# Perth Long-term Ocean Outlet Monitoring (PLOOM) Program

Beenyup Water Resource Recovery Facility

**2025 - 2026 Annual Report**

WATER CORPORATION

# Document Management

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### Status

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## Acronyms

| Acronym | Extension |
|---|---|
| **AF** | Assessment Factor |
| **ANZG** | Australian and New Zealand Guidelines for Fresh and Marine Water Quality |
| **AWRP** | Advanced Water Recycling Plant |
| **CFU** | Colony Forming Unit |
| **CTWWC** | Comprehensive Treated Wastewater Characterisation |
| **DO** | Dissolved Oxygen |
| **DoH** | Department of Health (Western Australia) |
| **DWER** | Department of Water and Environmental Regulation (Western Australia) |
| **EPA** | Environmental Protection Authority |
| **EQC** | Environmental Quality Criteria |
| **EQG** | Environmental Quality Guidelines |
| **EQMF** | Environmental Quality Management Framework |
| **EQO** | Environmental Quality Objective |
| **EQS** | Environmental Quality Standards |
| **EV** | Environmental Value |
| **GWRS** | Water Corporation's Groundwater Replenishment Scheme |
| **HEPA** | High Ecological Protection Area |
| **LAC** | Light Attenuation Coefficient |
| **LEPA** | Low Ecological Protection Area |
| **LoR** | Limit of Reporting |
| **MBMMP** | Marine Biotoxin Monitoring and Management Plan |
| **MMP** | Marine Monitoring Plan |
| **mL** | Millilitre (0.001 L) |
| **ML** | Megalitre (1,000,000 L) |
| **MPN** | Most Probable Number |
| **MS** | Ministerial Statement |
| **NATA** | National Association of Testing Authorities |
| **NHMRC** | National Health and Medical Research Council |
| **NOEC** | No Observed Effect Concentration |
| **OZE** | Observed Zone of Effect |
| **PLOOM** | Perth Long-term Ocean Outlet Monitoring |
| **SMZ** | Seafood Management Zone |
| **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 |

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

Ocean discharge of treated wastewater is practiced worldwide and is a safe, sustainable and cost-effective way to dispose of wastewater. Wastewater from Perth's Water Resource Recovery Facilities (WRRFs) is treated before being discharged to the ocean via ocean outlets. Treated wastewater is lighter and less dense than seawater, so it rapidly rises, mixes and dilutes into the ocean. Ocean discharges are regulated in Western Australia by the Department of Water and Environmental Regulation (DWER).

Water Corporation discharges treated wastewater from the Beenyup WRRF to the ocean via the Ocean Reef outlets. 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 150 metres (Ministerial Statement 1219, 22 April 2024 [MS1219]) as a Low Ecological Protection Area (or LEPA). Within this area, the EPA's principle of allowing for changes to marine quality is applied. 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's Perth Long-term Ocean Outlet Monitoring (PLOOM) program tests water quality around the Ocean Reef outlets to confirm it returns to the natural range expected in the High Ecological Protection Area (HEPA) and to protect the environment and recreational users (swimmers, boaters and fishers). Samples are collected within the Low Ecological Protection Area (LEPA), at the LEPA/HEPA boundary, and at reference sites representing background conditions. Results are assessed against nationally agreed criteria adopted by Western Australia's EPA: Environmental Quality Guidelines (EQG) as conservative early-warning triggers, and Environmental Quality Standards (EQS) for detailed assessment of potential impacts.

This annual report documents the findings of the 2025-26 Ocean Reef ocean monitoring as part of the PLOOM program. The compliance results for 2025-26 are summarised in report card format below. 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[1] | 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

The following section provides a summary of the key indicators assessed during the 2025/26 Perth Long-Term Ocean Outlet Monitoring (PLOOM) program at the Beenyup Water Resource Recovery Facility and Ocean Reef ocean outfalls. Refer to the main report for a more comprehensive overview.

## Ecosystem integrity

Ecosystem Integrity aims to protect the ecosystem from potential impacts from the treated wastewater 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 is measured in undiluted TWW against national guidelines that are designed to protect marine life. |  | Concentrations of cadmium and mercury were below the guideline values. |
| Non-bioaccumulating toxicants | Some low levels of contaminants (e.g. detergents, metals and oils) may persist in treated wastewater after treatment at the WRRF and are possibly discharged at the outlet. Monitoring ensures they are not directly toxic or likely to accumulate in marine life. |  | Concentrations of toxicants were below the 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 guideline value. |
| Whole of effluent toxicity (WET) | 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 how many dilutions of the TWW is required to be protective of 99% of marine life. |  | The TWW plume is sufficiently diluted to achieve the No Observed Effect Concentration (NOEC) at the management boundary. |

| Indicator | Indicator purpose | Result | Commentary |
|---|---|---|---|
| ***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 phytoplankton growth. Chlorophyll-*a* (the active constituent in phytoplankton) concentration is used as an indicator for phytoplankton biomass which is used as the indicator of nutrient enrichment as per the MMP. |  | Median chlorophyll-*a* concentration within the high ecological protection area (HEPA) did not exceed the 80$^{th}$ percentile of reference site concentrations (0.50 µg/L).<br><br>Phytoplankton biomass (measured as chlorophyll-*a*) exceeded EQG 1 (three times the reference median; 0.60 µg/L) on two occasions but did not exceed this in two consecutive years, therefore EQS 1 was met.<br><br>Phytoplankton biomass met EQG 2. |
| ***Physical and 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 normal at all locations near the outlets. DO levels near the outlets were higher than 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 outlets until the fresher water is fully mixed with the saline seawater. Low salinity water may cause stress to marine life. |  | Measurements of salinity near the outlets were low, whereas measurements of salinity at HEPA were more similar to the salinity at reference sites. Stress to marine life from low salinity is unlikely. |

## 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 to seafood safety from microorganisms is assessed using the indicator organism thermotolerant coliforms. |  | The relevant concentrations of thermotolerant coliforms near the outlets 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 | | | The relevant concentrations of thermotolerant coliforms 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 beaches was very low. |
| ***Algal biotoxins*** | | | |
| Toxic phytoplankton species | In some cases, phytoplankton can include species than can taint seafood. |  | There were no detections of potentially toxic phytoplankton species above 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 indicators we look at that give us an understanding of this are as follows:

| Indicator | Indicator purpose | Result | Commentary |
|---|---|---|---|
| ***Faecal Indicators*** | | | |
| *Enterococci* spp. near the outlets | The risk from microorganisms to recreation contact (swimming and boating) is assessed using the indicator organism *Enterococci* spp. |  | The relevant concentrations of *Enterococci* spp. near the outlets were below the level where they can be detected by the laboratory. The risk to public health from bacteria via recreation in the vicinity of the outfalls was very low. |
| Shoreline *Enterococci* spp. | |  | The relevant concentrations of *Enterococci* spp. adjacent the beaches were below the level where they can be detected by the laboratory. The risk to public health from bacteria via recreation in the vicinity of the outfalls was very low. |
| ***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 highest phytoplankton cell concentration detected in the HEPA during the monitoring program was 6,015 cells/mL. This was substantially lower than the threshold of the definition for a bloom (10,000 cells/mL). This would infer there were no blooms detected that were directly attributed to the discharge of treated wastewater during the monitoring period. |

## Aesthetics and fish tainting substances

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:

| Indicator | Indicator purpose | Result | Commentary |
|---|---|---|---|
| Aesthetic factors | Perth's coastal waters hold strong aesthetic value for the community and 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. |  | Standardised field observations developed and endorsed by EPA, and recorded during each monitoring event, confirmed that the EQG for odour was not met, while the EQG for all other Aesthetic Values were maintained during the monitoring season. No direct complaints concerning aesthetics were received by Water Corporation and therefore, the EQS was met. |
| Fish tainting substances | The guidelines for fish tainting substances are based on levels of contaminants that may make water or edible marine life unpalatable (but not toxic) to people. |  | Fish tainting substances were below the guideline values. |

# Executive Summary

This report documents the findings of the 2025-2026 Ocean Reef monitoring program. The report outlines the findings of three environmental monitoring programs:

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

The Ministerial Statement (MS) was updated in April 2024 for Ocean Reef from MS382 and MS569 to MS1219. MS1219 is EPA approved and sets the LEPA at 150 m. In the previous versions, the LEPA distance wasn't formally approved by EPA and therefore is stated as 'notional'. The 'notional' 100 m boundary has been informally applied since monitoring around the outfall commenced; since that time, inflow to the plant has increased. EPA has accounted for this in setting the LEPA at 150 m.

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

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

The compliance results for 2025-2026 are reported in this document which 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[1] | Colour |
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Note:

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## Environmental Quality Objective 'Maintenance of Ecosystem Integrity'

There are several EQC relevant to the Environmental Quality Objective (EQO) 'Maintenance of Ecosystem Integrity': the first is assessed based on the constituents of the treated wastewater (TWW) stream and their potential toxicity, while the remainder are based on monitoring of water column nutrients, phytoplankton abundance and physical-chemical stressors in the receiving environment. While nutrient data is collected during each sampling event, these results are not used as primary assessment criteria for the EQO, instead the nutrient data is used to provide contextual information, support further investigation of exceedances triggered by primary productivity indicators, and for comparison with ANZG (2018) trigger values where required.

Toxicants in treated wastewater

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

- **EQG 1**: Concentrations of bioaccumulating toxicants (specifically, cadmium and mercury) must be below their respective EPA (2017) 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.
- **EQG 2**: Concentrations of non-bioaccumulating contaminants must not exceed the EPA (2017) 99% species protection guideline at the Low Ecological Protection Area (hereafter LEPA) boundary (150 m radius from the diffuser). Initial dilution modelling for conditions on 21st January 2026 found that the Ocean Reef outlets were achieving a worst-case average initial dilution of 1:238. This was sufficient to dilute all contaminants to concentrations below their respective 99% species protection guidelines. The EQG 2 for toxicants in TWW was therefore met.
- **EQG 3**: 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 1.0 (ANZG 2018). The TTM following initial dilution was 0.56, which is lower than the guideline and EQG 3 was met.
- **EQG 4**: The typical dilutions achieved at the LEPA boundary were 1:238. The highest NOEC concentration of TWW recorded across the 1-hour sea urchin fertilisation tests was 12.5% (equivalent to 1:8 dilutions or 1:80 dilutions with application 0.1 assessment factor). As the dilutions achieved at the LEPA (238) was greater than the dilutions required (80), EQG 4 was met.

Water quality monitoring – receiving environment

Ocean sampling was conducted on ten occasions between November 2025 and March 2026 at fixed distance intervals down-current (determined using a drogue) of the outlets. There are five EQGs based on chlorophyll-*a* concentration (a measure of phytoplankton biomass), dissolved oxygen and salinity:

Nutrient enrichment:

- **EQG:** The median chlorophyll-*a* concentration of HEPA sites (i.e., 150 m and greater from the diffuser) during the non-river flow period must not exceed the 80th percentile of reference site data during the summer monitoring period. The median chlorophyll-*a* concentration of sites within the high ecological protection area (HEPA) was lower than the 80th percentile of reference site concentrations (0.50 µg/L) and the EQG was met.

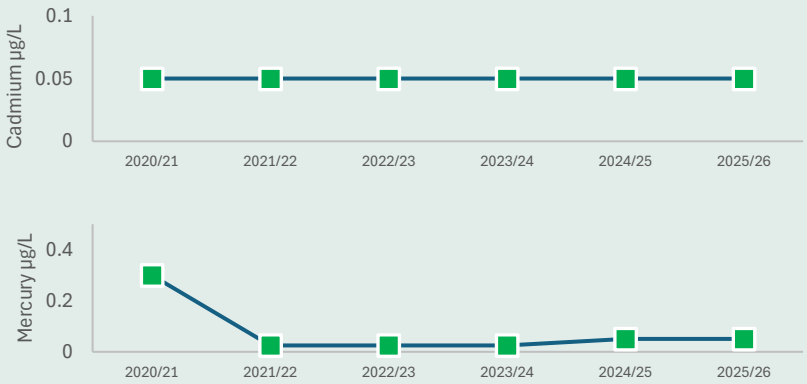
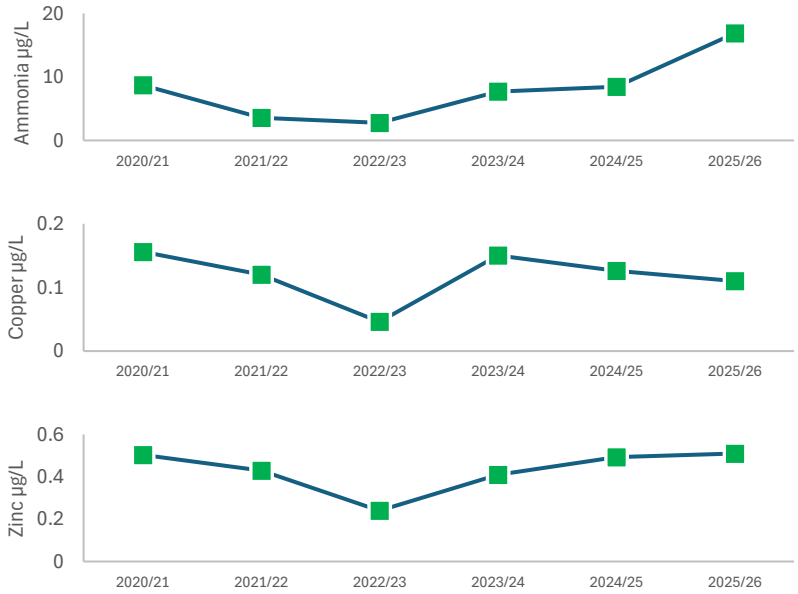
Phytoplankton blooms:

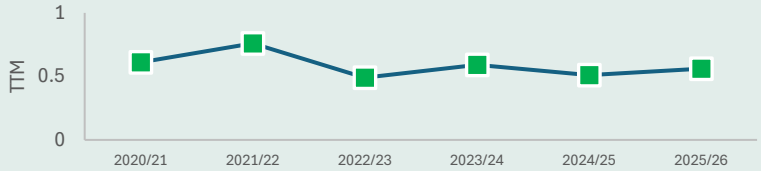
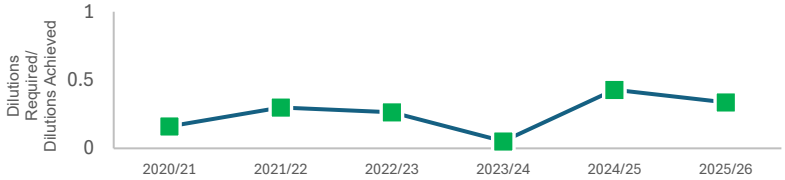
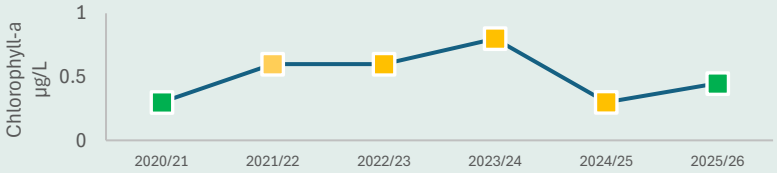
- **EQG 1:** Median phytoplankton biomass, measured as chlorophyll-*a*, at HEPA sites must not exceed three times the median chlorophyll-*a* concentration of reference sites, on any occasion during the summer monitoring period. Median chlorophyll-*a* concentrations exceeded three times the median of reference sites on two occasions (5/11/2025 and 19/03/2026) and the EQG was not met, triggering assessment against the EQS
- **EQS 1:** Median phytoplankton biomass measured as chlorophyll-*a* exceeded three times median chlorophyll-*a* concentration of reference sites on one occasion in 2024-25 and twice in 2025-26. As the exceedance did not occur on more than one occasion in both reporting years, the EQS was met.
- **EQG 2:** Phytoplankton biomass, measured as chlorophyll-*a*, at any HEPA site must not exceed three times the median chlorophyll-*a* concentration of reference sites, on 25% or more occasions during the summer monitoring period. Phytoplankton biomass, measured as chlorophyll-*a*, exceeded three times the median chlorophyll-*a* concentration of reference sites (0.6 µg/L) on 20% of occasions at HEPA sites and the EQG was met

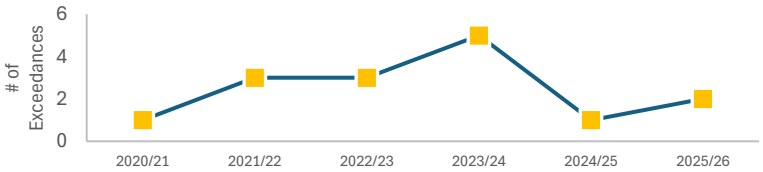
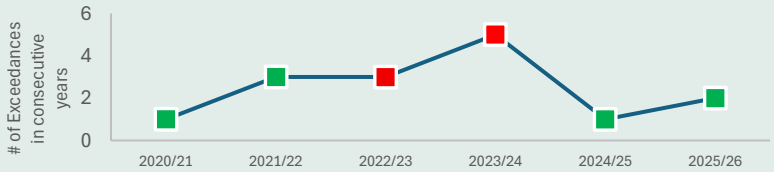
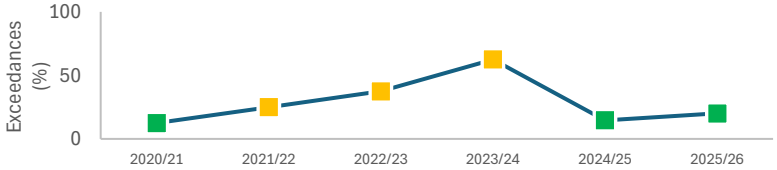
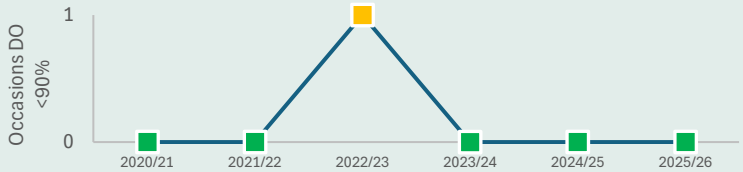
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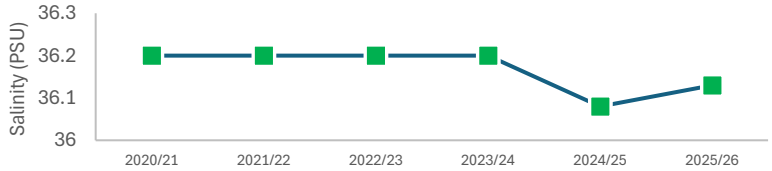
- **EQG 1**: Median dissolved oxygen in bottom waters (0 - 0.5 m above the sediment surface) in the HEPA must be greater than 90% saturation at any site for a defined period of not more than 6 weeks. Dissolved oxygen saturation within the HEPA was above 90% saturation at all times and the EQG was met.
- **EQG 2:** Median salinity (0.5 m below the water surface) at an individual HEPA site over any period is not to deviate beyond the 20$^{th}$ and 80$^{th}$ percentile of natural salinity range over the same period. Median salinity was between the 20$^{th}$ and 80$^{th}$ percentiles of the natural salinity range within the HEPA (at 150, 350, 1000, and 1,500 m from the outlets) and the EQG was met.

