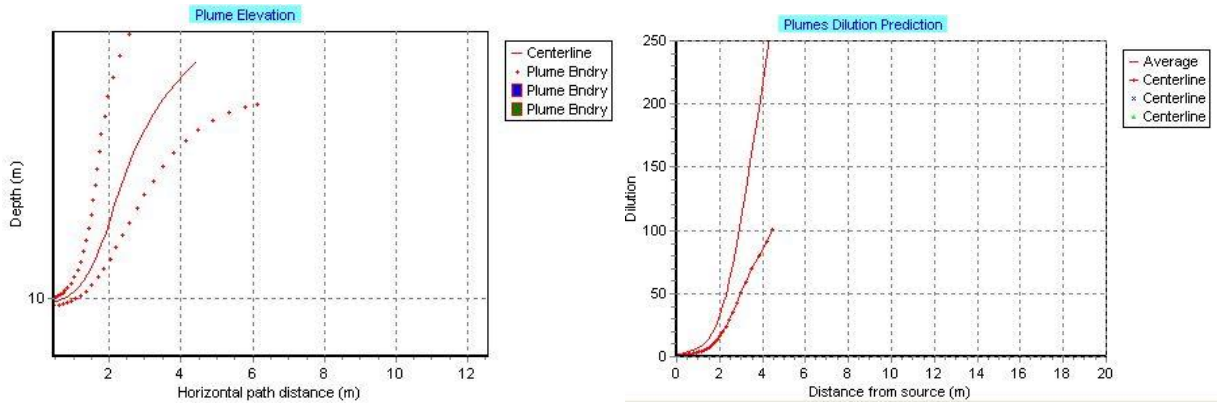


Figure 5 **Initial dilution modelling output showing predicted plume elevation trajectory (left) and predicted average and centreline dilutions (right)**

2.2.3 Initial dilution using the nutrient concentrations

The lowest dilution expected to occur at the Bunbury outlet based on measurement of in-water nutrient concentrations was 1:1133 for total phosphorus (Table 2). The most conservative estimate of initial dilution was the average initial dilution modelled via VPLUMES, which was 1:270 and it will be used in calculations below.

Table 2 **Minimum initial dilution achieved for total ammonia, nitrate+nitrite and total phosphorus**

Parameter	Undiluted TWW concentration (µg/L)	Surface maximum[1] (µg/L)	Surface background[2] (µg/L)	Minimum initial dilution achieved[3]
Total ammonia	2900	1.5	1.5	N/A
Nitrate+nitrite	4200	4	1	1400
Total phosphorus	3400	4	1	1133

Notes:

1. Highest surface concentration recorded at the nutrient dilution sites.
2. Average surface concentration of five reference sites (WQR1–WQR5); where this value was <LoR, the LoR was used to calculate the average surface concentration.
3. Minimum initial dilution = treated wastewater (TWW) concentration/surface maximum – surface background).
4. N/A = not applicable because surface maximum concentration equals surface background concentration.

2.2.4 Bioaccumulating toxicants

The EQG for bioaccumulating toxicants (cadmium and mercury) in the TWW is outlined in Table 3.

Table 3 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 in wastewater stream before dilution

Source: Water Corporation (2012)

Concentrations of cadmium and mercury (i.e. bioaccumulating toxicants) in the TWW sample before dilution were both below the analytical limit of reporting (and the ANZECC/ARMCANZ (2000) 80% species protection guideline trigger levels) and the EQG for bioaccumulating toxicants was met (Table 4).

2.2.5 Non-bioaccumulating toxicants

Non-bioaccumulating toxicants concentrations were generally below the analytical limit of reporting and the ANZECC/ARMCANZ 99% species protection guidelines with the exception of ammonia, copper and zinc (Table 4). After initial dilution of 1:270 (a conservative estimate of the dilution expected at the LEPA boundary; Appendix A),

contaminant concentrations of ammonia, copper and zinc were below ANZECC/ARMCANZ (2000) 99% species protection guidelines (Table 4) and the EQG for non-bioaccumulating toxicants was met.

Table 4 Toxicants in the Bunbury TWW compared with relevant guideline trigger levels after initial dilution

Toxicant	Bunbury TWW concentration (µg/L)	Concentration after initial dilution (µg/L)[1]	Trigger (µg/L)[2]
Ammonia-N	**2900**	12.2	500
Nitrate+Nitrite	4200	-	ID
Total phosphorus	3400	-	n/a
Total suspended solids	7000	-	<10[3]
Arsenic	<20	-	n/a
Cadmium	<0.6	-	36
Chromium	<1	-	0.14 (Cr VI)
Copper	**3**	0.09	0.3
Lead	<10	-	2.2
Mercury	<0.1	-	1.4
Nickel	<7	-	7
Selenium	<20	-	n/a
Silver	<10	-	0.8
Zinc	**47**	0.32	7
Molybdenum	<4	-	ID
Salinity (psu)	0.4	-	n/a
BOD (mg/L)	<5	-	n/a
Chloropyrifos	<0.1	-	0.0005
Endrin	<0.01	-	0.004
Endosulfan sulfate	<0.01	-	0.005

Notes:

1. Concentration after initial dilution and natural surface background. Initial dilution = 1:270. Natural surface background ammonia 1.5 µg/L; copper 0.08 µg/L and zinc 0.15 µg/L (Table 6). Contaminant dilution calculations were not performed (–) on any toxicants where concentrations were below the analytical limit of reporting or where the 99% species protection guideline value was not the trigger (i.e. cadmium, mercury and total suspended solids).
2. Assessment against ANZECC/ARMCANZ (2000) 99% species protection guidelines for non-bioaccumulating toxicants; guideline values for marine waters.
3. Guideline value for the protection of aquaculture species in saltwater production (ANZECC/ARMCANZ (2000))
4. 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.
5. ID = insufficient data to derive a reliable national trigger value.
6. Bold text represents an exceedance of guideline values prior to initial dilution.

2.2.6 Total toxicity of the mixture

The potential for additive toxic effects of TWW to marine organisms at the edge of the initial mixing zone (i.e. after initial dilution of the TWW with seawater) was assessed as per the ANZECC/ARMCANZ (2000) calculation for the total toxicity of the mixture (TTM). TTM is a relative score and does not have a unit of measurement. The EQG for the TTM is outlined in Table 5.

Table 5 Environmental Quality Guideline for the Total Toxicity of the Mixture (TTM)

EQG	Where there are mixtures of toxicants, the TTM at a single site or for a defined area, should not exceed 1, using the TTM formula.

Notes:

1. EQG = environmental quality guideline; TTM = total toxicity of the mixture
2. TTM = Σ(Ci/EQGi) where Ci is the concentration of the 'i'th component in the mixture and the EQGi is the guideline for that component.

The TTM following minimum initial dilution of 1:270 was 0.37 (Table 6) and was below the ANZECC/ARMCANZ (2000) guideline, meeting the EQG. As such, it is not expected that the combined additive effect of these contaminants will have an adverse effect on marine flora and fauna on the area surrounding the Bunbury ocean outlet.

Table 6 Total toxicity of treated wastewater (TWW) at the edge of the initial mixing zone associated with the Bunbury ocean outlet

Natural concentrations in Perth's coastal waters			Initial dilution of TWW with seawater	Total toxicity of the mixture (TTM)
Ammonia (µg/L)	Copper (µg/L)	Zinc (µg/L)		
1.5	0.08	0.15	1:270	0.37

Notes:

1. Background concentrations for copper and zinc from McAlpine et al. (2005); Perth marine waters (99. 19; Table 12). Surface background concentration for ammonia calculated as the average surface concentration of the five reference sites (WQR1-WQR5); where this value was less than the limit of reporting (LoR), half the LoR was used in calculations.
2. TTM = [ammonia]/guideline + [copper]/guideline + [zinc]/guideline.

3 Water quality monitoring – receiving environment

Water Corporation (2012) requires the assessment for indicators of nutrient enrichment and physico-chemical stress in receiving waters. Indicators of nutrient enrichment that were measured in receiving waters to assess marine water quality are:

- surface chlorophyll-a
- phytoplankton biomass
- light attenuation coefficient (LAC)
- periphyton
- seagrass shoot density

Dissolved oxygen (DO) was also measured and is the primary indicator of physico-chemical stress.

Sampling procedures were followed at compliance monitoring, plume tracking, periphyton monitoring and seagrass health sites over the summer monitoring period (Appendix B). Nutrients, phytoplankton biomass, light attenuation and the physico-chemical stressor DO were monitored during three separate surveys on 20 January, 16 February and 16 March 2022, along a down-current gradient away from the diffuser (Appendix B). Periphyton was monitored using collector plates deployed from 18 January 2022 to 17 February 2022 (Appendix B). Seagrass health was monitored through measuring shoot density on 17 and 18 January and 18 and 19 February 2022.

Nutrient concentrations (ammonia, ortho-phosphate, nitrate+nitrite) in receiving waters were measured with distance from the outlet (to test for nutrient gradients), for contextual purposes only (see Appendix C for results).

3.1 Nutrient enrichment

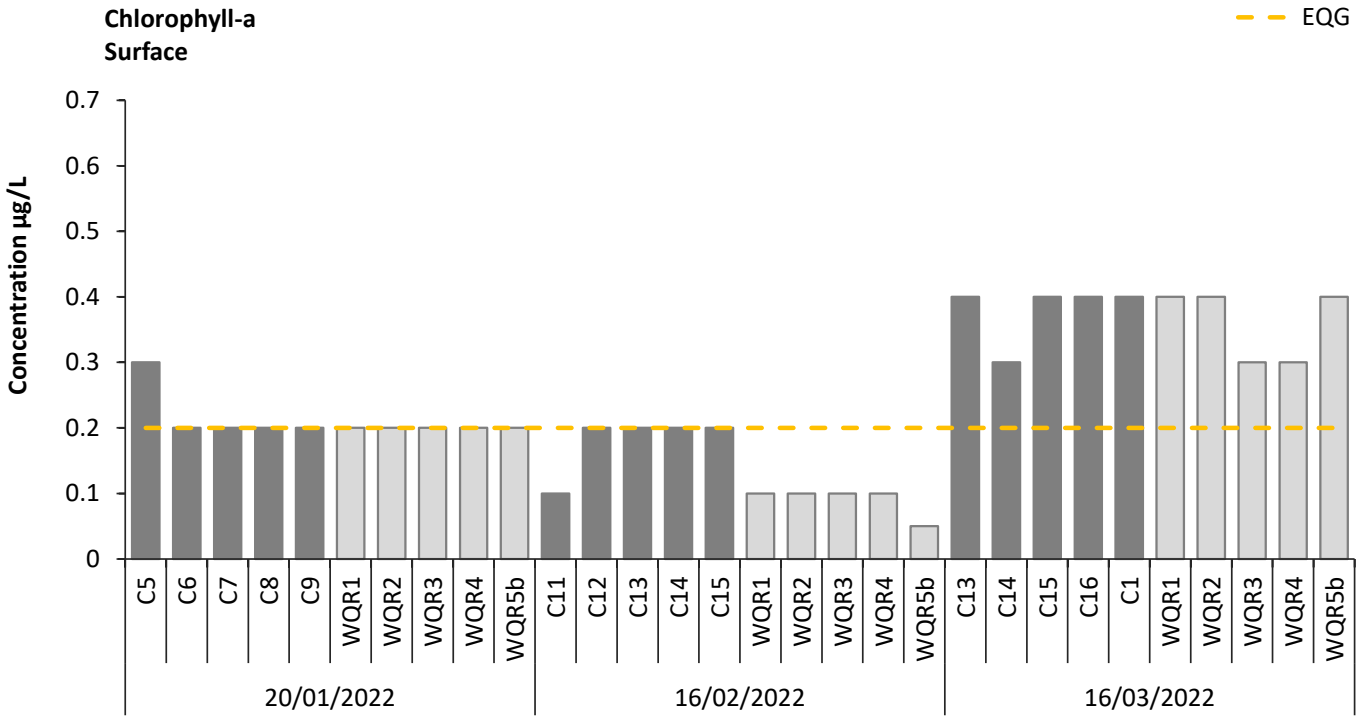
3.1.1 Surface water chlorophyll-a

The EQG for surface water chlorophyll-a is outlined in Table 7.

Table 7 Environmental quality guideline for surface water chlorophyll-a

EQG	The median surface chlorophyll-a concentration at the boundary of the LEPA is not to exceed the 80th percentile of historical reference site data.

Chlorophyll-a in surface waters ranged from below the analytical detection limit (<0.1 µg/L) in surface waters to 0.4 µg/L across all sites (Figure 6). The median chlorophyll-a concentration in surface waters for compliance monitoring sites was 0.2 µg/L. This was equal to the 80th percentile of historical reference site data (0.2 µg/L from 2003–2022: yellow dashed line in Figure 6), meeting the EQG for surface water chlorophyll-a.



Notes:

1. Water quality monitoring occurred at compliance sites C5–C9 on 20 January, C11–C15 on 16 February and C13–C16, C1 on 16 March 2022, as a result of prevailing currents at the time of sampling.
2. Dark grey bars indicate sites relevant to the Environmental Quality Guideline (EQG) for chlorophyll-a.
3. Yellow dashed line represents the 80th percentile of historical reference site data which is the Environmental Quality Guideline (0.2 µg/L) for surface chlorophyll-a.

Figure 6 Surface chlorophyll-a concentrations at compliance and reference sites in 2022 around Bunbury ocean outlet