## Summary report card for the Environmental Quality Objective 'Maintenance of Ecosystem Integrity'

| Environmental Quality Indicator | | EQC | Comments | Compliance[1] | 6-year compliance trend (including current year) |
|---|---|---|---|---|---|
| **Toxicants in treated wastewater (TWW)** | Bioaccumulating toxicants | EQG 1 | Concentrations of cadmium and mercury in the undiluted TWW stream were below their limit of reporting (LoR; 0.1 µg/L) and the EPA (2017) 80% species protection guidelines (36 and 1.4 µg/L, respectively). | |  |
| | Non-bioaccumulating toxicants and initial dilution | EQG 2 | Initial dilution, as predicted from metocean conditions recorded on 19/01/2026 (1:238) was sufficient to reduce non-bioaccumulating contaminant concentrations to below their EPA (2017) 99% species protection guidelines. | |  |

| Environmental Quality Indicator | | EQC | Comments | Compliance[1] | 6-year compliance trend (including current year) |
|---|---|---|---|---|---|
| | Total Toxicity of the Mixture (TTM) | EQG 3 | The TTM for the additive effect of ammonia, copper, and zinc after initial dilution (0.56) was below the ANZG (2018) guideline of 1.0 | |  |
| | Whole of Effluent Toxicity (WET) | EQG 4 | The highest NOEC concentration of TWW recorded across the 1-hour sea urchin fertilisation tests was 12.5% (equivalent to 1:8 dilutions or 1:80 dilutions with application 0.1 assessment factor), which is lower than the worst-case dilutions achieved at the LEPA[2] boundary during the monitoring period (1:238). | |  |
| **Nutrient enrichment** | Chlorophyll-*a* | EQG 1 | Median chlorophyll-*a* concentration of sites within the high ecological protection area (HEPA[2]) did not exceed the 80[th] percentile of reference site concentrations (0.50 µg/L) | |  |

| Environmental Quality Indicator | | EQC | Comments | Compliance[1] | 6-year compliance trend (including current year) |
|---|---|---|---|---|---|
| **Phytoplankton blooms** | Phytoplankton biomass (measured as chlorophyll-*a*) | EQG 1 | Median chlorophyll-*a* concentrations exceeded three times the median of reference sites (0.6 µg/L) on two occasions (5/11/2025 and 19/03/2026). | |  |
| | | EQS 1 | Median chlorophyll-*a* concentration exceeded three times the median of reference sites on two occasions in the 2025-26 non-river flow period and once in the previous 2024-25 non-river flow period. | |  |
| | | EQG 2 | Phytoplankton biomass, measured as chlorophyll-*a*, exceeded three times the median chlorophyll-*a* concentration of reference sites (0.6 µg/L) on 20% of occasions at HEPA[2] sites. | |  |
| **Physical-chemical stressors** | Organic enrichment | EQG 1 | Dissolved oxygen (DO) saturation within the HEPA[2] was above 90% saturation at all times. | |  |

| Environmental Quality Indicator | | EQC | Comments | Compliance[1] | 6-year compliance trend (including current year) |
|---|---|---|---|---|---|
| | Salinity | EQG 2 | Median salinity was between the 20th and 80th percentiles of the natural salinity range within the HEPA[2] (at 150, 350, 1,000, and 1,500 m from the outlets). | |  |



Notes:

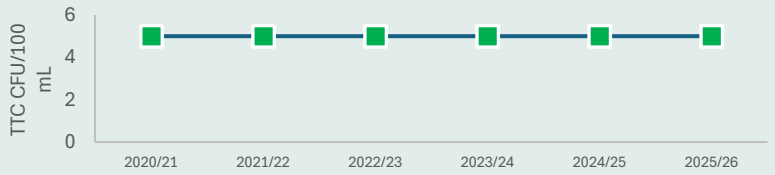
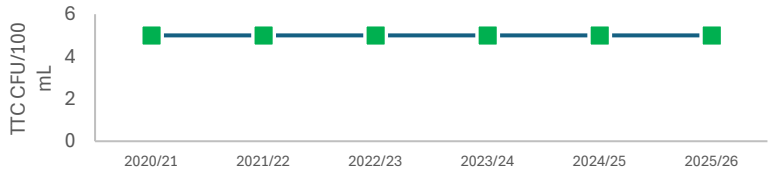
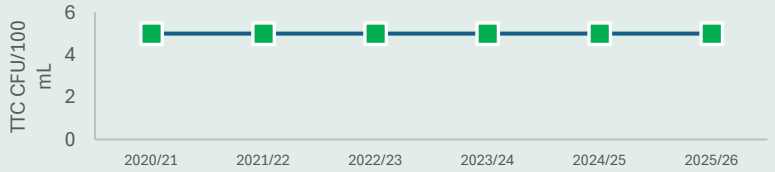
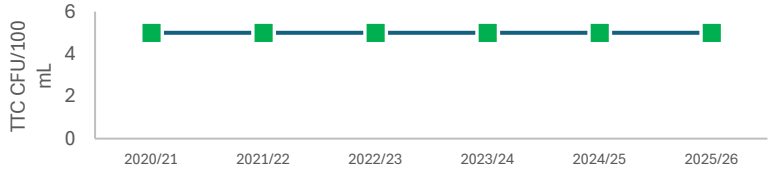
1. Green symbols indicate the Environmental Quality Guideline (EQG) was met; amber and red symbols represent an exceedance of the EQG or Environmental Quality Standard (EQS), respectively.
2. LEPA = low ecological protection area; HEPA = high ecological protection area.
3. NOEC = no observed effect concentration; the highest concentration of TWW at which there is no statistically significant observed effect on gamete fertilisation.

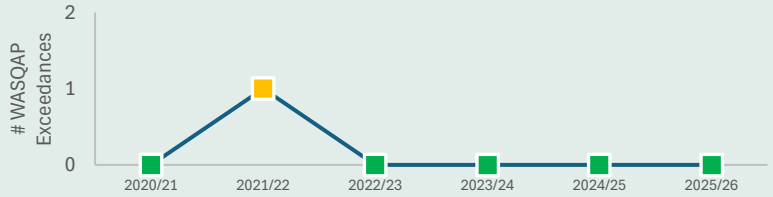
## Environmental Quality Objective ‘Maintenance of Seafood Safe for Human Consumption’

There are two EQC for the EQO 'Maintenance of the Seafood Safe 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). Monitoring of TTC was conducted at the boundaries of both the Observed Zone of Effect (OZE) and the Advanced Water Recycling Plan (AWRP) Seafood Management Zone (SMZ):

- **EQG 1**: To meet the EQG, median TTC counts (rolling median consisting of 100 samples) at the OZE boundary are not to exceed 14 CFU/100 mL and the 90$^{th}$ percentile of TTC concentrations must not exceed 21 CFU/100 mL. Median TTC concentration at OZE sites pooled for the 2024-25 and 2025-26 sampling seasons was at the limit of reporting (<10 CFU/100 mL) and below the 14 CFU/100 mL guideline. The 90$^{th}$ percentile TTC concentration was equal to the limit of reporting (<10 CFU/100 mL) and less than the 21 CFU/100 mL criteria. Additionally, the median and 90$^{th}$ percentile TTC concentrations derived from the past two summers sampled at the SMZ were also equal to the limit of reporting (<10 CFU/100 mL) and below the 14 and 21 CFU/100 mL criteria. The EQG for TTC was met at both the OZE and SMZ.
- Water Corporation conducts TTC monitoring additional to that required by the MMP along the shoreline. These results are informally assessed against the EQC. To meet the EQG at shoreline sites, median TTC concentrations are not to exceed 14 CFU/100 mL and the 90$^{th}$ percentile of TTC concentrations must not exceed 21 CFU/100 mL. Median TTC concentration at shoreline monitoring sites pooled from the 2024-25 and 2025-26 sampling seasons was at the limit of reporting (<10 CFU/100 mL) and below the 14 CFU/100 mL guideline. The 90$^{th}$ percentile TTC concentration was equal to the limit of reporting (<10 CFU/100 mL) and less than the 21 CFU/100 mL criteria. As such, the shoreline monitoring sites would meet the EQG.
- **EQG 2**: To meet the EQG for algal biotoxins, concentrations of potentially toxic algae at sites at the boundary of the OZE must not exceed the Western Australian Shellfish Quality Assurance Program (WASQAP; DoH 2025) concentrations. There were no exceedances recorded during the 2025-26 extended summer monitoring period and the EQG was met.

## Summary report card for the Environmental Quality Objective 'Maintenance of Seafood Safe for Human Consumption'

| Environmental Quality Indicator | | EQC | Comments | Compliance[1] | 6-year compliance trend (including current year) |
|---|---|---|---|---|---|
| **Microbiological contaminants (outlet sites)** | Thermotolerant coliforms (TTC)[2, 3] | EQG | Median TTC concentrations derived from 100 samples collected over the 2024-25 and 2025-26 sampling seasons was at the limit of reporting[6] (<10 CFU/100 mL) and below the 14 CFU/100 mL criteria. | |  |
| | | | The 90th percentile was equal to the limit of reporting[6] (<10 CFU/100 mL) and below the 21 CFU/100 mL criteria. | |  |
| **Microbiological contaminants (shoreline sites)[5]** | | EQG | Median TTC concentrations derived from 120 shoreline samples collected over the 2025-26 sampling seasons was at the limit of reporting[6] (<10 CFU/100 mL) and below the 14 CFU/100 mL criteria. | |  |
| | | | The 90th percentile of TTC at the shoreline was equal to the limit of reporting[6] (<10 CFU/100 mL) and below the 21 CFU/100 mL criteria. | |  |

| Environmental Quality Indicator | | EQC | Comments | Compliance[1] | 6-year compliance trend (including current year) |
|---|---|---|---|---|---|
| **Algal biotoxins** | Toxic phytoplankton species | EQG | Toxic phytoplankton species did not exceed the Western Australian Shellfish Quality Guidelines[4] during the 2025-26 monitoring period. | |  |



Notes:

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.
2. TTC results below the analytical limit of reporting (<10 CFU/100 mL) were halved (= 5 CFU/100 mL) to calculate median value (ANZG 2018).
3. TTC = Thermotolerant coliforms, CFU = colony forming units
4. Western Australian Shellfish Quality Assurance Program (WASQAP; DoH 2025)
5. Shoreline Monitoring commenced in the 2020-21 sampling season. Shoreline sites are not formally assessed against the EQC.
6. Where results were reported at or below the laboratory Limit of Reporting (LOR), a value of 0.5 × LOR was assigned for analysis.

## 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 indicators (*Enterococci* spp.), and the second is based on in-water measures of total phytoplankton cell densities.

- **EQG 1 and EQG 2:** To meet the *Enterococci* spp. EQGs, the 95th percentile value of faecal indicators (*Enterococci* spp.) outside the Observed Zone of Effect (OZE) boundary must not exceed 200 MPN/100 mL and 2,000 MPN/100 mL for primary and secondary contact recreation, respectively. The 95th percentile of *Enterococci* spp. concentrations outside the OZE, based on pooled data from two sampling seasons (2024–25 and 2025–26), was <10 MPN/100 mL, meeting the EQGs for both primary (EQG 1) and secondary (EQG 2) contact recreation.

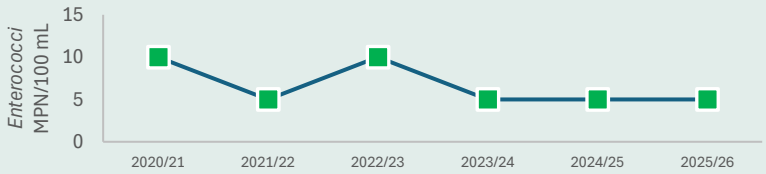
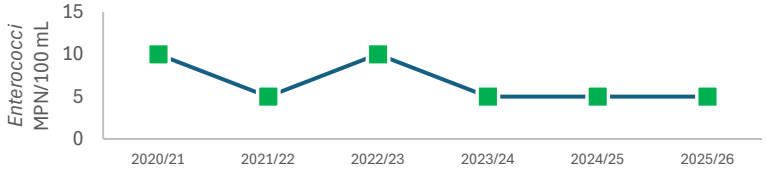
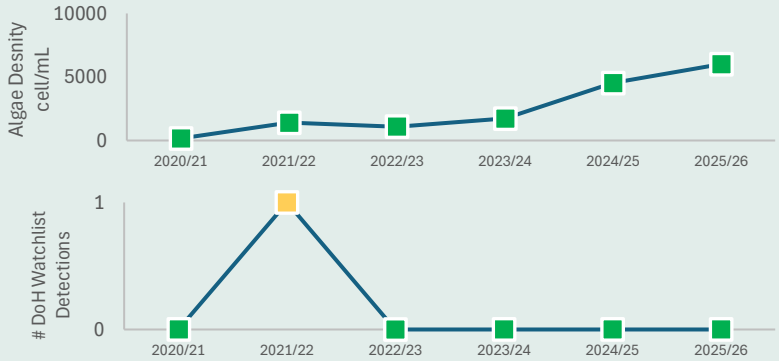
- Water Corporation conducts faecal indicator (*Enterococci* spp.) monitoring additional to that required by the MMP along the 12 sites along the shoreline. These results are informally assessed against the EQC. To meet the *Enterococci* spp. EQGs, the 95$^{th}$ percentile value of faecal indicators (*Enterococci* spp.) at monitoring sites along the shoreline must not exceed 200 MPN/100 mL and 2,000 MPN/100 mL for primary and secondary contact recreation, respectively. The 95$^{th}$ percentile of *Enterococci* spp. concentrations at shoreline sites, based on pooled data from two sampling seasons (2024–25 and 2025-26)[1], was <10 MPN/100 mL, meeting the requirements of the EQGs for both primary (EQG 1) and secondary (EQG 2) contact recreation at the shoreline sites.

- **EQG 1:** To meet the toxic algae EQG 1, the total phytoplankton cell count at a specified site should not exceed 10,000 cells/mL during normal plant operating conditions. Additionally, any watch-list species as defined by the Department of Health (DoH, 2022) should not exceed their trigger levels. The highest total phytoplankton cell concentration was 6,015 cells/mL and the EQG was met. Watch list species did not exceed their respective trigger levels during the monitoring period (DoH, 2022).

- **EQG 2:** To meet the algal biotoxin EQG 2, there should be no reports of skin or eye irritation or potential algal poisoning in swimmers considered by a medical practitioner as potentially resulting from toxic algae when less than 10,000 cells/mL is present in the water column. Primary and secondary contact recreation values were maintained. There was no reports to Water Corporation from the Department of Health regarding skin or eye irritation or potential algal poisoning in swimmers considered by a medical practitioner as potentially resulting from toxic algae and there was no confirmed incidences (by the Department of Health) of skin, eye or respiratory irritation caused by toxic algae, or of algal poisoning in recreational users and therefore the EQG and EQS was met.

[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*

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

| Environmental Quality Indicator | | EQC | Comments | Compliance[1] | 6-year compliance trend (including current year) |
|---|---|---|---|---|---|
| **Faecal Indicators Outlet sites** | | EQG 1<br>EQG 2 | The 95th percentile of *Enterococci* spp. concentrations (<10 MPN/100 mL) was lower than the primary and secondary contact EQGs (200 and 2,000 MPN/100 mL, respectively). | |  |
| **Faecal Indicators Shoreline sites[2]** | *Enterococci* spp. | EQG 1<br>EQG 2 | The 95th percentile of *Enterococci* spp. concentrations (<10 MPN/100 mL) was lower than the primary and secondary contact EQGs (200 and 2,000 MPN/100 mL, respectively). | |  |
| **Algal biotoxins** | Phytoplankton cell concentration | EQG 1 | During the 2025-26 monitoring period, there were no total phytoplankton cell concentrations exceeding 10,000 cells/mL, and no detections of DoH watch-list species exceeding their guidelines. | |  |

| Environmental Quality Indicator | EQC | Comments | Compliance[1] | 6-year compliance trend (including current year) |
|---|---|---|---|---|
| | EQG 2[3] | During the 2025-26 monitoring period, there were no reports to Water Corporation from the DoH regarding skin or eye irritation or potential algal poisoning in swimmers considered by a medical practitioner on any occasion, and no confirmed incidences of skin eye or respiratory irritation caused by toxic algae, or of algal poisoning in recreational users. | |  |

Notes:

1. Green symbols indicate the Environmental Quality Guideline (EQG) was met.
2. Shoreline Monitoring commenced in the 2020-21 sampling season. Shoreline sites are not formally assessed against the EQC.
3. Monitoring for EQG 2 for algal biotoxins commenced in the 2024-25 sampling season in accordance with Ministerial Statement 1219.