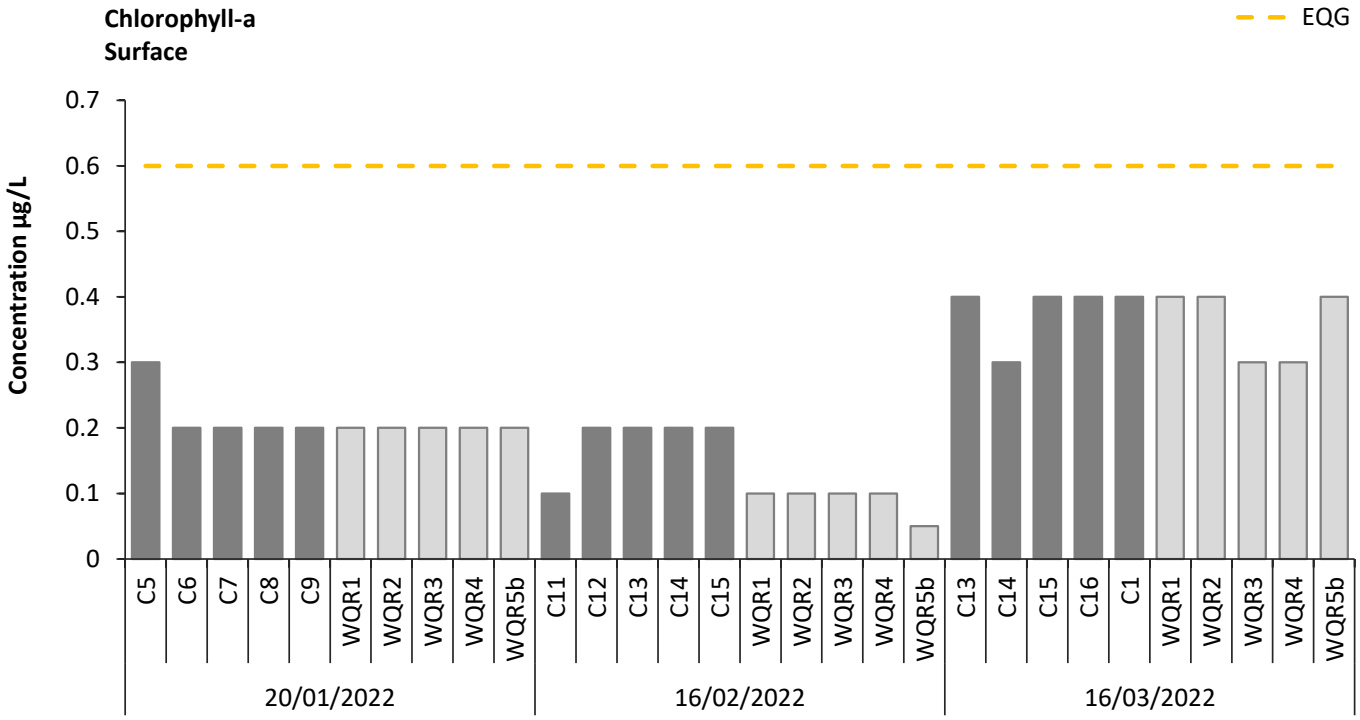
3.1.2 Phytoplankton biomass

The EQG for phytoplankton biomass (also measured as concentration of chlorophyll-a) is outlined in Table 8.

Table 8 Environmental quality guideline for phytoplankton biomass

EQG	Phytoplankton biomass (measured as chlorophyll-a concentration) does not exceed three times the median of chlorophyll-a concentrations of historical reference site data, on any occasion, during the non-river flow period.

Phytoplankton biomass (measured as chlorophyll-a) ranged from below the analytical detection limit (<0.1 µg/L) to 0.4 µg/L in surface waters across all compliance sites. Phytoplankton biomass did not exceed three times the median of historical reference site data (0.6 µg/L from 2003-2022: yellow dashed line in Figure 7) on any occasion during the non-river flow period, meeting the EQG.



Notes:

1. Water quality monitoring occurred at compliance sites C5–C9 on 20 January, C11–C15 on 16 February and C13–C16, C1 on 16 March 2022, as a result of prevailing currents at the time of sampling.
2. Dark grey bars indicate sites relevant to the Environmental Quality Guideline (EQG) for phytoplankton biomass.
3. Yellow dashed line represents 3 times the median chlorophyll-a concentration of historical reference site data which is the Environmental Quality Guideline (0.6 µg/L) for phytoplankton biomass.

Figure 7 Phytoplankton biomass at compliance and reference sites in 2022 around Bunbury ocean outlet

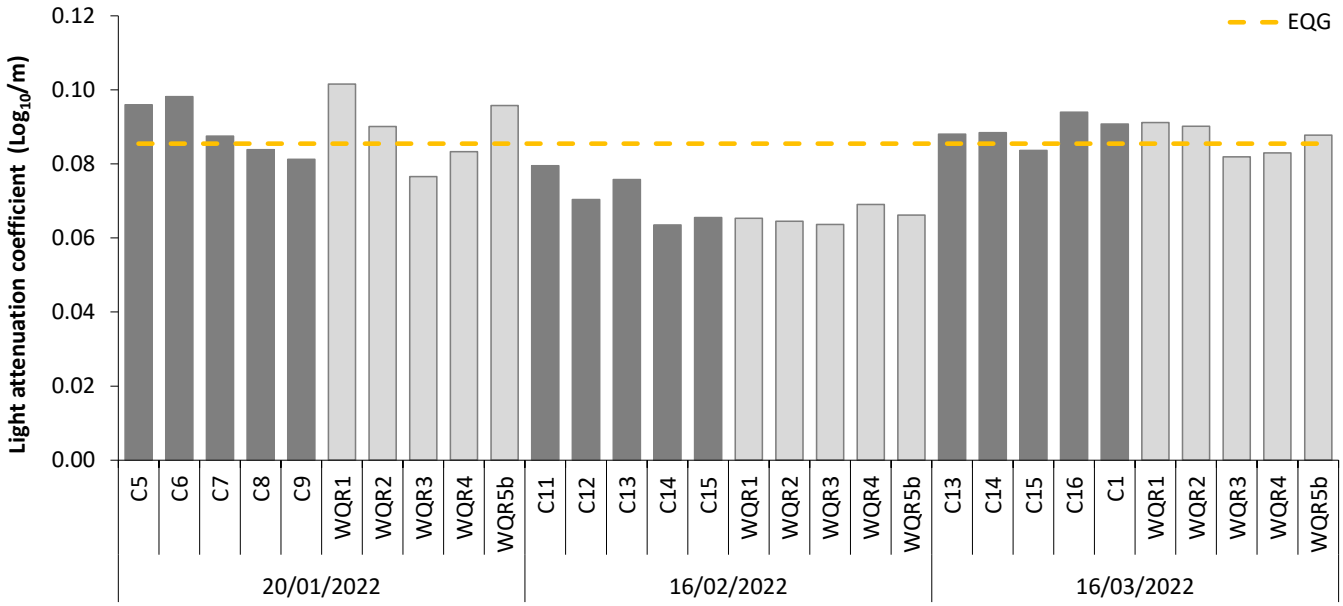
3.1.3 Light attenuation coefficient

The EQG relevant to the LAC is outlined in Table 9.

Table 9 Environmental Quality Guideline for light attenuation

EQG	The median LAC, during the summer period, is not to exceed 80th percentile of historical reference site data.

Median LAC measured over summer at compliance sites (0.0839 Log_{10}/m) did not exceed the 80th percentile of historical reference site data (0.0856 Log_{10}/m from 2013-2022 yellow dashed line in Figure 8), meeting the EQG for this indicator (Figure 8).



Notes:

1. Water quality monitoring occurred at compliance sites C5–C9 on 20 January, C11–C15 on 16 February and C13–C16, C1 on 16 March 2022, as a result of prevailing currents at the time of sampling.
2. Dark grey bars indicate sites relevant to the Environmental Quality Guideline (EQG) for light attenuation, median of which is 0.0839 Log_{10}/m.
3. Yellow dashed line is 80th percentile of historical reference site data which is the Environmental Quality Guideline (0.0856 Log_{10}/m).