## Environmental Quality Objective 'Maintenance of Aesthetic Values'

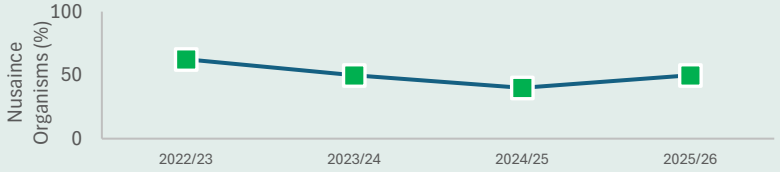
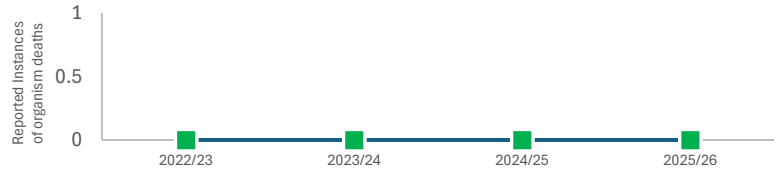
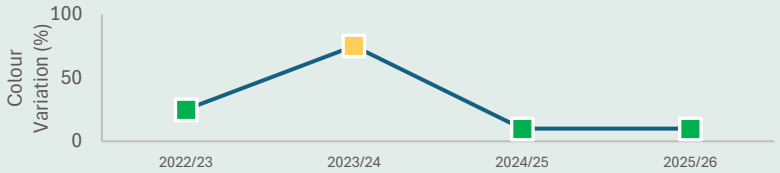
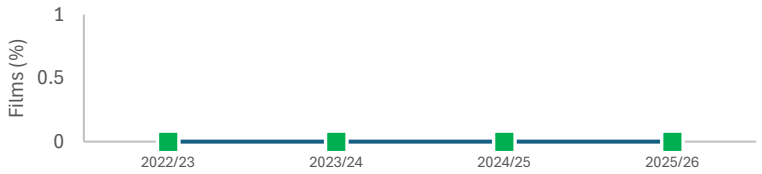
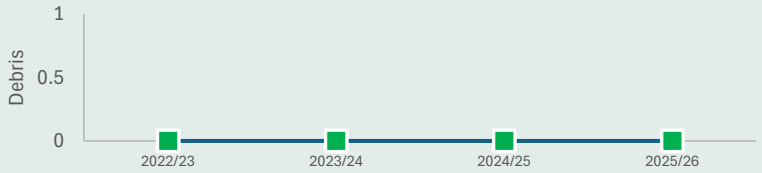
The EQO 'Maintenance of Aesthetic Values' is to ensure that Perth's coastal waters are aesthetically pleasing and that the aesthetic value is protected.

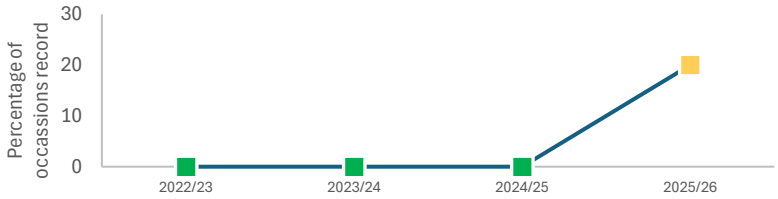
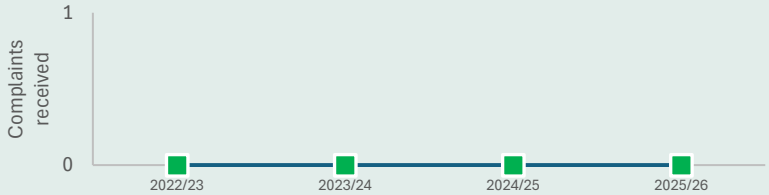
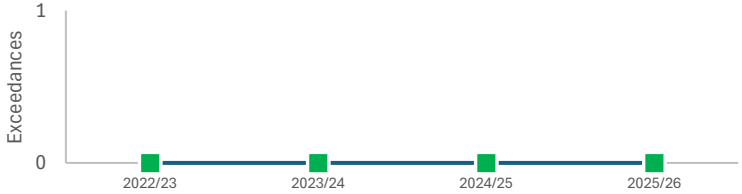
There are a series of EQGs that ensure this EQO is being met:

- Macrophytes, phytoplankton scums, filamentous algal mats, blue-green algae, and sewage fungus should not be present in excessive amounts. Nuisance organisms were not present in excessive amounts and the EQG was met.
- 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 and the EQG was met.
- The natural visual clarity of the water should not be reduced by more than 20% at the Primary Contact Recreation boundary. Measurements of light attenuation determined that the natural visual clarity of the water was reduced by ~3% (i.e. <20%) and the EQG was met.
- The natural hue of the water should not be changed by more than ten points on the Munsell scale. There was a noticeable colour variation (green/turbid) on one (10%) sampling occasion and the EQG was met.
- 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 event and the EQG was met.
- 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.
- There should be no objectionable odour. There was noticeable sewerage odour on two occasions (19/01/2026 and 03/03/2026), representing 20% sampling occasions and the EQG was not met, triggering assessment against the EQS.
    - EQS: There should be no overall decrease in the aesthetic water quality values of the marine receiving environment using direct measures of the community's perception of aesthetic value. Water Corporation maintains a complaints' register for the Ocean Reef PLOOM program, with trends in complaints used to inform assessment of the EQS. The EQG for odour was not met. An investigation into Beenyup WRRF treatment was undertaken to assess ocean discharge quality prior to and on the day of the Ocean Reef ocean monitoring event (03/03/2026). The investigation confirmed normal plant operation and that the observed aesthetic changes were not attributable to the ocean outfall discharge. The EQGs for all other aesthetics were met within the criteria for the monitoring season. Water Corporation received no direct complaints concerning aesthetics and thus, the EQS was met.
- Concentrations of contaminants will not exceed the aesthetics guidelines for fish tainting substances at the Primary Contact Management Zone boundary during normal plant operating conditions. None of the parameters assessed exceeded their respective guidelines, and the EQG for fish tainting substances was met.

Further information on water quality at Mullaloo and Ocean Reef beaches, including findings from the 2024/25 O2 Marine (2025) review and an upcoming supplementary report, is available via the DWER Environment Watch website.

## Summary report card for the Environmental Quality Objective 'Maintenance of Aesthetic Values'

| Environmental Quality Indicator[2] | EQC | Comments | Compliance[1] | 4-year compliance trend (including current year) |
|---|---|---|---|---|
| **Nuisance organisms** | EQG | Nuisance organisms were not present in excessive amounts. | |   |
| **Faunal deaths** | EQG | There were no instances of dead marine organism observed. | |   |
| **Colour** | EQG | There was a noticeable colour variation (green/turbid) on one (10%) sampling occasions. | |   |
| **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. | |   |

| Environmental Quality Indicator[2] | EQC | Comments | Compliance[1] | 4-year compliance trend (including current year) |
|---|---|---|---|---|
| **Odour** | EQG | There was noticeable odour detected on two occasions (19/01/2026 and 03/03/2026) | |  |
| **Overall aesthetic water quality values of the marine receiving environment** | EQS | Water Corporation did not receive any direct complaints during the summer monitoring period (November 2025 - March 2026). | |  |
| **Fish Tainting Substances** | EQG | Fish tainting substances, as measured in the comprehensive treated wastewater characterisation, did not exceed the guideline values. | |  |







Notes:

1. Green symbols indicate the Environmental Quality Guideline (EQG) was met.
2. Aesthetics monitoring commenced in the 2022-23 sampling season

# 1 Introduction

## 1.1 Document purpose

This annual report documents the findings of the 2025 to 2026 Ocean Reef ocean monitoring program, completed as part of the Perth Long-term Ocean Outlet Monitoring (PLOOM) Program. Monitoring was completed according to Western Australia's Environmental Quality Management Framework (EQMF, EPA 2016) and the Beenyup Ocean Outlets Monitoring and Management Plan, under Ministerial Statement 1219 (BMT, 2023).

## 1.2 Water Resource Recovery Facility (WRRF) infrastructure and discharge

Water Corporation operates the Beenyup Water Resource Recovery Facility (WRRF) in metropolitan Perth, which treats approximately 116 ML wastewater per day to produce secondary treated wastewater (TWW). Its operation is licenced through the Department of Water and Environmental Regulation (DWER) licence (L7882/1991/14) with associated monitoring and reporting requirements.

The secondary TWW is discharged to the sea through two ocean outlets at Ocean Reef (Figure 1). The outlets are 1.65 km (Outlet A) and 1.85 km (Outlet B) in length and located in ~10 m deep of water (Figure 1). Discharge commenced from Outlet A in 1978 and Outlet B in 1992. Ocean outfall compliance is regulated through the DWER licence, Ministerial Conditions set by the Minister for Water (Ministerial 1219), and the associated Beenyup Marine Monitoring and Management Plan (MMP) endorsed by the Environmental Protection Authority (EPA) to protect the environmental values (and associated Environmental Quality Objectives) of the marine environment.

Since 2016, a portion of secondary TWW from the Beenyup WRRF is diverted into the Advanced Water Recycling Plant (AWRP) and further treated via ultrafiltration (UF), reverse osmosis (RO) and ultraviolet (UV) disinfection processes to produce drinking water for recharge into a confined aquifer licenced through DWER (L9034/2017/1). AWRP reduces the volume of secondary TWW discharged to the ocean. Stage 1 of Water Corporation's Perth Groundwater Replenishment Scheme (GWRS) consisted of a 14 GL/year capacity. Stage 2 of the GWRS increased the capacity of the AWRP to 28 GL/year, treating a larger proportion of the secondary TWW from the Beenyup WRRF, further reducing the volume of secondary TWW discharged to the ocean (Figure 1).

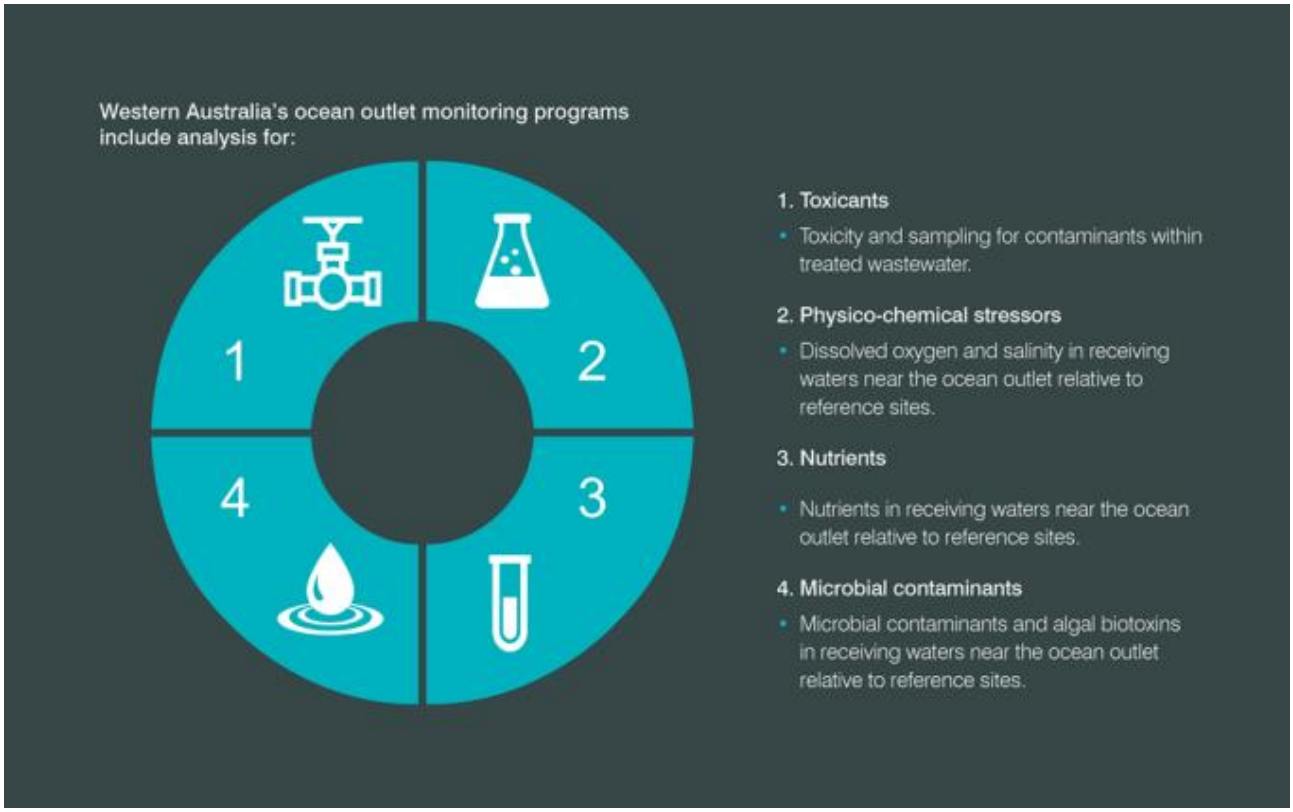
### 1.2.1 Independent Review into Water Quality and Local Current Flows at Mullaloo

Water Corporation acknowledges the broader community interest in the aesthetic values of the marine environment in the Ocean Reef area. During the summer monitoring period (November 2025 – March 2026), no complaints were received directly by Water Corporation. Further information on water quality at Mullaloo and Ocean Reef beaches is available via the DWER Environment Watch website.




**Figure 1 Location of the Beenyup Water Resource Facility (WRRF; includes the Advanced Water Recycling Plant, AWRP) and Ocean Reef ocean outlets**

## 1.3 Potential stressors in treated wastewater




### 1.3.1 Toxicants

Metals and persistent organic compounds may be directly toxic to marine biota and/or may accumulate in marine biota at concentrations sufficient to pose a risk to humans if consumed. Under the PLOOM program, TWW is screened for bioaccumulating and non-bioaccumulating toxicants, and the concentrations are compared to relevant EPA guidelines. To account for the synergistic effects of multiple toxicants and toxicants without guidelines, the overall toxicity of the TWW is determined using whole effluent toxicity (WET) testing.

### 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. Measurements of DO saturation in receiving waters near the outlets, relative to measurements at reference sites, provide an indication of the risk posed by deoxygenation.

Reduced salinity near the outlets, resulting from freshwater in the TWW plume, may cause osmotic stress in marine biota. Measurements of salinity in receiving waters near the outlets are compared to the salinity at appropriate reference sites. The comparison allows evaluation of whether salinity near the outlets is within the range of natural variation.

### 1.3.3 Nutrients

TWW contains elevated concentrations of biologically available nutrients such as total nitrogen, ammonia, nitrate + nitrite [NOx], total phosphorus 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/or macroalgae. The potential for shading is measured using in-water measures of chlorophyll-*a* (a proxy for phytoplankton biomass).

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.

Nutrient concentrations are monitored in each sampling season however these are not presented within the report unless required as supporting evidence if primary productivity indicators are exceeded or require further investigation. This data also serves as a backup, allowing comparison against ANZG (2018) default trigger values if primary productivity samples are unavailable or compromised.

### 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) criteria for primary and secondary contact, and the criteria for seafood safe for human consumption.

## 1.4 Environmental management approach

Water Corporation’s formal environmental commitments pertaining to this report are outlined in Ministerial Statement 1219. Ministerial Statement 1219 implements the Beenyup Ocean Outlets Monitoring and Management Plan (Water Corporation 2023) which aligns the management framework with the contemporary Department of Water and Environmental Regulation policy (EPA 2017) and establishes formal management areas around the outlets.

To maintain consistency with the other metropolitan ocean outlet programs, the Ocean Reef outlets (Figure 2) were monitored as part of the Perth Long-term Ocean Outlet Monitoring (PLOOM) program. The ocean monitoring program is consistent with the approach advocated under the State Government’s EQMF, which is applied to Western Australia’s coastal waters (EPA 2016).




**Figure 2 Aerial image of the Ocean Reef outlets (captured 30/08/2025, Nearmap)**

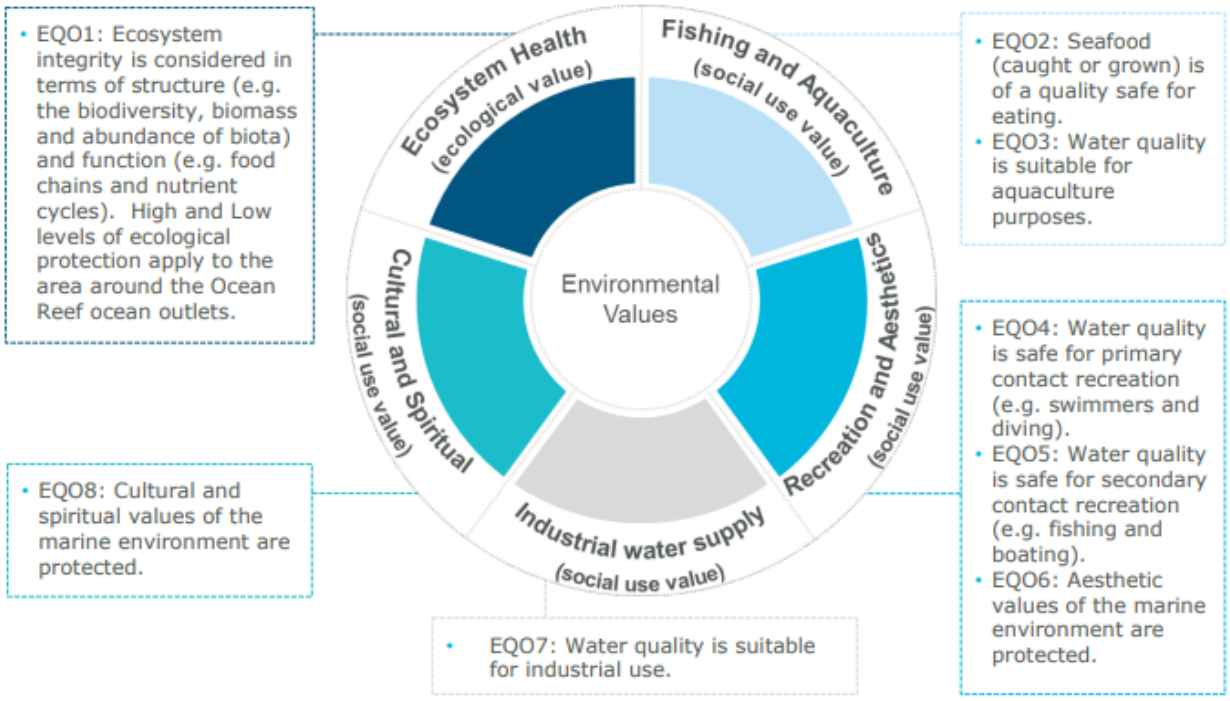
## 1.5 Environmental Quality Management Framework (EQMF)

The EQMF is based on:

- Identifying Environmental Values (EVs) (Figure 3).
- Establishing and spatially defining Environmental Quality Objectives (EQOs) that need to be maintained to ensure the associated EVs are protected (Figure 3).
- 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 'guidelines' against which monitoring results can be compared.

There are two levels of EQC:

1. **Environmental Quality Guidelines (EQG)** are quantitative investigative guidelines 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 EQS is triggered.
2. **Environmental Quality Standards (EQS)** are management guidelines which, if exceeded, signify that the EQO is at risk of not being met and that a management response may be required.




*Source: EPA (2016)*

**Figure 3 Environmental Values and Environmental Quality Objectives (EQO) for the marine waters of Western Australia.**

The compliance results for 2025-26 are summarised in Report Card format (Table 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 1 Report card legend**

| Management response[1] | 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.

### 1.5.1 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 around the Ocean Reef outlets and occupies the area within a 150 m radius of the diffusers (Figure 1; Ministerial Statement 1219 in April 2024). Waters outside the LEPA are maintained to a High Level of Ecological Protection (HEPA). The 2024-25 monitoring period was the first to implement the 150 m LEPA boundary around the Ocean Reef Ocean Outlets as required under MS1219. Previous monitoring used an informal or Notional LEPA with an approximately 100 m boundary around the outlet diffusers. In the 2025-26 monitoring season, sampling was conducted at both 100 m and 150 m from the diffuser however, in this report LEPA refers specifically to the 150 m radius (as per MS1219).

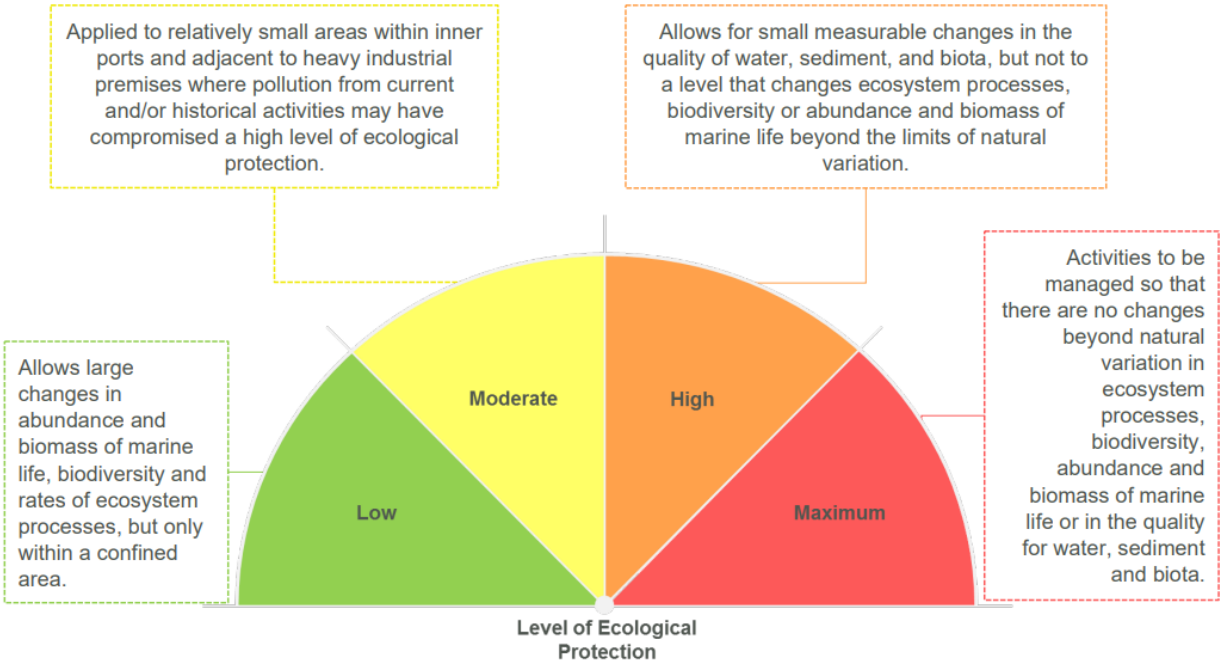



**Figure 4 Levels of Ecological Protection**

### 1.5.2 Maintenance of Seafood Safe for Human Consumption EQO

The intent of this EQO is to maintain seafood safe for human consumption (a social value) outside a small area surrounding the ocean outlets where EQO 2 may not be achieved, and seafood may be unsafe to eat. A formal zone has been developed for the Ocean Reef outlets encompassing the management area for seafood safe for human consumption based on microbiological observations from historical ocean monitoring data (Figure 5). The zone represents the area where microbiological organism concentrations are most likely to exceed the EPA's criteria for seafood safe for human consumption under worst-case conditions.

### 1.5.3 Maintenance of Primary and Secondary Contact Recreation EQOs

The primary and secondary contact EQOs support swimming and boating activities, respectively. The EQOs apply throughout Perth's coastal waters except for areas immediately surrounding the ocean outlets, where water quality may not be suitable for swimming. A formal zone has been developed for the Ocean Reef outlets encompassing the management area for primary and secondary contact recreation (Figure 5).

### 1.5.4 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.

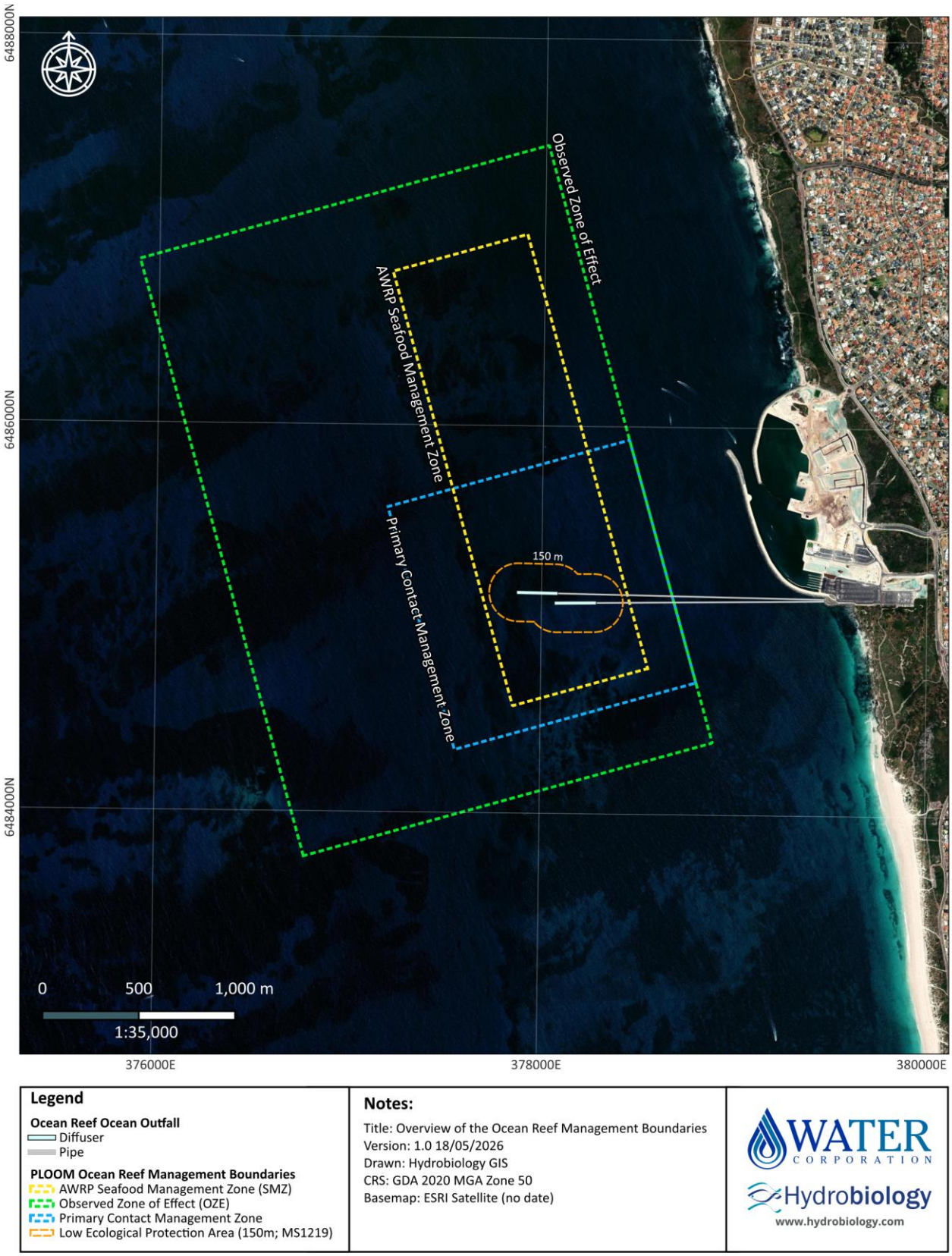



**Figure 5 Ocean Reef ocean outlet protection area and management zones**

# 2 Toxicants in treated wastewater

## 2.1 Comprehensive treated wastewater characterisation (CTWWC)

Treated wastewater (TWW; final effluent) from both outlet A and outlet B was analysed for a suite of parameters comprising the major contaminants of concern for the Ocean Reef ocean outlets:

- nutrients (total nitrogen, ammonia, nitrate + nitrite [$NO_x$], 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.

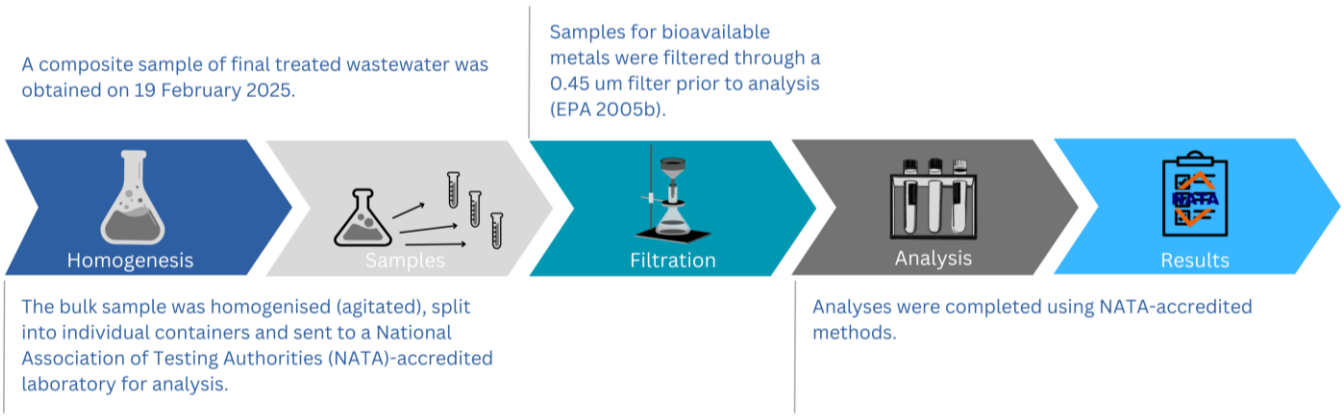



**Figure 6 Treated wastewater sampling and analysis process**

### 2.1.1 Bioaccumulating toxicants

Concentrations of both cadmium and mercury (i.e. bioaccumulating toxicants) in the TWW sample were below their analytical limit of reporting (LoR; 0.1 µg/L) and the EQG concentrations for cadmium and mercury as bioaccumulating toxicants (36 and 1.4 µg/L, respectively) were met (Table 2). Concentrations of bioaccumulating toxicants in the discharge have been consistent over time and generally reflect the LoR (Table 3; Figure 7).

**Table 2 Environmental Quality Guideline (EQG) for bioaccumulating toxicants**

| | |
|---|---|
| **EQG** | Concentrations of bioaccumulating toxicants (cadmium and mercury) will not exceed the EPA (2017) 80% species protection guideline. |

Note:

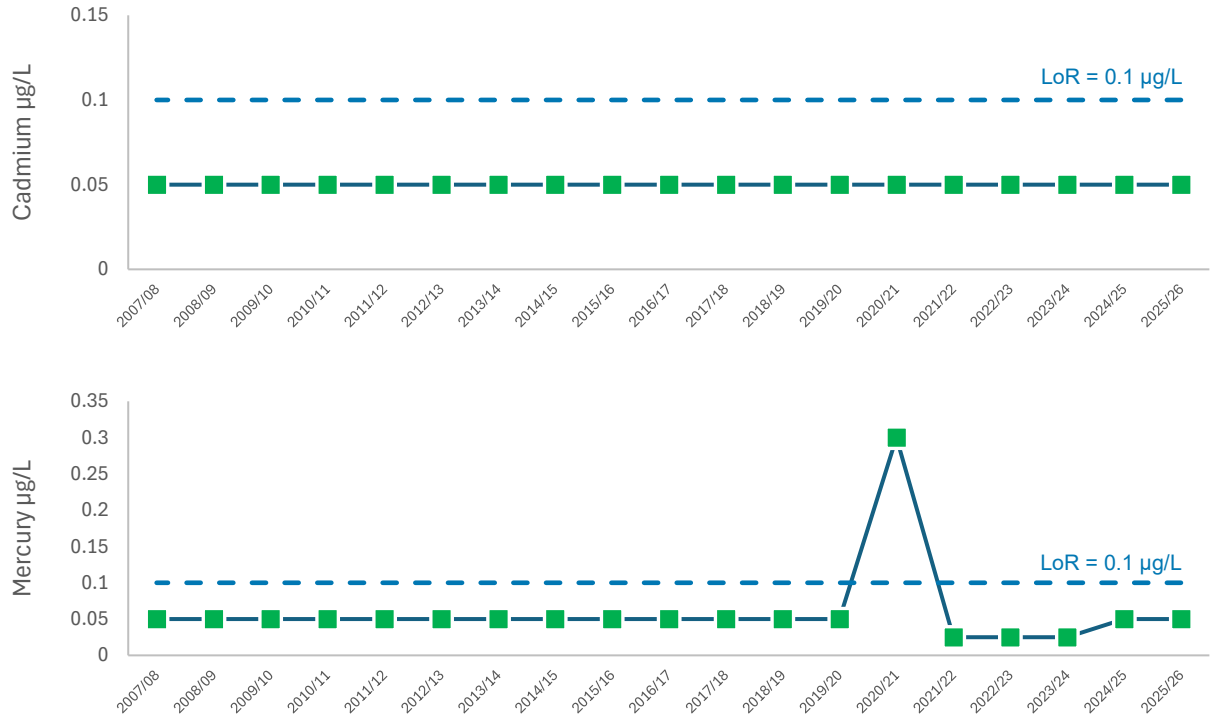
1. EQG = Environmental Quality Guideline

**Table 3 Bioaccumulating toxicants in the Ocean Reef treated wastewater stream**

| Toxicant | Ocean Reef TWW concentration (µg/L)[2] | Value used for assessment (half the LoR)[3] | EPA (2017) 80% species protection guideline (µg/L) | Compliance (EQC)[1] |
|---|---|---|---|---|
| Cadmium | <0.1 | 0.05 | 36 | ■ |
| Mercury | <0.1 | 0.05 | 1.4 | ■ |

Note:

1. Green symbols indicate the Environmental Quality Criteria (EQC) were met
2. TWW = treated wastewater
3. Cadmium and mercury concentrations below the detection limit of 0.1 µg/L are assigned a value of 0.05 µg/L (half the LoR) for reporting purposes.




Note:

1. Green symbols indicate the Environmental Quality Guideline (EQG) was met. In order to meet the EQG, must not exceed the 80% species protection level for cadmium (36 µg/L) and mercury (1.4 µg/L).
2. Cadmium and mercury concentrations below the detection limit of 0.1 µg/L are assigned a value of 0.05 µg/L (half the LoR) for reporting purposes.
3. Blue dashed line = Limit of reporting (LoR = 0.1 µg/L).
4. The use of half the LoR represents a conservative assumption that cadmium and mercury may be present at low concentrations despite being below the analytical limit of reporting.

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

### 2.1.2 Non-bioaccumulating toxicants

Initial dilution modelling is used to estimate dilution rates of treated wastewater (TWW) surrounding the low and high ecological protection areas. From the discharge point on the seabed, the TWW plume becomes increasingly diluted as it rises towards the surface. The highest concentration of TWW plume at the surface (corresponding to the minimum dilution) is used to assess compliance.

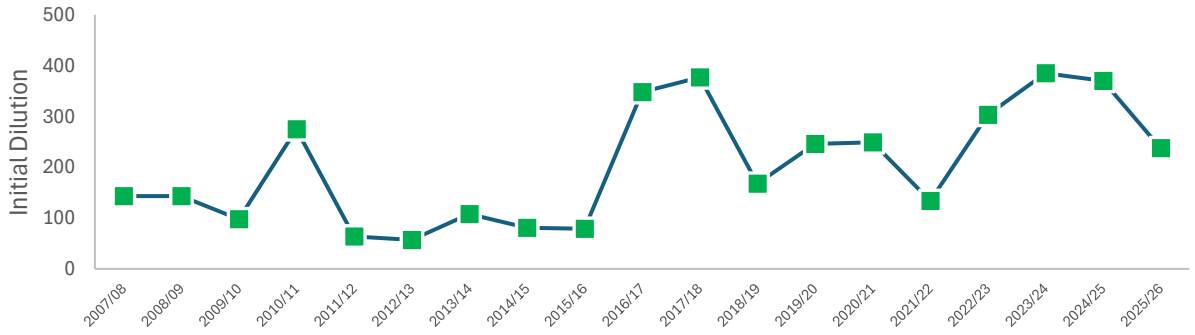
Modelling predicted an average initial dilution of 1:238, based on metocean conditions observed on 19th January 2026. Contaminant concentrations after the initial dilution (1:238) were below the EPA (2017) 99% species protection guidelines (Table 4), and the EQG for non-bioaccumulating toxicants was met. Historical initial dilution predictions are provided in Figure 8. Variability over time can be attributed to changes in the physical properties of the effluent and/or local metocean conditions.

Historical compliance of concentrations of the highest risk (based on concentrations relative to guidelines) non-bioaccumulating toxicants are presented in Figure 9.

**Table 4 Environmental Quality Guideline for non-bioaccumulating toxicants**

| | |
|---|---|
| **EQG** | Concentrations of contaminants will not exceed the EPA (2017) 99% species protection guideline for toxicants after initial dilution equivalent to that between the discharge point and the boundary of the Low/High Ecological Protection Area. |

Note:
1. EQG = Environmental Quality Guideline




Note:
1. Environmental Quality Criteria (EQC): Green symbols indicate the Environmental Quality Guideline (EQG) was met.