Figure 8 Light attenuation coefficient measured at compliance and reference sites in 2022

3.1.4 Periphyton biomass

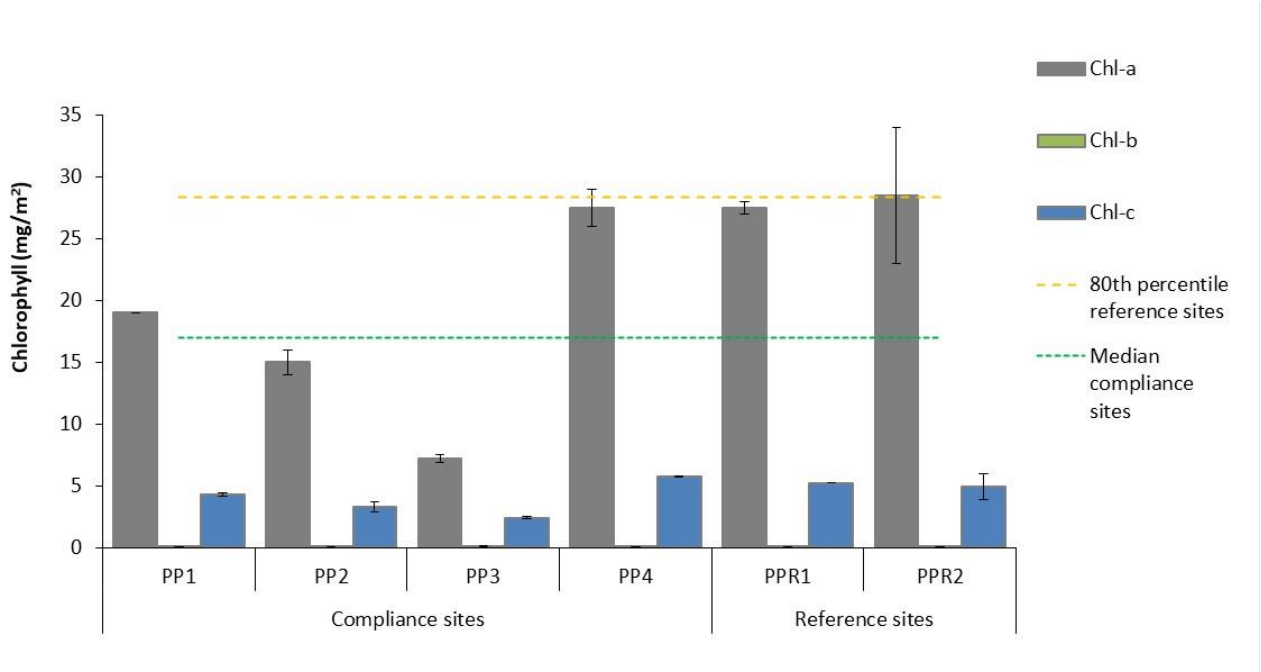
Periphyton collectors provide a time-integrated measure of attached algal growth (epiphytes). Increased periphyton biomass on artificial substrata (measured as chlorophyll-a, -b and -c) in response to nutrient enrichment has been confirmed as an indicator of enhanced productivity resulting from wastewater discharge in Perth's coastal waters (Cosgrove et al. 2004). The EQG for periphyton biomass is in Table 10.

Table 10 Environmental Quality Guideline for periphyton biomass

EQG	Median periphyton biomass (measured as chlorophyll a) from compliance sites is not to exceed the 80th percentile of reference site data from the same sampling period at 8 m depth.

The median chlorophyll-a concentration for the 8 m depth was 17.0 mg/m^2 and was below the 80th percentile of reference site data from the same 2022 sampling period at the 8 m depth (28.3 mg/m^2) (Figure 10). Therefore, the EQG was met.

Of the three chlorophyll types (chlorophyll-a, -b and -c) measured on periphyton collector plates, chlorophyll-a was present in the highest biomass, followed by chlorophyll-c and then chlorophyll-b (Figure 9). The more dominant chlorophyll-a content is indictive of a periphyton assemblage dominated by diatoms and/or brown algae (SKM 1999).



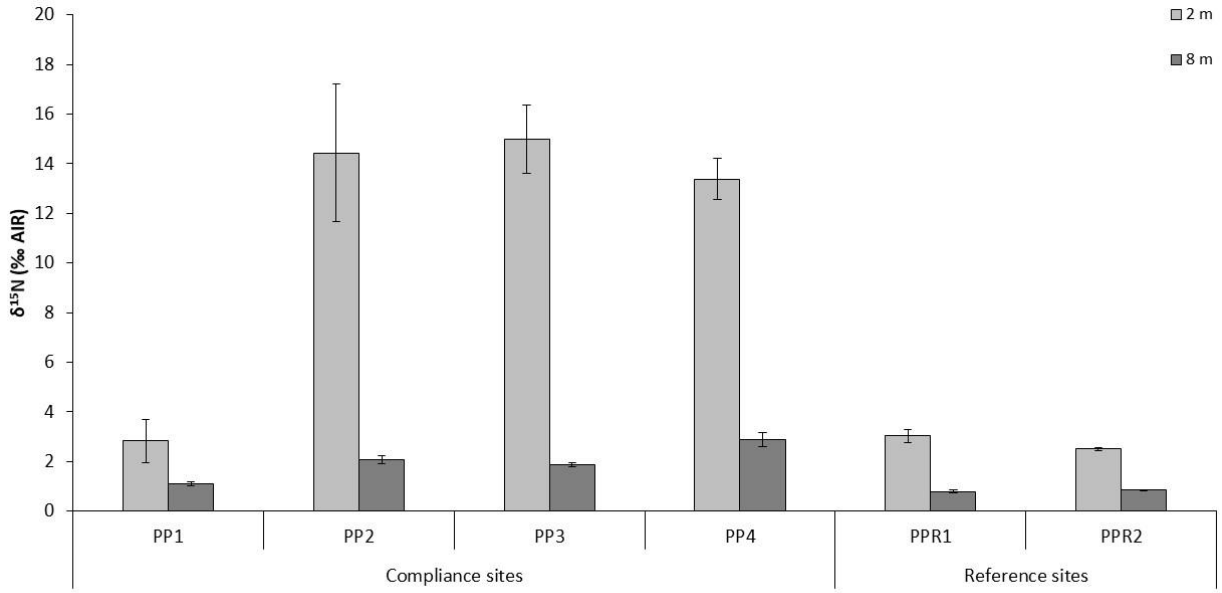
Notes:

1. Bars=mean (± standard error) chlorophyll-a, -b and -c concentration at compliance sites (PP1-PP4) and reference sites (PPR1 and PPR2).
2. Green dashed line = median of chlorophyll-a concentration across compliance sites (17.0 mg/m^2 where n=8).
3. Yellow dashed line = 80th percentile of chlorophyll-a concentration at reference sites (28.3 mg/m^2 where n=4).

Figure 9 Periphyton chlorophyll-a,-b and-c content at compliance and reference sites at 8 m depth

Periphyton samples were analysed for nitrogen isotopic composition, to determine if the periphyton growth patterns can be attributed to nutrient-rich wastewater around the Bunbury ocean outlet.