**Figure 8 Initial dilution modelling predictions, reported for each monitoring period (2007/08 – 2025/26)**

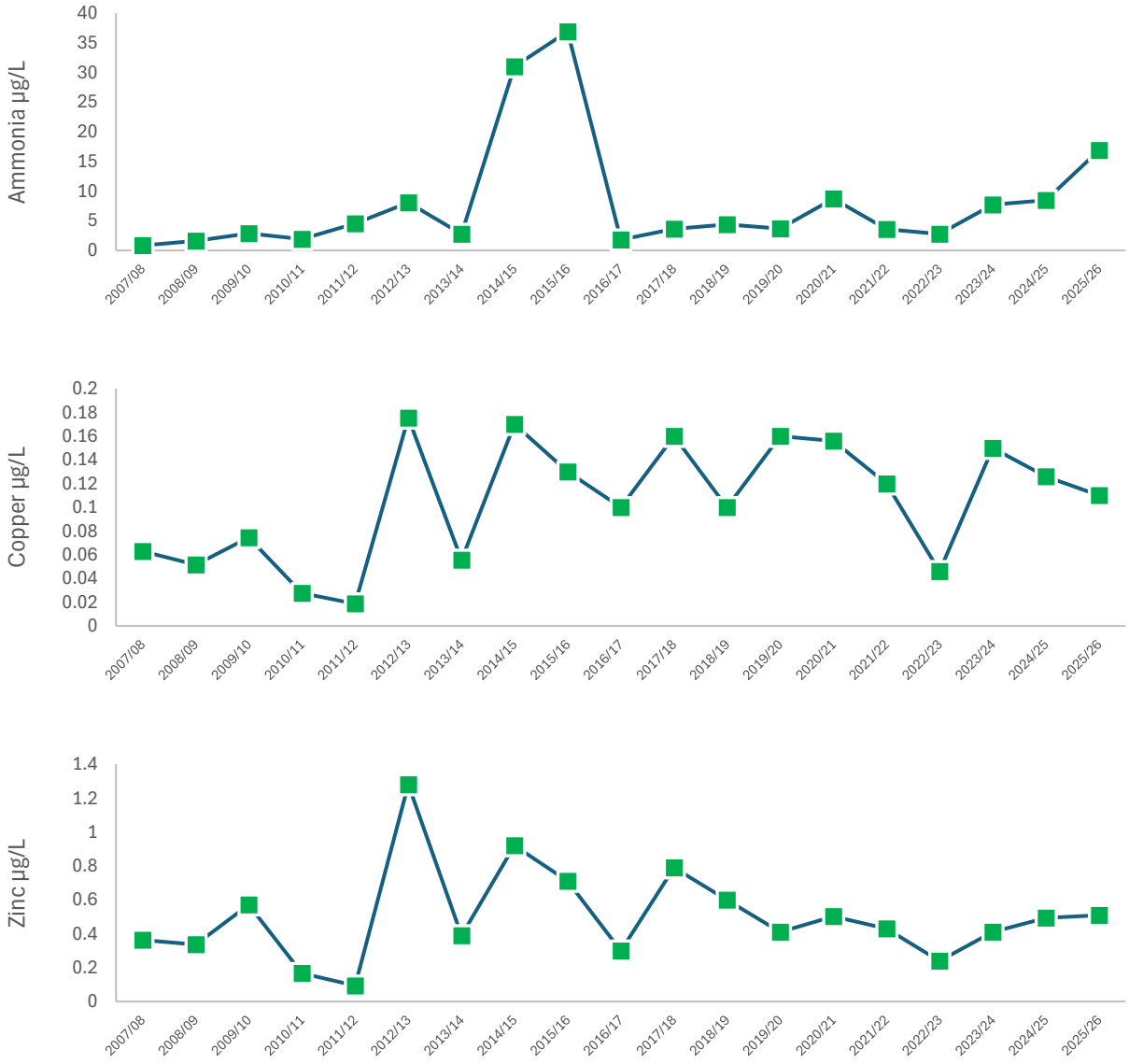
**Table 5 Non-bioaccumulating toxicant concentrations in the Ocean Reef TWW stream compared with relevant guideline levels after initial dilution**

| Toxicant | TWW[2] concentration (µg/L) | Concentration after initial dilution (µg/L)[3,4] | ANZG (2018) 99% species protection guideline (µg/L)[1,4] | Compliance (EQG) [1,2] |
|---|---|---|---|---|
| **Nutrients** | | | | |
| Ammonia-N | 3,660 | 16.87 | 500 | ■ |
| **Dissolved metals (0.45 µm filtered)** | | | | |
| Chromium III* | 2 | 0.008 | 7.7 | ■ |
| Chromium VI* | <0.1 | - | 0.14 | - |
| Copper* | 8 | 0.11 | 0.3 | ■ |
| Lead* | <1 | - | 2.2 | - |
| Nickel* | 3 | 0.013 | 7 | ■ |
| Silver* | <0.1 | - | 0.8 | ■ |
| Zinc* | 88 | 0.51 | 3.3 | ■ |
| **Organophosphate pesticides** | | | | |
| Chlorpyrifos | <0.02 | - | 0.0005 | - |
| **Organochlorine pesticides** | | | | |
| Endrin | <0.01 | - | 0.004 | - |
| Endosulfan sulfate[5] | <0.01 | - | 0.005 | - |
| **Phenols** | | | | |
| Phenol | <1.0 | - | 270 | - |
| Pentachlorophenol (PCP) | <2.0 | - | 11 | - |
| **Chlorinated hydrocarbons** | | | | |
| 1,2,4-Trichlorobenzene | <5.0 | - | 20 | - |
| **BTEX** | | | | |
| Benzene | <1.0 | - | 500 | - |
| **Polyaromatic hydrocarbons (PAHs)** | | | | |
| Naphthalene | <5.0 | - | 50 | - |
| Benzo(a)pyrene | <0.005 | - | 0.1 | - |
| **Chlorination by-products** | | | | |
| Residual chlorine | 0.16 | 0.00067 | - | ■ |

Notes:

1. Green symbols indicate the Environmental Quality Criteria (EQC) were met. '-' indicates where compliance is not applicable.
2. Assessment against EPA (2017) 99% species protection guidelines was undertaken only for those toxicants where guideline levels were available.
3. TWW = treated wastewater.
4. Initial dilution = 1:238 (predicted average dilution value). Contaminant dilution calculations were not performed (-) on any toxicants where concentrations were below the analytical limit of reporting.
5. The guidelines for marine waters are from EPA (2017) The EPA has provided advice that in WA waters where a high level of protection applies, the 99% species protection levels should be used.
6. Trigger values are for endosulfan, not endosulfan sulfate; EPA (2017)

* = dissolved metals 0.45 µm filtered.




Note:

1. Environmental Quality Criteria (EQC): Green symbols indicate the Environmental Quality Guideline (EQG) was met.
2. Ammonia, Copper and Zinc have historically been the contaminants with the highest concentrations relative to their guidelines
3. ANZG (2018) 99% species protection guidelines for Ammonia = 500 µg/L, Copper = 0.3 µg/L and Zinc = 3.3 µg/L.
4. Values are reported after the initial dilution and have therefore been corrected to account for the minimum dilution expected at the LEPA boundary.

**Figure 9 Historical compliance of concentrations of the highest risk non-bioaccumulating toxicants following initial dilution.**

### 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 6). For the combined effect of ammonia, copper and zinc (historically the contaminants with the highest concentrations relative to their guidelines) following dilution, the TTM (0.56, Table 7) was less than the ANZG (2018) guideline of 1.0 and the EQG (Table 6) was met. Total toxicity of the mixture has exceeded the EQG criteria on one occasion (2012-13, Table 7 and Figure 10)

**Table 6 Environmental Quality Guideline for the Total Toxicity of the Mixture**

| | |
|---|---|
| **EQG** | The total toxicity of the mixture (TTM[1,2]) for the additive effect of ammonia, dissolved copper and dissolved zinc following initial dilution, as per ANZG (2018) guidelines, will be less than 1.0. |

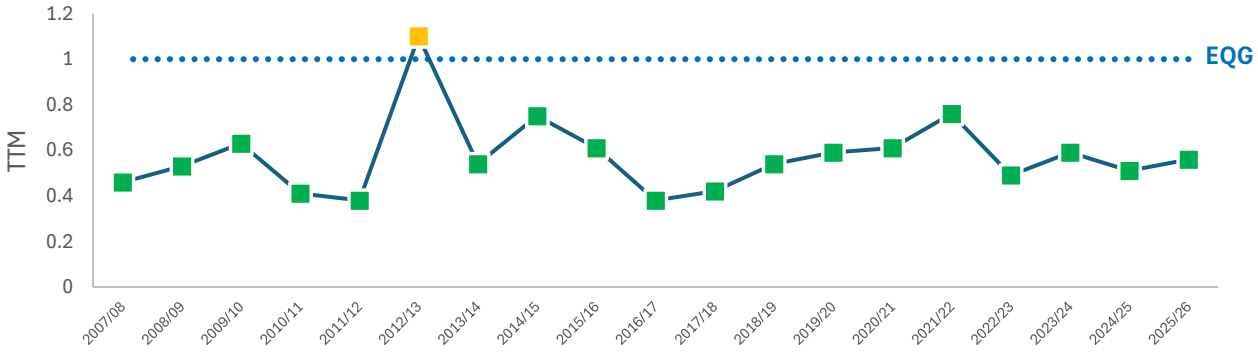
Notes:
1. EQG = Environmental Quality Guideline; TTM = Total Toxicity of the Mixture
2. TTM = Σ(Ci/EQGi) where Ci is the concentration of the 'i'th component in the mixture and the EQGi is the guideline for that component.

**Table 7 Total toxicity of treated wastewater at the edge of the initial mixing zone associated with the Ocean Reef ocean outlets**

| Toxicant | TWW concentration (µg/L) | Background concentration (µg/L)[2] | Dilution | Concentration after dilution (µg/L)[3] | Contaminant concentration/ guideline (µg/L)[3] | TTM[4] | Compliance (EQC)[1] |
|---|---|---|---|---|---|---|---|
| Ammonia | 3660 | 1.5 | 1:238 | 16.87 | 0.03 | 0.56 | |
| Copper | 8 | 0.08 | | 0.11 | 0.37 | | |
| Zinc | 88 | 0.15 | | 0.51 | 0.16 | | |

Notes:
1. Green symbols indicate the Environmental Quality Criteria (EQC) were met.
2. Background concentrations for copper and zinc from McAlpine et al. (2004); Perth marine waters (pp.19). Surface background concentrations for ammonia calculated as median of reference site data from 2003–2023 (BMT Oceanica, unpublished data).
3. Guideline values are from Table 5
4. TTM = total toxicity of the mixture = [ammonia]/guideline + [copper]/guideline + [zinc]/guideline, TWW = treated wastewater.
5. The formula used to correct chemicals for dilution is:

$$[After\ dilution] = \frac{[undiluted] + (dilution\ factor - 1) \times [background]}{dilution\ factor}$$




Note:
1. Environmental Quality Criteria (EQC): Green symbols indicate the Environmental Quality Guideline (EQG) was met; amber symbols represent an exceedance of the EQG.
2. The blue dotted line represents the EQG limit of 1. TTM values must be below 1 to be considered compliant the EQG.

**Figure 10 Historical compliance of total toxicity of the mixture.**

## 2.2 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 a series of 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). All test dilutions of TWW were salt-adjusted (using artificial sea salts) to achieve marine salinities to ensure that only the toxicity due to the presence of contaminants is examined and not the toxic effect of freshwater on the marine organisms (Table 8).

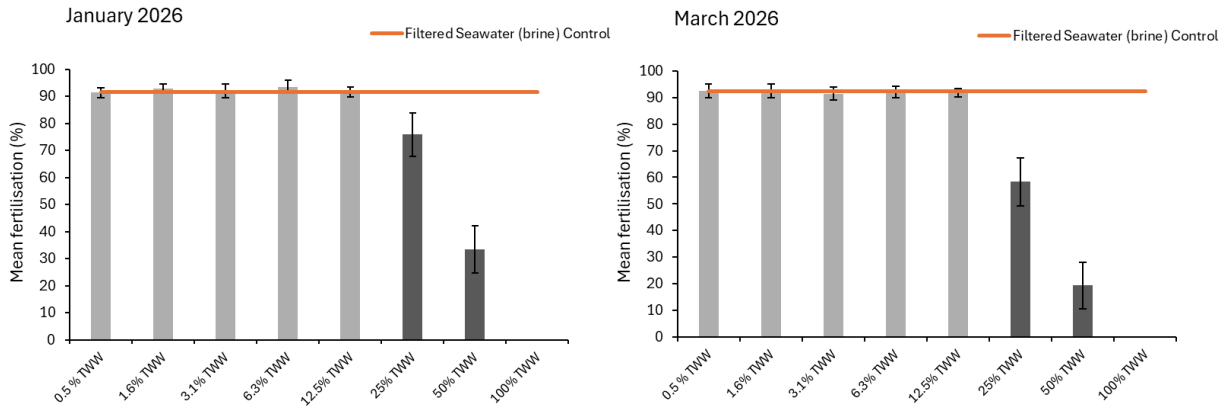
The frequency and timing of WET testing was revised for the 2025-26 monitoring period as part of a review of the ongoing requirements for this activity and sensitivity of the testing. In previous years WET testing was undertaken on TWW samples from the Beenyup WRRF on three occasions across the summer monitoring period (e.g. for 2023-24 WET testing was undertaken in October, January and March). The frequency of testing has been reduced to biannual as per Ministerial 1219 MMP since the 2024/25 program (January and March).

In January and March 2026, sea urchin fertilisation in samples exposed to 100%, 50% and 25% TWW were significantly lower than the artificial seawater control. Fertilisation success in all other dilutions were not significantly different to the control (Figure 11). The typical dilutions achieved at the LEPA boundary were 1:238. For both sampling events, the highest NOEC concentration of TWW recorded across the 1-hour sea urchin fertilisation tests was 12.5% (equivalent to 1:8 dilutions or 1:80 dilutions with the application 0.1 assessment factor). As the dilutions achieved at the LEPA (238) was greater than the dilutions required (80), the EQG was met (Table 9). Historically, the dilutions achieved has always been greater than the dilutions required after the application of a 0.1 assessment factor (Figure 12).

**Table 8 Environmental Quality Guideline for Whole of Effluent Toxicity testing**

| | |
|---|---|
| **EQG** | The typical dilutions achieved at the LEPA boundary will be greater than the number of dilutions required to achieve the No Observed Effects Concentration in a 1-hour sea urchin test after application of a 0.1 assessment factor. |

Note:
1. EQG = Environmental Quality Guideline



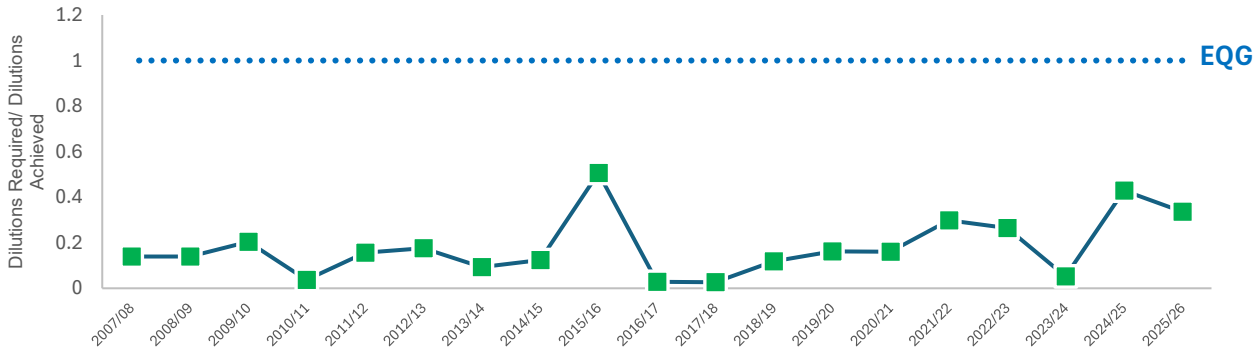

Note:
1. Error bars represent ± 1 standard deviation; n = 4
2. TWW = treated wastewater
3. Light grey bars represent concentrations of TWW at which there is no observed significant effect on fertilisation.
4. Dark grey bars represent a significantly lower percentage fertilised eggs compared with the Filtered Seawater Control (Dunnett's Test, 1-tailed, $p$ = 0.05)

**Figure 11 Comparison of whole effluent toxicity TWW dilution to filtered seawater control for Ocean Reef treated wastewater**

### Table 9 Calculated parameters from Whole of Effluent Toxicity tests

| Indicator | January 2026 | March 2026 | Compliance[1] (EQC) |
|---|---|---|---|
| **NOEC[2] (%)** | 12.5 | 12.5 | |
| **Dilutions required to meet the NOEC[2]** | 8 | 8 | |
| **Dilutions required to meet the NOEC[2] with 0.1 AF[2] application** | 80 | 80 | |
| **Dilutions required / dilution achieved** | 0.03 | 0.03 | |
| **Dilutions required (0.1 AF[2]) / dilutions achieved** | 0.3 | 0.3 | |
| **Under ≤1** | Yes | Yes | |

Notes:
1. Green symbols indicate the Environmental Quality Criteria (EQC) were met.
2. NOEC = No Observed Effect Concentration, AF = Assessment Factor




Note:
1. Environmental Quality Criteria (EQC): Green symbols indicate the Environmental Quality Guideline (EQG) was met.
2. NOEC = No Observed Effect Concentration
3. Blue dotted line indicates the EQG. To meet the EQG, dilutions required/ dilutions achieved must be ≤1 after application of a 0.1 assessment factor.

### Figure 12 Historical compliance of required dilutions to achieve the NOEC against dilutions achieved at the LEPA boundary

# 3 Water quality monitoring - Receiving Environment

Nutrients, phytoplankton biomass and physical and chemical stressors were monitored on ten occasions from early November 2025 to late March 2026 (coinciding with the summer non-river flow period) along a down-current gradient away from the diffuser (Table 10). Wind direction, strength, current grid direction and cloud cover were recorded on the day of sampling (Table 11).