Mean $\delta^{15}N$ was higher in surface samples at all compliance sites (PP1–PP4), compared to surface samples from the two reference sites (PPR1 and PPR2) (Figure 10). At each site, mean $\delta^{15}N$ of periphyton was higher in the surface samples than for the bottom samples (Figure 10). In bottom samples, mean $\delta^{15}N$ was very low compared to surface samples and similar between the compliance sites and reference sites (Figure 10). The high mean periphyton $\delta^{15}N$ at the surface but not in bottom samples (Figure 10) suggests that the influence of the buoyant TWW plume is restricted to the surface.



Notes:

1. PP1-PP4 = periphyton compliance sites; PPR1 and PPR2 = periphyton reference sites
2. At each site and each depth there was sufficient epiphyte growth on the collector plates for 2 replicates.
3. Error bars represent ± standard error.

Figure 10 Mean $\delta^{15}N$ content in periphyton collected at compliance and reference sites

3.1.5 Seagrass health

All nutrient enrichment water quality monitoring EQG were met during the 2022 monitoring and therefore assessment against the seagrass health EQS was not required.

3.2 Physico-chemical stressor

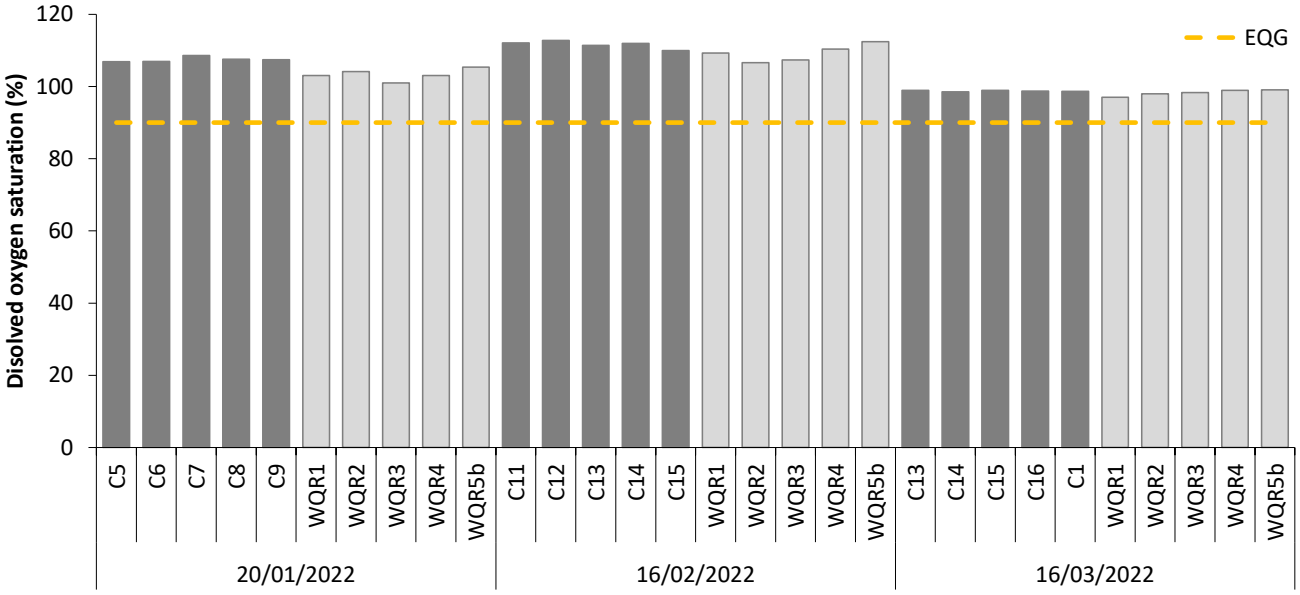
3.2.1 Dissolved oxygen

The EQG for DO is outlined in Table 11.

Table 11 Environmental Quality Guideline for dissolved oxygen

EQG	Ambient dissolved oxygen in bottom waters (0-0.5 m above the sediment surface) is greater than 90% saturation at any site for a defined period of not more than six weeks.

Percent saturation of dissolved oxygen in the bottom remained above the 90% saturation limit at compliance monitoring sites, at all times, meeting the EQG (Figure 11).



Notes:

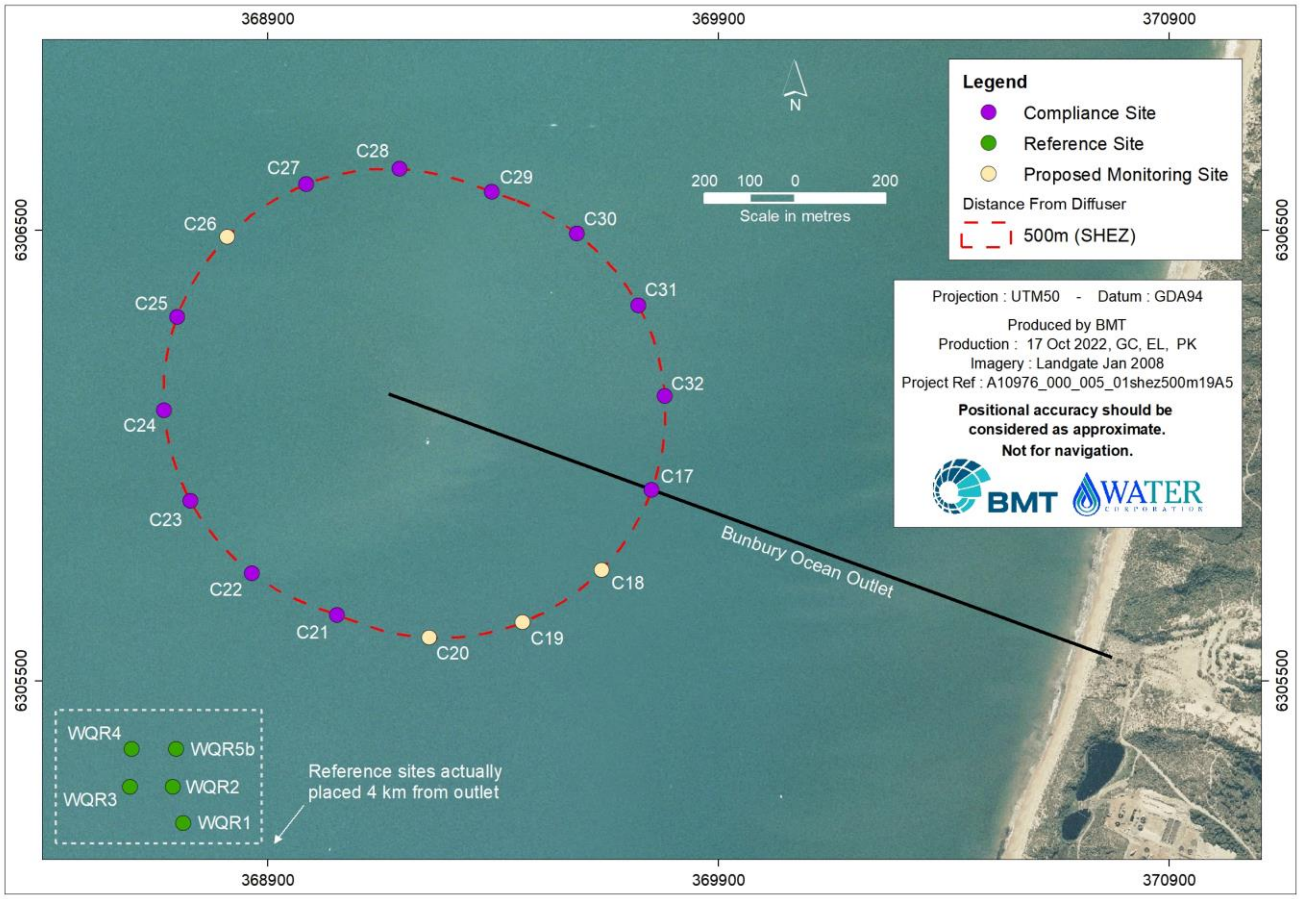
1. Water quality monitoring occurred at compliance sites C5–C9 on 20 January, C11–C15 on 16 February and at C1, C13–C16 on 16 March 2022, as a result of prevailing currents at the time of sampling.
2. Dark grey bars indicate sites relevant to the Environmental Quality Guideline for dissolved oxygen (DO).
3. Yellow dashed lines is the EQG for DO (90% saturation).
4. DO was measured from the seabed to 0.5 m above seabed.