**Table 10 Water quality monitoring dates near the Ocean Reef ocean outlets between November 2025 and March 2026.**

| Sampling Event | Sampling Month | Date |
|---|---|---|
| **1** | November | 05/11/2025 |
| **2** | November | 18/11/2025 |
| **3** | December | 03/12/2025 |
| **4** | December | 17/12/2025 |
| **5** | January | 06/01/2026 |
| **6** | January | 19/01/2026 |
| **7** | February | 02/02/2026 |
| **8** | February | 16/02/2026 |
| **9** | March | 03/03/2026 |
| **10** | March | 19/03/2026 |

**Table 11 Weather and current grid during water quality monitoring near the Ocean Reef ocean outlets**

| Date | Wind Direction[1,2,3] | Wind Strength (knots)[3] | Cloud cover (%) | Current grid[2] |
|---|---|---|---|---|
| **5/11/2025** | NW | 2 to 4 | 40 | S |
| **18/11/2025** | E | 14 to 16 | 100 | SW |
| **3/12/2025** | S | 12 to 14 | 10 | N |
| **17/12/2025** | SW | 14 to 16 | 60 | N |
| **6/01/2026** | S | 10 to 12 | 0 | N |
| **19/01/2026** | ESE | 8 to 10 | 0 | SW |
| **2/02/2026** | NE | 7 to 9 | 30 | S |
| **16/02/2026** | SSE | 14 to 16 | 80 | N |
| **3/03/2026** | S | 12 to 14 | 0 | N |
| **19/03/2026** | NNW | 4 to 6 | 20 | S |

Notes:

1. NW = northwest, NNW = north northwest, WNW = west northwest, S = south, E = east, SW = southwest, SE = southeast, ENE = east northeast, ESE = east southeast.
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

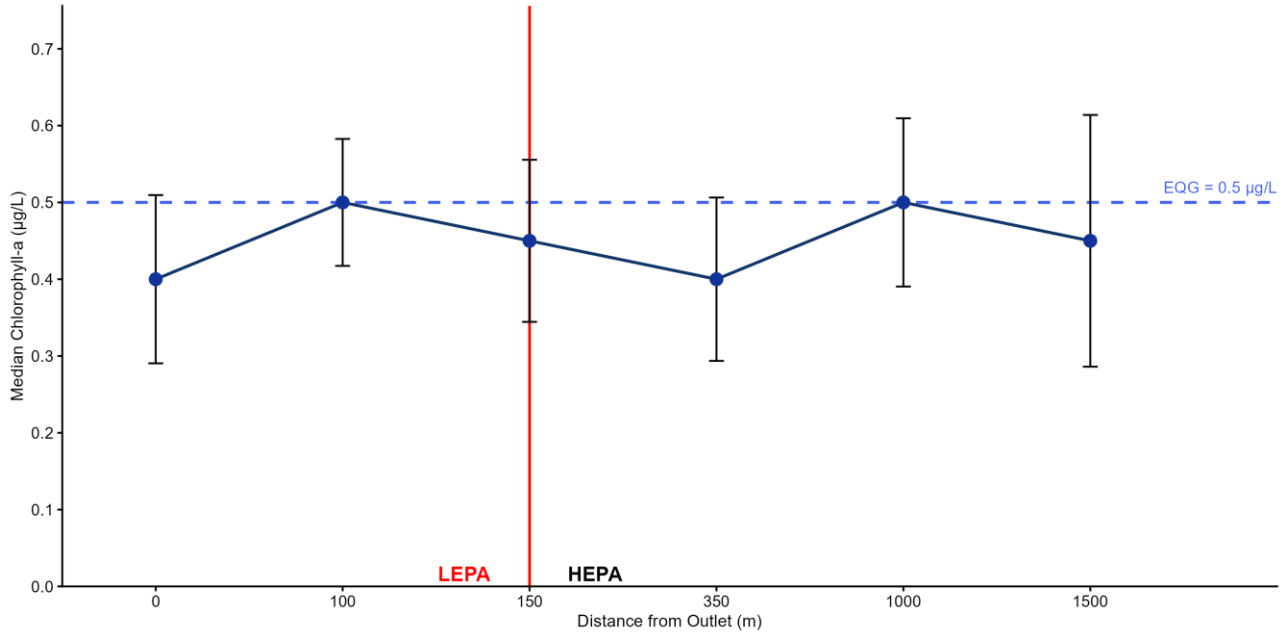
Median chlorophyll-*a* concentrations within the HEPA (150, 350, 1,000 and 1,500 m from the outlets) in 2025-26 (0.45 µg/L) did not exceed the 80th percentile of reference site concentrations (0.50 µg/L) and the EQG was met (Table 12, Figure 13 and Figure 14).

As there was no exceedance of the EQG recorded in the current 2025-26 survey, an assessment of the EQS was not required, however the Light Attenuation Coefficient (LAC) data was assessed to provide continuity with the previous monitoring survey (2024/25). Median LAC data pooled from sites outside of the LEPA from the 2025-26 extended summer monitoring period (0.085 $m^{-1}$) was below the rolling two-year (2024-25 and 2025-26) 80$^{th}$ percentile of reference site data (0.088 $m^{-1}$). Consecutive exceedances were not recorded; therefore, the EQS was met.

**Table 12 Environmental Quality Guideline for nutrients**

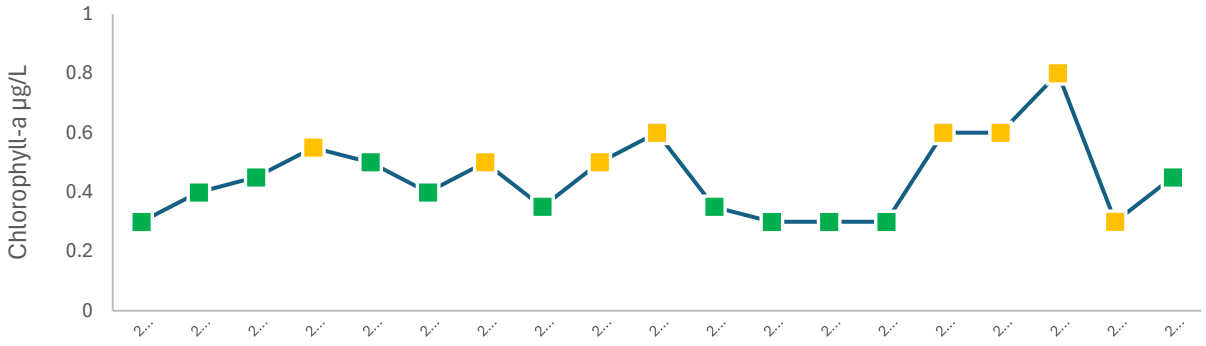
| | |
|---|---|
| **EQG** | Median chlorophyll-*a* of HEPA sites down current of the LEPA boundary during the summer monitoring period not to exceed the 80$^{th}$ percentile of reference site data. |
| **EQS** | Median light attenuation (LAC $m^{-1}$) derived from pooled HEPA sites down current of the LEPA boundary during the summer monitoring period not to exceed the two-year rolling 80$^{th}$ percentile of the reference site data in two consecutive years. |

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




Notes:
1. Data at each distance were pooled from November 2025 to March 2026. Error bars represent ± 95% confidence intervals.
2. Blue dashed line = Environmental Quality Guideline (EQG) is the 80$^{th}$ percentile of reference site data (0.5 µg/L chlorophyll-*a*).
3. LEPA = low ecological protection area; HEPA = high ecological protection area.

**Figure 13 Median chlorophyll-*a* concentrations down-current of the Ocean Reef outlets during the summer monitoring period**




Note:

1. Environmental Quality Criteria (EQC): Green symbols indicate the Environmental Quality Guideline (EQG) was met; amber represent an exceedance of the EQG. To meet the EQG, median chlorophyll-*a* (µg/L) must not exceed the 80th percentile of reference site data.
2. HEPA = High Ecological Protection Area

**Figure 14 Historical compliance assessment of the median chlorophyll-*a* concentration at HEPA sites over time**

## 3.2 Phytoplankton biomass

Median phytoplankton biomass (measured as chlorophyll-*a*) exceeded EQG 1 (three times the reference median; 0.60 µg/L) on two occasions (05/11/2025 and 19/03/2026; Figure 15, Figure 16) but did not exceed this in two consecutive years, therefore EQS 1 was met (Table 13, Figure 17).

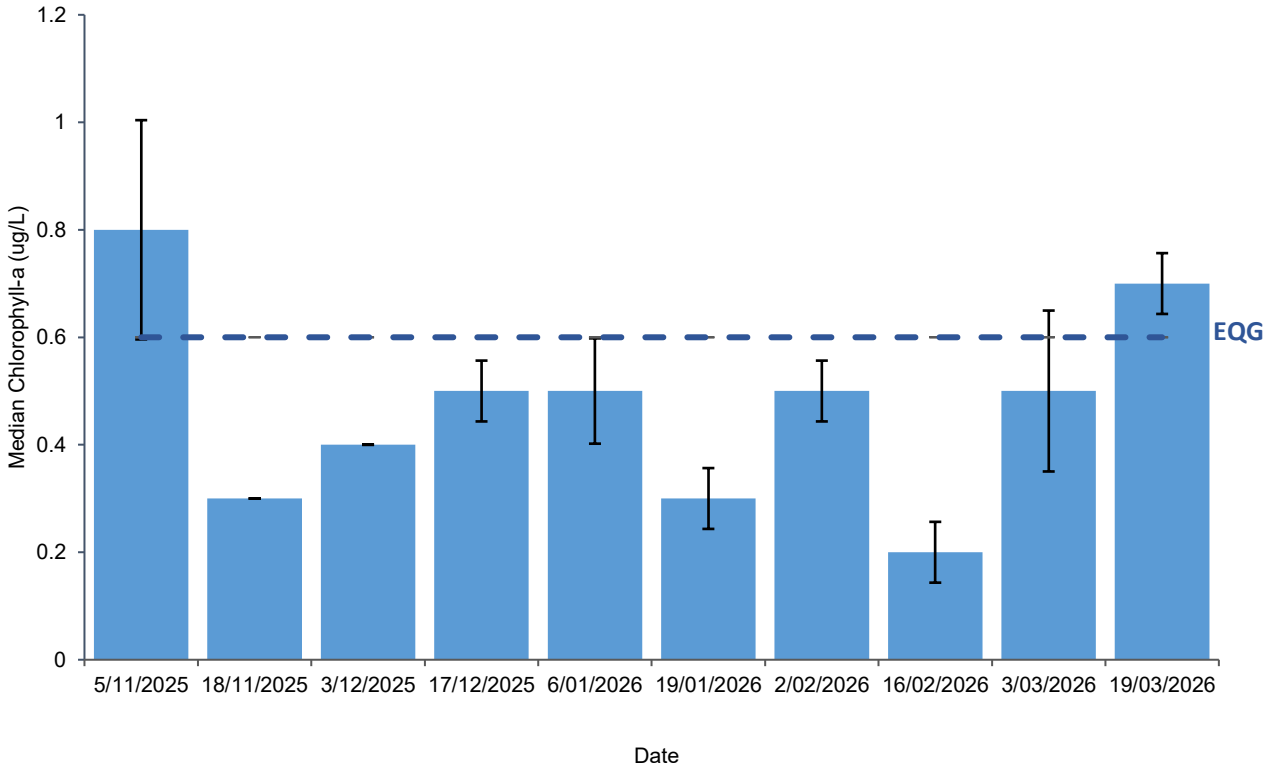
While the 2025-26 monitoring season recorded exceedances three times the median chlorophyll-*a* concentration of reference sites on two occasions, there was only one recorded exceedance in the 2024-25 monitoring season, and therefore the median phytoplankton biomass measured as chlorophyll-*a* at HEPA sites did not exceed three times the median chlorophyll-*a* concentration of reference sites on more than one occasion and in two consecutive years and thus EQS 1 was met.

Median phytoplankton biomass (measured as chlorophyll-*a*) exceeded three times the median at the reference sites on 20% of occasions, therefore EQG 2 was met (i.e. < 25% of sampling occasions during the non-river flow period; Figure 18). The individual exceedances occurred at five sites (ORT-100 m, ORT-150 m, ORT-350 m, ORT-1000 m, ORT-1,500 m) on the 05/11/2025 as well as at all four reference sites (ORR1, ORR2, ORR3 and ORR4), one site (ORT-1,500m) on 03/03/2026, and five sites (ORT-0 m, ORT-100 m, ORT-150 m, ORT-350 m and ORT-1,500 m) on 19th March 2026.

**Table 13 Environmental Quality Criteria for phytoplankton biomass in receiving waters**

| | |
|---|---|
| **EQG 1** | Median phytoplankton biomass measured as chlorophyll-*a* at the HEPA sites down current of the LEPA boundary not to exceed 3 times median chlorophyll-*a* concentration of reference sites, on any occasion during the summer monitoring period. |
| **EQS 1** | Median phytoplankton biomass measured as chlorophyll-*a* at HEPA sites down current of the LEPA boundary will not exceed 3 times median chlorophyll-*a* concentration of reference sites, on more than one occasion during the summer monitoring period and in two consecutive years. |
| **EQG 2** | Phytoplankton biomass measured as chlorophyll-*a* at any HEPA site down current of the LEPA boundary does not exceed 3 times median chlorophyll-*a* concentration of reference sites, on 25% or more occasions during the summer monitoring period. |
| **EQS 2** | Median phytoplankton biomass measured as chlorophyll-*a* at the HEPA sites down current of the LEPA boundary not to exceed 3 times median chlorophyll-*a* concentration of reference sites, on any occasion during the summer monitoring period, on more than one occasion during the summer monitoring period and in two consecutive years. |

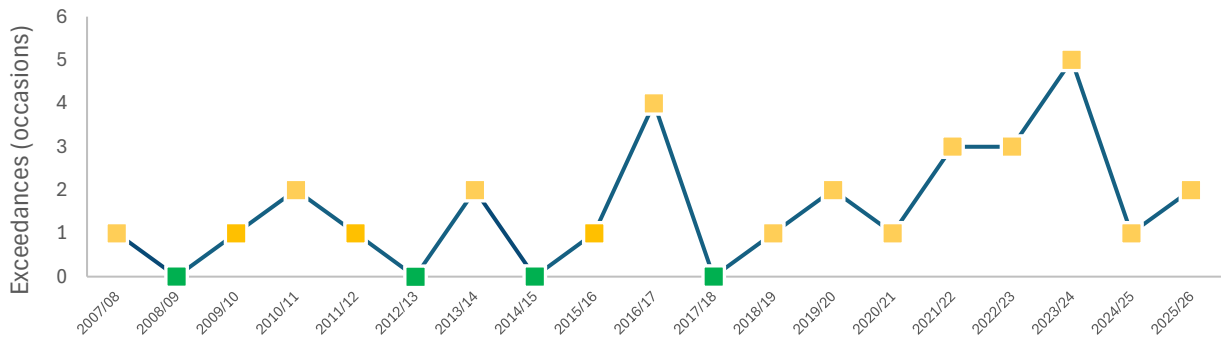
Note:
1. EQG = Environmental Quality Criteria; EQS = Environmental Quality Standard




Notes:

1. Error bars represent ± 95% confidence intervals: n = 4 for every date.
2. LEPA = low ecological protection area; HEPA = high ecological protection area. The HEPA (350 m – 1500 m) was utilised for all sampling events.
3. Blue dashed line = Environmental Quality Guideline (EQG) is 3-times the median chlorophyll-*a* concentration of reference site data (0.6 µg/L chlorophyll-*a*).
4. Data pooled from fixed sites >150 m down-current of the outlets. Concentrations at 0-150 m radius are not included in the figure or EQC assessment as they fall within the LEPA.

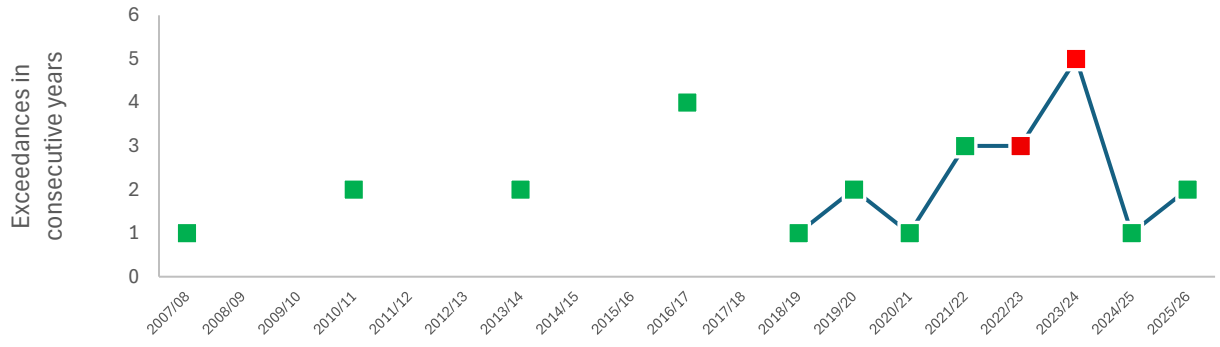
**Figure 15 Median phytoplankton biomass during the 2025-26 summer monitoring period**




Note:

1. Environmental Quality Criteria (EQC): Green symbols indicate the Environmental Quality Guideline (EQG) was met; amber symbols represent an exceedance of the EQG. To meet the EQG, the median phytoplankton biomass (measured as chlorophyll-*a*) at the HEPA sites must not exceed three times the reference site median on any occasion.

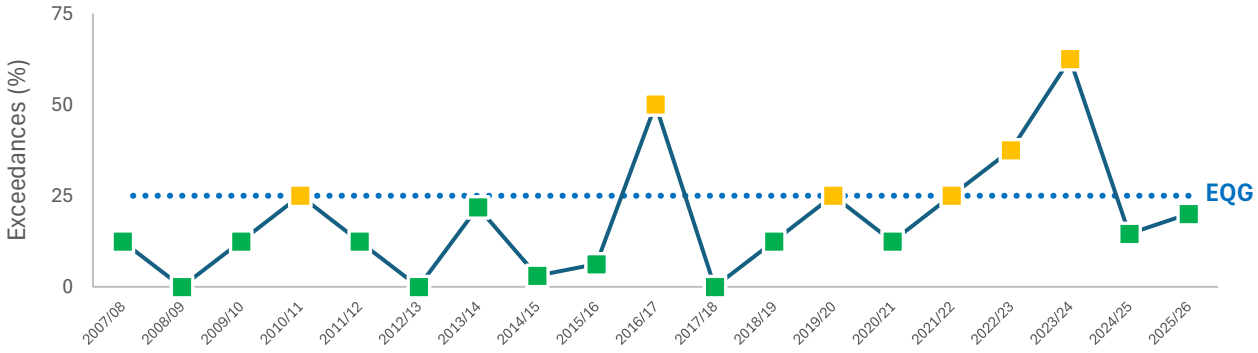
**Figure 16 Historical exceedances of three times the median chlorophyll-a concentrations of reference sites on any occasion**




Notes

1. Environmental Quality Criteria (EQC): Green symbols indicate the Environmental Quality Standard (EQS) was met, red symbols represent an exceedance of the EQS. To meet the EQS, the median phytoplankton biomass (measured as chlorophyll-a) at the HEPA sites must not exceed three times the reference site median on any occasion in two consecutive years.
2. No data are reported for years where monitoring results did not exceed the EQG.

**Figure 17 Historical exceedances of three times the median chlorophyll-a concentration of reference on more than one occasion and in two consecutive years**




Note:

1. Environmental Quality Criteria (EQC): Green symbols indicate the Environmental Quality Standard (EQG) was met, amber symbols represent an exceedance of the EQG.
2. Blue dotted line indicates the EQG. To meet the EQG, phytoplankton biomass (measured as chlorophyll-*a*) cannot exceed three times the reference median on 25% or more of occasions over the summer monitoring period.