Figure 11 Dissolved oxygen in bottom waters at compliance and reference sites

4 Seafood safe for human consumption

4.1 Sampling approach and site locations

The EQO for the EV 'Fishing and Aquaculture' is aimed at ensuring that seafood is safe for human consumption. To ensure the EQO is met, thermotolerant coliforms (TTC) and algal biotoxins are monitored. The social health EQO of 'Seafood Safe for Human Consumption' must be met at the boundary of the Shellfish Harvesting Exclusion Zone (SHEZ, or S2 area), represented by a concentric ring 500 m from the diffuser (Figure 12). Shellfish compliance monitoring sites (C17–C32) are positioned at the boundary of the SHEZ, but only the five compliance sites directly down-current of the outlet are sampled during each monitoring period (January, February and March).



Note:

1. Compliance sites C21–C25 were sampled on 20 January, C27–C31 were sampled on 16 February and compliance sites C29–C32 and C17 were sampled on 16 March 2022, as a result of prevailing currents at the time of sampling.

Figure 12 Aquatic life for human consumption compliance (C17–C32) and reference (WQR1-WQR5b) monitoring sites

The EQO, Maintenance of Seafood Safe for Human Consumption, is primarily concerned with the harvesting and consumption of raw shellfish (meaning filter-feeding bivalve molluscs including oysters, mussels, pipis, scallops, cockles and razor clams), and not other forms of seafood. The Department of Health (DoH) discourages the public from taking wild shellfish recommending that instead shellfish are only consumed if grown commercially under strict monitoring programs. There is no aquaculture within 250 m of the diffuser, and there are no licensed shellfish growing areas located in the Bunbury region (DoH 2015). The DoH has further indicated that "it is impossible to guarantee the safety of eating wild shellfish without having a comprehensive monitoring program that tests the waterway concerned for harmful microorganisms and toxins" (EPA 2005) and has formally advised the Department

of Environment Regulation (DER) that, in the absence of a full monitoring program, the application of the TTC criteria (EPA 2005) is insufficient to protect those who wish to collect and eat wild shellfish.

4.2 Thermotolerant coliforms sampling

Many disease-causing organisms are transferred from human and animal faeces to water via TWW and can then be ingested by marine fauna, adversely affecting the suitability of such fauna for human consumption. TTCs are bacteria that primarily originate in the intestines of warm-blooded animals. By testing for TTC, it can be determined whether the ocean water around the Bunbury ocean outlet has been exposed to faecal contamination.

Water samples were taken from the surface and bottom of the water column for TTC analyses at compliance monitoring sites, shoreline monitoring sites, plume tracking sites and reference sites over the three sampling dates 20 January, 16 February and 16 March 2022. Samples were collected in pre-sterilised bottles before being chilled to 4 C and placed in the dark. On completion of sampling, the samples were transferred to the PathWest Laboratory and analysed to NATA-accredited methods.

4.3 Thermotolerant coliforms results

The EQG for microbial contaminants for the protection of aquatic life for human consumption is outlined in Table 12.

Table 12 Environmental Quality Guideline for thermotolerant coliforms

EQG	Median TTC concentrations across compliance sites are not to exceed 14 CFU/100 mL and that no more than 10% of samples are to exceed 21 CFU/100 mL

All concentrations of TTC in both surface and bottom waters and at all compliance monitoring sites were below the analytical limit of detection (<10 CFU/100 mL; Table 13). Median concentrations of TTC were below 14 CFU/100 mL and less than 10% of samples exceeded 21 CFU/100 mL (Table 13), meeting the EQG (Table 12).

Table 13 Confirmed thermotolerant coliform concentrations downstream of the Bunbury treated wastewater ocean outlet

Date	Compliance Site	TTC in surface waters (CFU/100 mL)	TTC in bottom waters (CFU/100 mL)
20 January 2022	C21	<10	<10
	C22	<10	<10
	C23	<10	<10
	C24	<10	<10
	C25	<10	<10
16 February 2022	C27	<10	<10
	C28	<10	<10
	C29	<10	<10
	C30	<10	<10
	C31	<10	<10
16 March 2022	C29	<10	<10
	C30	<10	<10
	C31	<10	<10
	C32	<10	<10
	C17	<10	<10

Notes:

1. Water quality samples for microbiological contaminants were sampled ~1 m below the surface of the water and 2 m above the seabed (Water Corporation 2012).
2. TTC = thermotolerant coliforms.

4.4 Algal biotoxins sampling

Nutrient enrichment (as a result of the TWW discharge) can induce shifts in the naturally occurring planktonic algae community to more harmful species. Water Corporation (2012) includes a requirement to monitor for potentially toxic phytoplankton species (as per DoF 2007) in the area surrounding Bunbury ocean outlet. Although most algal blooms are non-toxic, some may contain species that produce toxins and/or have a potentially harmful effect on the surrounding marine environment. For example, algae species *Heterosigma akashiwo and Prymnesium parvum* (*Prymnesiophyta*) cause large and recurrent fish mortalities. In terms of trophic consequences of algal biotoxins (i.e. flow-on effects up the food chain), there are ~2000 species that can induce poisonings in humans (DoF 2013).

Water samples were taken from the surface and bottom of the water column at compliance monitoring sites and reference sites (outlined in Figure 14), at the SHEZ – 500 m, boundary from the diffuser, and analysed for toxic species of phytoplankton (defined by Western Australian Shellfish Quality Assurance Program (WASQAP) guidelines; DoF 2007). Phytoplankton samples were preserved in Lugol's iodine solution and identified to the lowest taxonomic level possible.

4.5 Algal biotoxins results

The EQG for toxic phytoplankton species (Table 14) states that concentrations of potentially toxic algae are not to exceed the WASQAP trigger concentrations in any samples (DoF 2007). Table 15 lists the phytoplankton species known to produce toxins that may be concentrated in shellfish and their WASQAP (DoF 2007) guideline trigger concentrations.

Table 14 Environmental Quality Guideline for toxic phytoplankton species

EQG	Concentrations of potentially toxic algae at the boundary of the SHEZ are not to exceed the WASQAP[1] trigger concentrations in any sample for any of the following: • *Alexandrium* spp. (100 cells/L) • *Gymnodinium catenatum* (1000 cells/L) • *Karenia* spp. (1000 cells/L) • *Dinophysis* spp. (500 cells/L) • *Dinophysis acuminata* (3000 cells/L) • *Prorocentrum lima* (500 cells/L) • *Pseudo-nitzschia* spp. (250 000 cells/L) • *Gonyaulax cf. spinifera* (100 cells/L) • *Protoceratium reticulatum* (50 000 cells/L)

Notes:

1. Western Australian Shellfish Assurance Program (WASQAP; DoF 2007) as stipulated by Water Corporation 2012.

There were no instances where toxic phytoplankton species were present at densities greater than the WASQAP (DoF 2007) guideline values (Table 15).

Table 15 Estimated cell density of phytoplankton species known to produce toxins that may be concentrated in shellfish downstream of the Bunbury treated wastewater ocean outlet

Date	Site	Depth	Species	Estimated cell density (cells/L)	WASQAP[1] (cells/L)	Compliance
20 January 2022	C21	S	No toxic species detected	-	-	■
	C21	B	No toxic species detected	-	-	■
	C22	S	No toxic species detected	-	-	■
	C22	B	No toxic species detected	-	-	■
	C23	S	*Pseudo-nitzschia "seriata"*	80	250 000	■
	C23	B	No toxic species detected	-	-	■
	C24	S	No toxic species detected	-	-	■
	C24	B	No toxic species detected	-	-	■
	C25	S	No toxic species detected	-	-	■
	C25	B	No toxic species detected	-	-	■
16 February 2022	C27	S	No toxic species detected	-	-	■
	C27	B	*Karenia papilionaceae*	80	1000	■
	C28	S	No toxic species detected	-	-	■
	C28	B	No toxic species detected	-	-	■
	C29	S	No toxic species detected	-	-	■
	C29	B	No toxic species detected	-	-	■
	C30	S	No toxic species detected	-	-	■
	C30	B	No toxic species detected	-	-	■
	C31	S	*Pseudo-nitzschia "delicatissima"*	80	250 000	■
	C31	B	No toxic species detected	-	-	■
16 March 2022	C29	S	No toxic species detected	-	-	■
	C29	B	No toxic species detected	-	-	■
	C30	S	*Prorocentrum lima*	80	500	■
	C30	B	*Pseudo-nitzschia "delicatissima"*	80	250 000	■
	C31	S	*Prorocentrum lima*	80	500	■
	C31	B	*Pseudo-nitzschia "delicatissima"*	80	250 000	■
	C32	S	No toxic species detected	-	-	■
	C32	B	*Pseudo-nitzschia "delicatissima"*	80	250 000	■
	C17	S	*Prorocentrum lima*	160	500	■
	C17	B	*Pseudo-nitzschia "delicatissima"*	160	250 000	■

Notes:

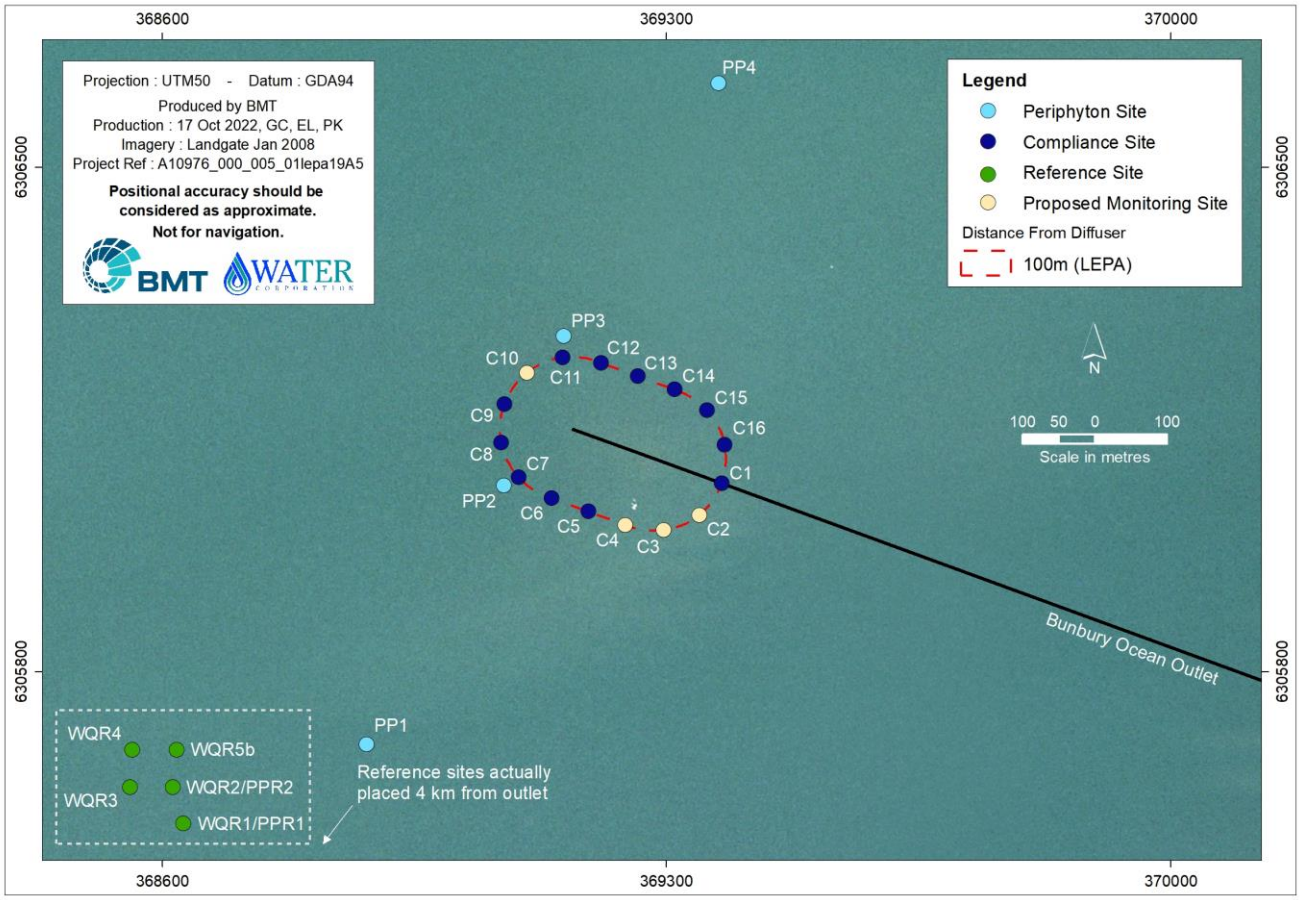
1. WASQAP = Western Australian Quality Assurance Program (DoF 2007, as per Water Corporation 2012).
2. NA = not applicable.
3. Green symbols indicate the estimated cell density was below the WASQAP toxic algae trigger concentration.

5 Primary and secondary contact recreation

5.1 Sampling approach and site locations

The EQO for the EV 'Recreation' [and Aesthetics'] is aimed at ensuring coastal waters are safe for primary and secondary contact recreation activities such as swimming and boating, respectively. To meet the EQO, water quality around the Bunbury ocean outlet is to be maintained so that primary and secondary contact recreation is safe in all waters except those areas designated otherwise.

Water quality monitoring sites (C1–C16) are positioned along the boundary of the LEPA, but on each sampling occasion (January, February and March), only the five sites directly down current of the diffuser are sampled (Figure 13).