**Figure 18 Historical compliance with the EQG, based on the percentage of monitoring occasions where chlorophyll-*a* concentrations exceeded three times the reference site median**

## 3.3 Physical-chemical stressors

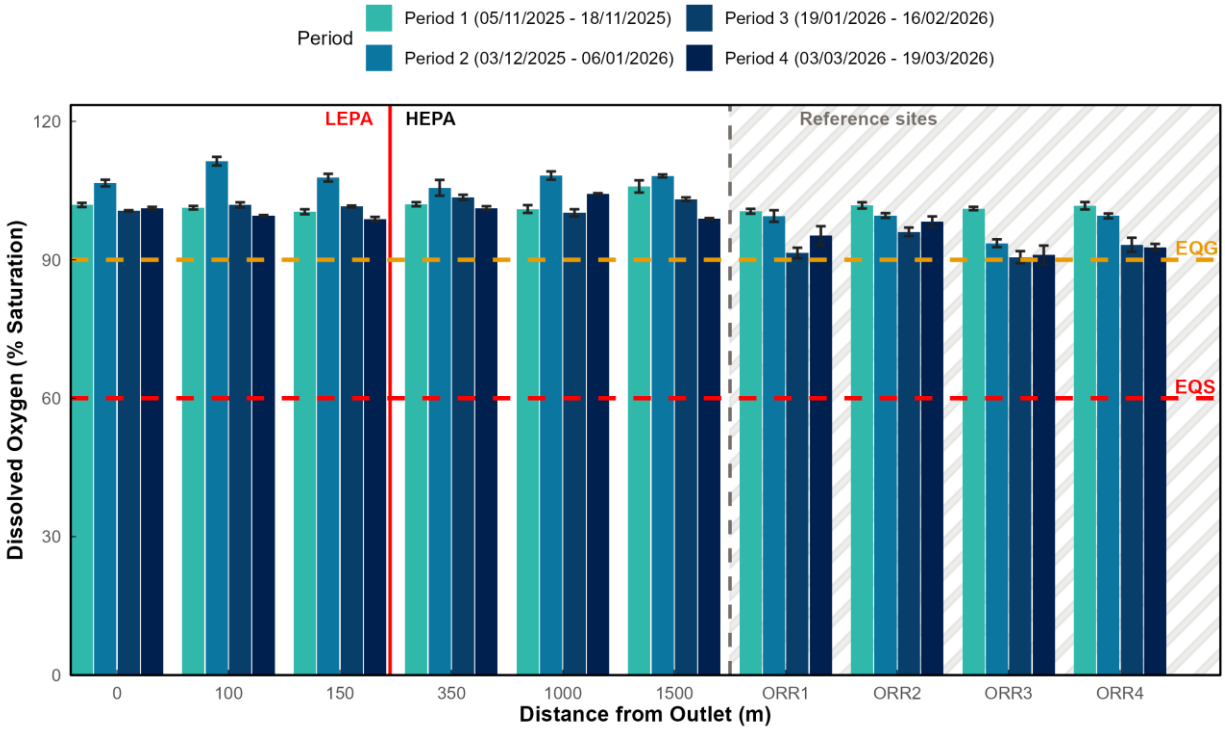
### 3.3.1 Dissolved oxygen (DO)

The median of bottom (0-0.5 m) dissolved oxygen saturation at HEPA sites (150, 350, 1000 and 1500 m from the outlets) was >90% at all sites and times throughout the summer survey period (Figure 19), and the EQG for organic enrichment (Table 14) was met. Historically, DO has fallen below 90% over a period of 1-week on two occasions (Figure 20).

**Table 14 Environmental Quality Guideline for dissolved oxygen**

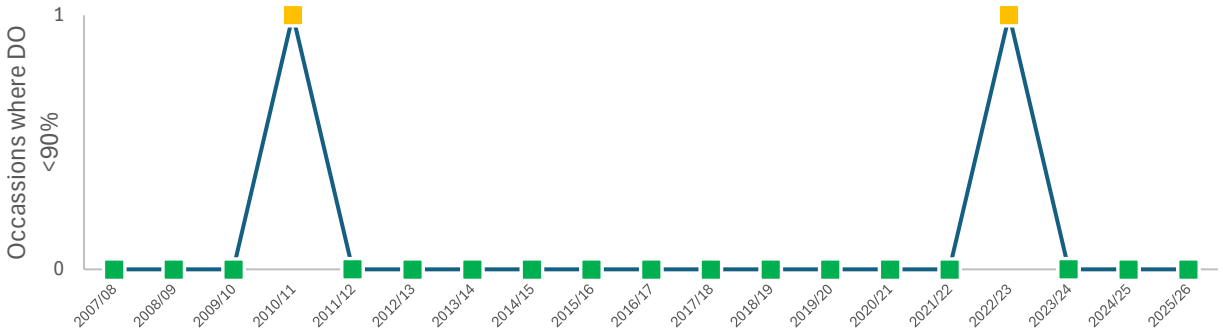
| | |
|---|---|
| **EQG** | Median dissolved oxygen in bottom waters (0–0.5 m above the sediment surface) greater than 90% saturation at any HEPA site down current of the LEPA boundary for a defined period of not more than one week. |

Note:
1. EQG = Environmental Quality Guideline.




Notes:
1. Error bars ±95% confidence intervals [n = 2 for Period 1 and 4 (two sampling trips each) and n = 3 for Period 2 and 3 (three sampling trips each)].Data divided into four periods for the 2025-26 program due to the inclusion of additional sampling in November 2025.
2. Dissolved oxygen (DO%) measure 0-0.5 m above the seabed.
3. Yellow 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. Plot shaded grey to indicate reference sites. Reference data (ORR1–ORR4) are compared against EQG for contextual purposes only.

**Figure 19 Median dissolved oxygen for defined periods of ≤6 weeks during the summer monitoring period**




Note:

1. Environmental Quality Criteria (EQC): Green symbols indicate the Environmental Quality Guideline (EQG) was met; amber symbols represent an exceedance of the EQG.

**Figure 20 Historical exceedances of 1-week periods where DO was below 90%**

### 3.3.2 Salinity

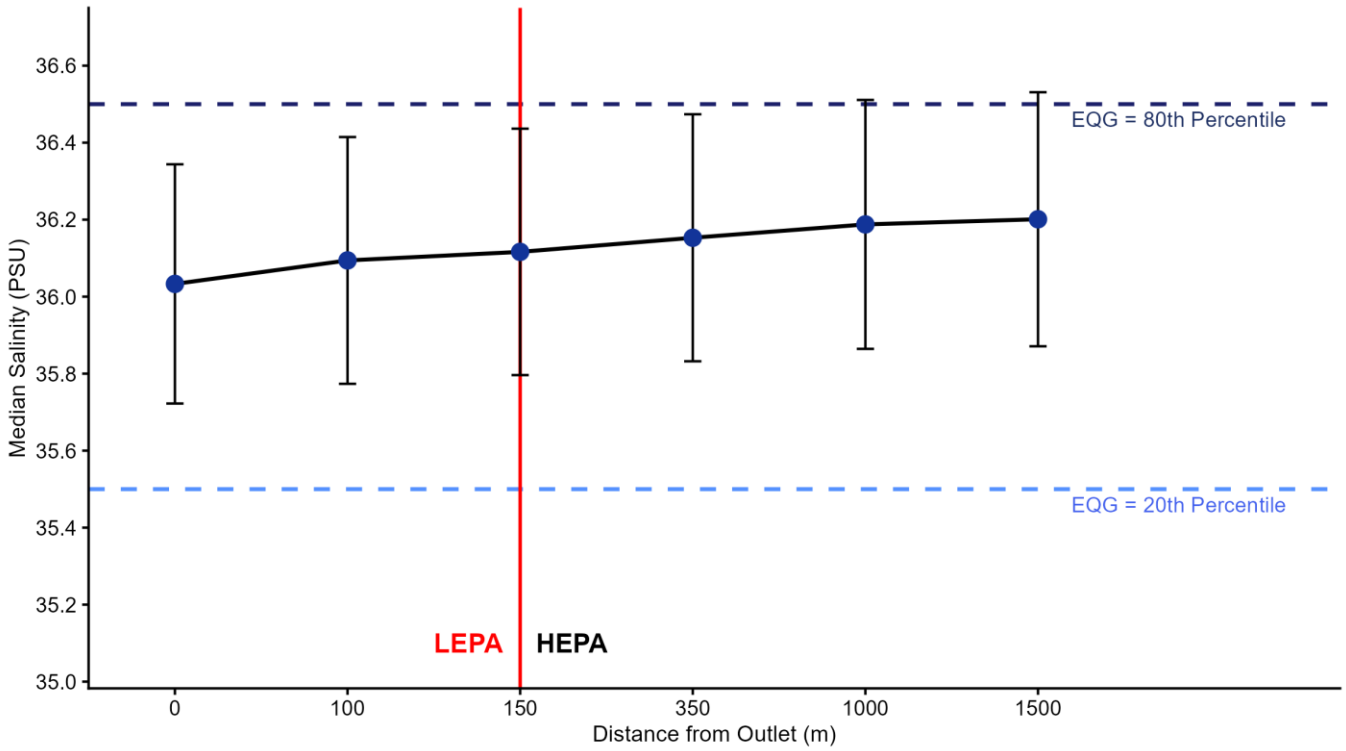
Median salinity was between the 20$^{th}$ and 80$^{th}$ percentile of the natural (reference site) salinity range (35.5 and 36.5 PSU, respectively) at all HEPA sites (150, 350, 1,000 and 1,500 m from the outlets) across the summer monitoring period, meeting the EQG (Table 15, Figure 21). In the past, median salinity has deviated beyond the 20$^{th}$ and 80$^{th}$ percentile of the natural salinity range for the same period on two occasions (Figure 22).

**Table 15 Environmental Quality Guideline for salinity**

| | |
|---|---|
| **EQG** | Median salinity (0.5 m below the water surface) at an individual HEPA site down current of the LEPA boundary over the summer monitoring period not to deviate beyond the 20$^{th}$ and 80$^{th}$ percentile of reference site salinity over the same period. |

Note:

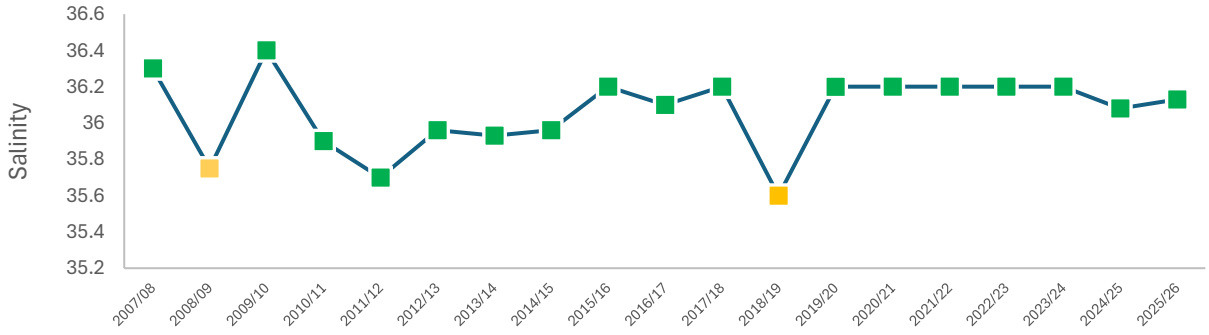
1. EQG = Environmental Quality Guideline.




Notes:

1. Error bars ± 95% confidence intervals; n = 10 for all sites.
2. Salinity measured ~0.5 m below the sea surface (closest measurement to 0.5 m depth taken for each distance, for each trip November 2025 – March 2026).
3. Dark blue line = 80$^{th}$ percentile of reference sites over the same period; light blue dashed line = 20$^{th}$ percentile of reference sites over the same period.
4. LEPA = low ecological protection area; HEPA = high ecological protection area.

**Figure 21 Median salinity compared to the 20th and 80th percentile of reference site salinity during the extended summer monitoring period**




Note:

1. Environmental Quality Criteria (EQC): Green symbols indicate the Environmental Quality Standard (EQG) was met; and amber symbols represent an exceedance of the EQG.
2. The median salinity values presented are the overall median salinity for the HEPA sites each survey. Compliance with the EQG is determined from the median salinity at individual HEPA sites relative to the 20th and 80th percentile of reference site salinity. Therefore, EQG symbols are shown in amber where one or more HEPA sites recorded an EQG deviated from beyond the 20th or 80th percentile during the corresponding survey.

**Figure 22 Historical median salinity down current of the Ocean Reef outlets**

# 4 Microbiological contaminants and algal biotoxins

## 4.1 Thermotolerant coliforms (TTC)

TTC were sampled 10 times over the 2025–26 extended summer period at the boundary of the Observed Zone of Effect (OZE) and the AWRP Seafood Management Zone (SMZ), yielding 50 samples at each management boundary. The OZE defines the boundary at which the EQC for TTC are met 50% of the time under the historical worst-case discharge scenario, based on 15 years of long-term monitoring data. The SMZ is approximately 75% of the size of the OZE and represents the modelled footprint for when the AWRF is operating normally, however long-term operational data for the AWRF is not available yet, as such, both management boundaries have been monitored in this report to determine whether compliance can be maintained at each zone (Table 16).

NHMRC (2008) guidelines and EPA (2005) require a minimum of 100 samples for an 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 local pollution conditions have not changed, the 50 samples collected at the OZE boundary during the 2024–25 summer were pooled with the 50 samples collected at the OZE boundary during the 2025–26 summer to yield 100 samples for that boundary. Similarly, the 50 samples collected at the SMZ boundary during 2024–25 were pooled with the 50 samples collected at the SMZ boundary during 2025–26 to yield 100 samples for that boundary. The OZE and SMZ datasets were analysed separately.

The EQG for primary and secondary contact recreation are outlined in Table 16.

The median and 90$^{th}$ percentile TTC concentrations derived from the past two summers (2024-25 and 2025-26 extended monitoring period) samples collected at the OZE were both equal to the limit of reporting (<10 CFU/100 mL) and less than the 14 and 21 CFU/100 mL criteria, respectively, meeting the EQG (Table 17).

Additionally, the median and 90$^{th}$ percentile TTC concentrations derived from the past two summers sampled at the SMZ were also equal to the limit of reporting (<10 CFU/100 mL) and less than 14 and 21 CFU/100 mL criteria, as such, the EQG was met for both management boundaries (Table 18).

Median (Figure 23) and 90$^{th}$ percentile (Figure 24) TTC concentrations sampled in the OZE have generally been equivalent to the limit reporting over time and have never exceeded the 14 or 21 CFU/100 mL criteria respectively.

**Table 16 Environmental Quality Guideline for Thermotolerant Coliforms (TTC)**

| | |
|---|---|
| **EQG** | Median thermotolerant coliform (TTC) counts (rolling median consisting of 100 samples) at sites at the Observed Zone of Effect (OZE) or AWRF Seafood Management Zone (SMZ) boundary are not to exceed 14 CFU[2]/100 mL and the estimated 90$^{th}$ percentile concentration will not exceed 21 CFU[2]/100 mL as measured using the membrane filtration method during normal plant operating conditions. |

Notes:
1. EQG = Environmental Quality Guideline
2. CFU = Colony Forming Units

**Table 17 Median and 90th percentile of thermotolerant coliforms concentrations sampled at the fixed monitoring sites at the Observed Zone of Effect (OZE) for the Ocean Reef outlets pooled from the 2024-26 period and comparison to the EQC.**

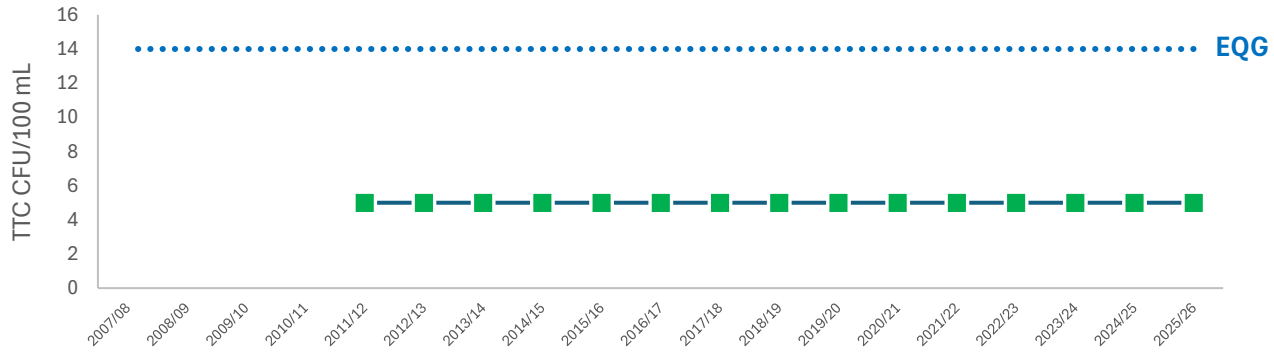
| Sampling period | Median[2] | 90th percentile[2] | Compliance (EQC)[1,3] |
|---|---|---|---|
| Nov 2024 – Mar 2025<br>Nov 2025 – Mar 2026 | <10 CFU/100 mL | <10 CFU/100 mL | |

Notes:
1. Green symbols indicate the Environmental Quality Criteria (EQC) were met
2. Thermotolerant coliform results below the analytical limit of reporting (<10 CFU/100 mL) were halved (= 5 CFU/100 mL) to calculate the median and 90th percentile.
3. Environmental Quality Criteria are based on EPA (2017).

**Table 18 Median and 90th percentile of thermotolerant coliforms concentrations sampled at the fixed monitoring sites at the AWRP Seafood Management Zone (SMZ) for the Ocean Reef outlets pooled from the 2024-26 period and comparison to the EQC.**

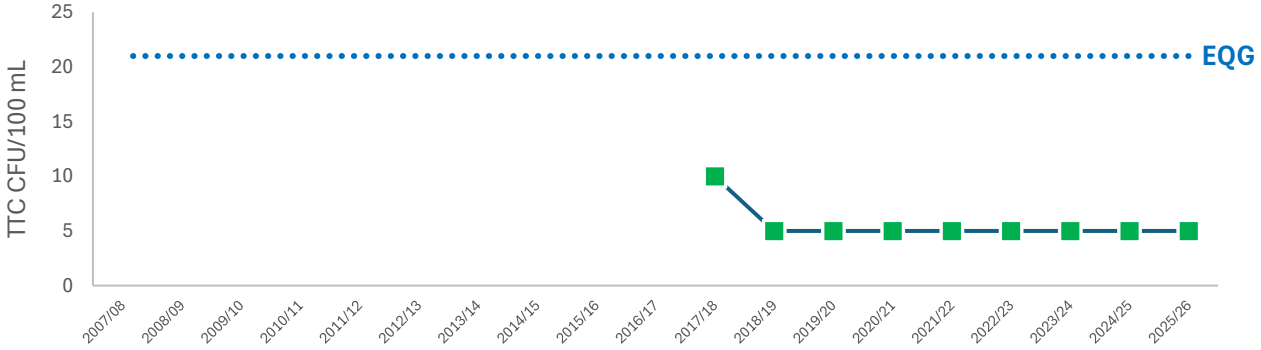
| Sampling period | Median[2] | 90th percentile[2] | Compliance (EQC)[1,3] |
|---|---|---|---|
| Nov 2024 – Mar 2025<br>Nov 2025 – Mar 2026 | <10 CFU/100 mL | <10 CFU/100 mL | |

Notes:
1. Green symbols indicate the Environmental Quality Criteria (EQC) were met
2. Thermotolerant coliform results below the analytical limit of reporting (<10 CFU/100 mL) were halved (= 5 CFU/100 mL) to calculate the median and 90th percentile.
3. Environmental Quality Criteria are based on EPA (2017).