Note:

1. Compliance sites C5–C9 were sampled on 20 January, C11–C15 were sampled on 16 February and compliance sites C13–C16 and C1 were sampled on 16 March 2022, as a result of prevailing currents at the time of sampling.

Figure 13 Primary and secondary recreational contact compliance (C1-C16) sites and reference monitoring sites (WQR1–WQR5b)

5.2 Faecal pathogens sampling

Disease-causing microorganisms (pathogens) associated with bathing areas include salmonellae, shigellae, enteropathogenic *Escheria coli*, cysts of *Entamoeba histolytica*, parasite ova and infectious hepatitis (Hart 1974, McNeil 1985; cited in ANZECC/ARMCANZ 2000). The most common types of diseases associated with water borne pathogens are eye, ear, nose and throat infections, skin diseases and gastrointestinal disorders

(ANZECC/ARMCANZ 2000). Detecting faecal pathogens within water samples is difficult, therefore 'indicator' micro-organisms are used to assess the health risks associated with pathogens in recreational waters (Elliot & Colwell 1985; cited in ANZECC/ARMCANZ 2000).

To test for presence of pathogens, water samples were taken from the surface and bottom of the water column at compliance monitoring sites, shoreline monitoring sites, plume tracking sites and reference sites on 20 January, 16 February and 16 March 2022 and analysed for *Enterococci* spp. Samples were collected in pre-sterilised bottles before being chilled and placed in the dark. On completion of sampling, the samples were transferred to the PathWest Laboratory and analysed according to NATA-accredited methods.

5.3 Faecal pathogen results

The EQG for faecal pathogens is outlined in Table 16.

Table 16 Environmental Quality Guideline for faecal pathogens

EQG	The 95th percentile of pooled Enterococci spp. concentrations in surface waters is not to exceed 40 MPN/100 mL outside the LEPA boundary

Source: Water Corporation (2012)

Notes:

1. MPN = most probable number; LEPA = low ecological protection area.

The 95th percentile of pooled *Enterococci spp.* concentrations in surface waters was 10 MPN/100 mL (Table 17) and the EQG was met.

Table 17 *Enterococci* spp. concentrations downstream of the Bunbury ocean outlet

Date	Compliance Site	*Enterococci* spp. in surface waters (MPN/100 mL)	*Enterococci* spp. in bottom waters (MPN/100 mL)
20 January 2022	C5	<10	<10
	C6	10	<10
	C7	<10	<10
	C8	<10	<10
	C9	<10	<10
16 February 2022	C11	<10	<10
	C12	10	<10
	C13	10	<10
	C14	<10	<10
	C15	10	<10
16 March 2022	C13	<10	10
	C14	<10	<10
	C15	<10	<10
	C16	<10	<10
	C1	<10	<10
95th percentile of compliance sites		**10**	NA

5.4 Algal biotoxins sampling

Algal biotoxins resulting from increased nutrient loads can be harmful to human/animal health if encountered via ingestion or skin contact. Although most algal blooms are considered harmless, some may contain species that produce toxins that are harmful to humans. For this reason, phytoplankton cell counts were monitored on three sampling occasions during summer (20 January, 16 February and 16 March 2022) to ensure concentrations are occurring within acceptable guideline limits (NHMRC 2008).

5.5 Algal biotoxin results

The EQG for algal biotoxins is outlined in Table 18.

Table 18 Environmental Quality Guideline for algal biotoxins

EQG	Median total phytoplankton cell count (either from one sampling occasion or from a single site over an agreed period of time) should not exceed 10 cells/mL *Karenia brevis* and/or have *Lyngbya majuscula* and/or *Pfiesteria* present in high numbers outside the LEPA

Source: Water Corporation (2012)

Note:

1. LEPA = low ecological protection area

Toxic algae species *Karenia brevis, Lyngbya majuscula* and *Pfiesteria* spp. were not recorded at compliance monitoring sites at the boundary of the LEPA during the 2022 summer monitoring and the EQG relevant to algal biotoxins (for the EQO, Maintenance of Primary and Secondary Contact Recreation) was met.

6 References

ANZECC/ARMCANZ (2000) National Water Quality Management Strategy Paper No 4 – Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Volume 1 – The Guidelines (Chapters 1–7). Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand, Canberra, Australian Capital Territory, October 2000

BMT (2018) Bunbury Wastewater Treatment Plant Ocean Outlet Monitoring Program Annual Report 2017/2018. Prepared for Water Corporation of Western Australia by BMT, Report No. 1136_001/1_Rev0, Perth, Western Australia, October 2018

Cosgrove J, Walker D, Morrison P, Hillman K (2004) Periphyton indicate effects of wastewater discharge in the near-coastal zone, Perth (Western Australia). Estuarine, Coastal and Shelf Science 61:331–338

Costanzo SD, O'Donohue MJ, Dennison WC, Loneragan NR, Thomas M (2001) A new approach for detecting and mapping sewage impacts. Marine Pollution Bulletin 42:149-156

DALSE (2002) Bunbury Ocean Outfall Operations EMP Marine Impacts Monitoring and Management Plan. Prepared for Water Corporation of Western Australia by DAL Science & Engineering Pty Ltd, Report No. 02/189/3, Perth, Western Australia, August 2002

DALSE (2003) Tracing Treated Wastewater from Bunbury Ocean Outfall using 15N. Prepared for Water Corporation of Western Australia by DAL Science & Engineering Pty Ltd, Report No. 275/01, Perth, Western Australia, May 2003

DoF (2013) Poisonous Algae. Department of Fisheries, Perth, Western Australia. Available from http://www.fish.wa.gov.au/Sustainability-and-Environment/Fisheries-Science/Aquatic-Animal-Health/Pages/Poisonous-Algae.aspx [Accessed 23 May 2014]

DoF (2007) Western Australian Shellfish Quality Assurance Program (WASQAP) Operations Manual. Department of Fisheries, Perth, Western Australia, June 2007

DoH (2015) Western Australian Shellfish Quality Assurance Program (WASQAP) Operations Manual. Department of Fisheries, Perth, Western Australia, May 2016

EPA (2005) Environmental Quality Criteria Reference Document for Cockburn Sound (2003–2004) – A Supporting Document to the State Environmental (Cockburn Sound) Policy 2005. Environmental Protection Authority, Report No. 20, Perth, Western Australia, January 2005

EPA (2016) Technical Guidance: Protecting the Quality of Western Australia's Marine Environment. Environmental Protection Authority, Perth, Western Australia, December 2016

EPA (2017) Environmental Quality Criteria Reference Document for Cockburn Sound – A supporting document to the State Environmental (Cockburn Sound) Policy 2015. Environmental Protection Authority, Perth, Western Australia, April 2017

McAlpine KW, Wenziker KJ, Apte SC, Masini RJ (2005) Background Quality for Coastal Marine Waters of Perth, Western Australia. Department of Environment, Perth, Western Australia, March 2005

NHMRC (2008) Guidelines for Managing Risks in Recreational Water. National Health and Medical Research Council, Canberra, Australian Capital Territory, February 2008

SKM (1999) Bunbury WWTP Ocean Outlet. Prepared for GHD Pty Ltd by Sinclair Knight Merz, Perth, Western Australia, April 1999

Water Corporation (2012) Bunbury Ocean Outlet Operations EMP – Marine Impacts Monitoring and Management Plan. Water Corporation, Report No. 5542160 v3A, June 2012