Note:
1. Environmental Quality Criteria (EQC): Green symbols indicate the Environmental Quality Guideline (EQG) was met.
2. Thermotolerant coliform results below the analytical limit of reporting (<10 CFU/100 mL) were halved (= 5 CFU/100 mL) to calculate the median and 90th percentile.
3. Sampling of thermotolerant coliforms commenced in the 2011-12 sampling season.
4. Blue dotted line represents the EQG. To meet the EQG, median thermotolerant coliform (TTC) concentration must not exceed 14 CFU/100 mL

**Figure 23 Historical compliance of median thermotolerant coliform concentrations at the boundary of the Observed Zone of Effect**




Note:

1. Environmental Quality Criteria (EQC): Green symbols indicate the Environmental Quality Guideline (EQG) was met.
2. Thermotolerant coliform results below the analytical limit of reporting (<10 CFU/100 mL) were halved (= 5 CFU/100 mL) to calculate the median and 90$^{th}$ percentile.
3. Reporting of 90$^{th}$ percentile monitoring of thermotolerant coliforms commenced in 2017/18.
4. Blue dotted line indicates the EQG. To meet the EQG, the 90$^{th}$ percentile for thermotolerant coliform (TTC) concentrations must not exceed 21 CFU/100 mL

**Figure 24 Historical compliance of 90th percentile thermotolerant coliform concentrations at the boundary of the Observed Zone of Effect**

## 4.2 *Enterococci* spp.

Samples were collected at the Primary Contact Management Zone boundary 10 times over the 2025-26 extended summer monitoring period (yielding a total of 50 samples) for faecal indicator analyses (measured as *Enterococci* spp.). NHMRC (2008) guideline 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 two summers (summer of 2024–25 and 2025-26) were pooled to yield 100 samples. The EQG for primary and secondary contact recreation are outlined in Table 19.

Over the past two summers, the 95$^{th}$ percentile of *Enterococci* spp. concentrations at the boundary of the observed zone of effect (contact recreation management zone) for the Ocean Reef ocean outlets was equal to the limit of reporting (<10 MPN/100 mL), and the EQG for faecal indicators (Table 20) in the water were met. The 95$^{th}$ percentile *Enterococci* spp. concentrations have varied little over time and have never exceeded the EQG (Figure 25).

**Table 19 Environmental Quality Guidelines (*Enterococci* spp.) for contact recreation**

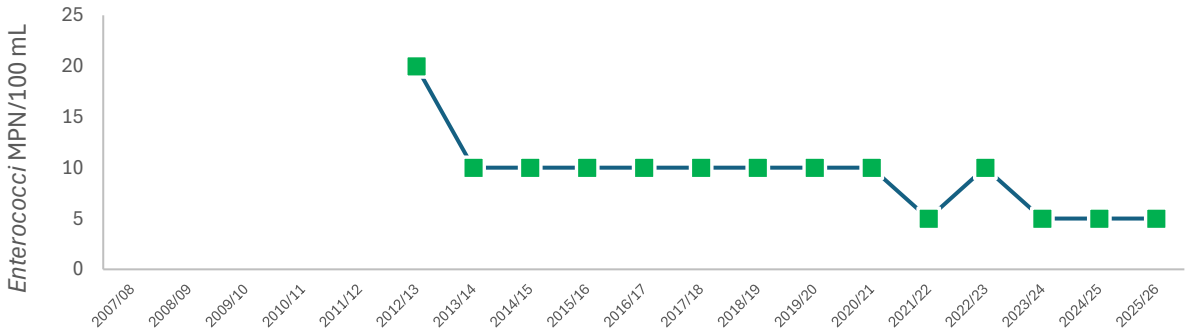
| | |
|---|---|
| **EQG** | The 95$^{th}$ percentile concentration of *Enterococci* spp. (rolling Hazen 95$^{th}$ percentile consisting of 100 samples) taken over the bathing season not to exceed 200 MPN/100 mL, outside the Primary Contact Management Zone boundary during[2] normal plant operating conditions. |

Notes:
1. EQG = Environmental Quality Guideline
2. Primary contact recreation = activities where humans are in direct contact with the water (e.g. swimming, snorkelling and diving).

**Table 20 The 95$^{th}$ percentile of *Enterococci* spp. concentrations at the boundary of the Primary Contact Management Zone for the Ocean Reef ocean outlets**

| Sampling period | Median[2,3] | 95$^{th}$ percentile[2,3] | Compliance (EQC)[1] |
|---|---|---|---|
| Nov 2024 – Mar 2025<br>Nov 2025 – Mar 2026 | <10 MPN/100 mL | <10 MPN/100 mL | |

Notes:
1. Green symbols indicate the Environmental Quality Criteria (EQC) were met.
2. MPN = most probable number of *Enterococci* spp.
3. *Enterococci* spp. concentrations below the analytical limit of reporting (<10 *Enterococci* spp. MPN/100 mL) were halved (= 5 MPN/100 mL) to calculate the 95$^{th}$ percentile and median.
4. Environmental Quality Criteria (EQC) based on EPA (2017) water quality guidelines for recreation waters.




Note:

1. Environmental Quality Criteria (EQC): Green symbols indicate the Environmental Quality Guideline (EQG) was met.
2. Sampling of *Enterococci* spp. commenced in the 2012-13 sampling season.
3. The 95th percentile *Enterococci* spp. concentration must be <200 MPN/100mL to meet the primary contact EQG

**Figure 25 Historical compliance of 95th percentile *Enterococci* spp. concentrations at the Primary Contact Recreation Zone boundary**

## 4.3 Algal biotoxins

The EQG for algal biotoxins states that concentrations of potentially toxic algae are not to exceed the WASQAP Marine Biotoxin Monitoring and Management Plan (MBMMP; DoH 2025) guideline concentrations in any Observed Zone of Effect (OZE) boundary samples (sites OR-17 to OR-32). Table 21 lists the phytoplankton species known to produce toxins that may be concentrated in shellfish and their WASQAP (DoH 2025) guideline concentrations (alert level to initiate flesh testing) for all sites.

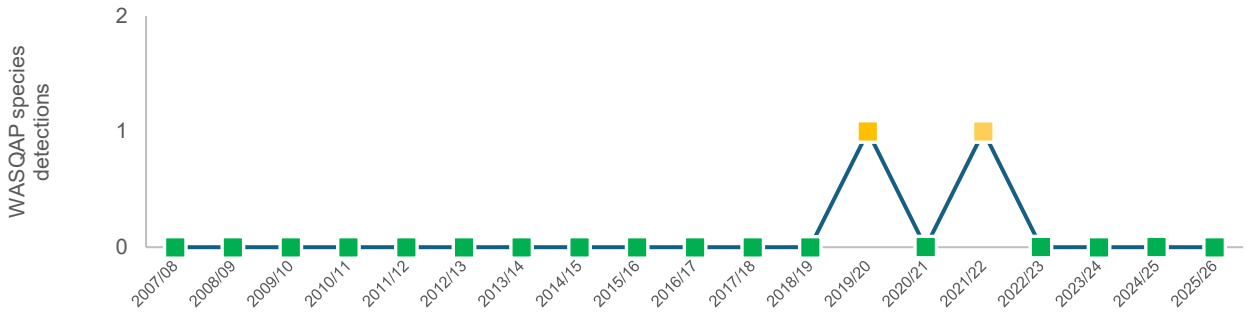
Phytoplankton sampling was undertaken on 10 occasions over the 2025/26 summer monitoring period at one of the OZE fixed monitoring sites, the date and site sampled for each occasion are presented in Table 22. There were no exceedances recorded during the 2025-26 extended summer monitoring period (Table 22). The historic assessment of the EQG for algal biotoxins is presented in Figure 26.

**Table 21 Environmental Quality Guideline for toxic phytoplankton species**

| | |
|---|---|
| **EQG[1]** | Concentrations of potentially toxic algae in any sample at the Observed Zone of Effect (OZE) boundary are not to exceed the WASQAP[4] guideline concentrations for any of the following during normal plant operating conditions:<br>Paralytic shellfish poison:<br>• *Alexandrium catenella*[5] (100 cells/L)<br>• *Alexandrium minutum*[5] (100 cells/L)<br>• *Alexandrium ostenfeldii*[5] (100 cells/L)<br>• *Alexandrium tamarense*[5] (100 cells/L)<br>• *Gymnodinium catenatum* (1,000 cells/L)<br>Diarrhoetic shellfish poison[3]:<br>• *Dinophysis acuminata* (1,000 cells/L)<br>• *Dinophysis acuta* (1,000 cells/L)<br>• *Dinophysis caudata* (1,000 cells/L)<br>• *Dinophysis fortii* (1,000 cells/L)<br>• *Prorocentrum lima* (500 cells/L)<br>• *Prorocentrum rathymum*[10]<br>Amnesic shellfish poison:<br>• *Psuedo-nitzschia seriata* group[6,7] (500,000 cells/L)<br>• *Pseudo-nitzschia delicatissima* group[6,8] (500,000 cells/L)<br>Neurotoxic shellfish poison:<br>• *Karenia* cf. *brevis* (1,000 cells/L)<br>*Karenia, Karlodinium* and *Gymnodinium* group[9] (250,000 cells/L) |
| **EQS[1,2]** | Following an exceedance of the EQG, sentinel mussels will be deployed at sites along the Observed Zone of Effect (OZE) Management Zone boundary.<br>The shellfish tissue concentration of the following algal toxins will be assessed:<br>• Paralytic shellfish poison (0.8 mg Saxitoxin eq/kg)<br>• Diarrhoetic shellfish poison (0.2 mg/kg)<br>• Neurotoxic shellfish poison (200 mouse units/kg)<br>• Amnesic shellfish poison (domoic acid; 20 mg/kg)<br>• Yessotoxins (1 mg Yessotoxin eq./kg) |

Notes:

1. EQG = Environmental Quality Guideline, EQS = Environmental Quality Standard
2. If this EQG is breached, assessment of sentinel mussel tissues against the EQS will be conducted.
3. The cell levels within each toxin group are cumulative (e.g. 600 cells/L of both *D. acuta* and *D. fortii* in the diarrhoetic shellfish poison group are totalled to 1,200 cells/L, exceeding the critical level to initiate flesh testing).
4. Western Australian Shellfish Quality Assurance Program (WASQAP) Marine Biotoxin Monitoring and Management Plan (MBMMP; DoH 2025).
5. *Alexandrium* species may be difficult to identify when numbers are low, and they are being treated as potentially toxic.
6. Species within the *Pseudo-nitzschia* groups are difficult to identify, and they are being treated as potentially toxic.
7. The *Pseudo-nitzschia seriata* group includes *P. australis, P. pungens* and *P. multiseries*.
8. The *Pseudo-nitzschia delicatissima* group includes *P. turgidula, P. fraudulenta, P. delicatissima, P. pseudodelicatissima* and *P. multistriata*.
9. The *Karenia, Karlodinium* and *Gymnodinium* group includes *Karenia bidigitata, Karenia brevisulcata, Karenia mikimotoi, Karenia papilionacea, Karenia selliformis, Karlodinium micrum* and *Gymnodinium impudicim*.
10. Trigger levels have not been established for *P. rathymum*, but presence and cell density are to be reported




Note:

1. Environmental Quality Criteria (EQC): Green symbols indicate the Environmental Quality Guideline (EQG) was met; amber symbols represent an exceedance of the EQG. To meet the EQG, concentrations of potentially toxic algae in any sample at the Observed Zone of Effect (OZE) boundary are not to exceed the WASQAP (DoH 2025) guideline concentrations
2. WASQAP = Western Australian Shellfish Quality Assurance Program

**Figure 26 Historical compliance of concentrations of potentially toxic phytoplankton species**

**Table 22 Estimated cell densities of phytoplankton species known to produce toxins at Ocean Reef outfall sites.**

| Date | Site[2,3] | Species[6,7,8] | Estimated density (cells/L)[5] | WASQAP Guideline (cells/L)[4,6] | Compliance[1,3] |
|---|---|---|---|---|---|
| 05/11/2025 | OR-15 | Gymnodinium/Karenia group | 5,200 | 250,000 | - |
| | | Pseudo-nitzschia "delicatissima" group | 1,760 | 500,000 | |
| | | Pseudo-nitzschia "seriata" group | 20,800 | 500,000 | |
| | OR-32 | Gymnodinium/Karenia group | 240 | 250,000 | |
| | | Pseudo-nitzschia "seriata" group | 9,040 | 500,000 | |
| | ORR2 | Gymnodinium/Karenia group | 240 | 250,000 | - |
| | | Pseudo-nitzschia "delicatissima" group | 4,960 | 500,000 | |
| | | Pseudo-nitzschia "seriata" group | 27,520 | 500,000 | |
| 18/11/2025 | OR-13 | Gymnodinium/Karenia group | 80 | 250,000 | - |
| | | Pseudo-nitzschia "delicatissima" group | 2,400 | 500,000 | |
| | | Pseudo-nitzschia "seriata" group | 80 | 500,000 | |
| | OR-30 | *Alexandrium pseudogonyaulax* | 80 | - | |
| | | Gymnodinium/Karenia group | 80 | 250,000 | |
| | | Pseudo-nitzschia "delicatissima" group | 1,040 | 500,000 | |
| | ORR3 | Gymnodinium/Karenia group | 320 | 250,000 | - |
| | | Pseudo-nitzschia "delicatissima" group | 3,680 | 500,000 | |
| 3/12/2025 | OR-22 | Gymnodinium/Karenia group | 160 | 250,000 | |
| | | Pseudo-nitzschia "delicatissima" group | 560 | 500,000 | |
| | | Pseudo-nitzschia "seriata" group | 80 | 500,000 | |
| | OR-7 | Gymnodinium/Karenia group | 160 | 250,000 | - |
| | | Pseudo-nitzschia "delicatissima" group | 80 | 500,000 | |
| | ORR2 | Gymnodinium/Karenia group | 240 | 250,000 | - |

| Date | Site[2,3] | Species[6,7,8] | Estimated density (cells/L)[5] | WASQAP Guideline (cells/L)[4,6] | Compliance[1,3] |
|---|---|---|---|---|---|
| 17/12/2025 | OR-22 | Gymnodinium/Karenia group | 80 | 250,000 | |
| | | Pseudo-nitzschia "delicatissima" group | 14,960 | 500,000 | |
| | OR-7 | Gymnodinium/Karenia group | 400 | 250,000 | - |
| | | Pseudo-nitzschia "delicatissima" group | 9,760 | 500,000 | |
| | | Pseudo-nitzschia "seriata" group | 80 | 500,000 | |
| | ORR2 | Gymnodinium/Karenia group | 160 | 250,000 | - |
| | | Pseudo-nitzschia "delicatissima" group | 50,560 | 500,000 | |
| | | Pseudo-nitzschia "seriata" group | 160 | 500,000 | |
| 6/01/2026 | OR-22 | Pseudo-nitzschia "delicatissima" group | 19,040 | 500,000 | |
| | OR-7 | Gymnodinium/Karenia group | 160 | 250,000 | - |
| | | Pseudo-nitzschia "delicatissima" group | 9,440 | 500,000 | |
| | | Pseudo-nitzschia "seriata" group | 2,400 | 500,000 | |
| | ORR3 | Gymnodinium/Karenia group | 80 | 250,000 | - |
| | | *Karlodinium spp.* | 240 | 250,000 | |
| | | Pseudo-nitzschia "delicatissima" group | 400 | 500,000 | |
| | | Pseudo-nitzschia "seriata" group | 160 | 500,000 | |
| | | *Trichodesmium erythraeum* | 160 | - | |
| 19/01/2026 | OR-11 | Gymnodinium/Karenia group | 80 | 250,000 | - |
| | | Pseudo-nitzschia "delicatissima" group | 240 | 500,000 | |
| | OR-28 | Gymnodinium/Karenia group | 1,840 | 250,000 | |
| | | Pseudo-nitzschia "delicatissima" group | 80 | 500,000 | |
| | ORR1 | Gymnodinium/Karenia group | 80 | 250,000 | - |
| 2/02/2026 | OR-15 | Gymnodinium/Karenia group | 800 | 250,000 | - |

| Date | Site[2,3] | Species[6,7,8] | Estimated density (cells/L)[5] | WASQAP Guideline (cells/L)[4,6] | Compliance[1,3] |
|---|---|---|---|---|---|
| | | Karlodinium group | 3,440 | 250,000 | |
| | | Pseudo-nitzschia "delicatissima" group | 4,480 | 500,000 | |
| | OR-32 | Gymnodinium/Karenia group | 240 | 250,000 |  |
| | | Karlodinium group | 80 | 250,000 | |
| | | Pseudo-nitzschia "delicatissima" group | 560 | 500,000 | |
| | ORR2 | Gymnodinium/Karenia group | 560 | 250,000 | - |
| | | Karlodinium group | 80 | 250,000 | |
| | | Pseudo-nitzschia "delicatissima" group | 3,680 | 500,000 | |
| | | Pseudo-nitzschia "seriata" group | 160 | 500,000 | |
| 16/02/2026 | OR-22 | Karlodinium group | 80 | 250,000 |  |
| | | *Prorocentrum rhathymum* | 80 | - | |
| | | Pseudo-nitzschia "delicatissima" group | 9,680 | 500,000 | |
| | OR-7 | Pseudo-nitzschia "delicatissima" group | 20,080 | 500,000 | - |
| | ORR3 | Pseudo-nitzschia "delicatissima" group | 1,920 | 500,000 | - |
| 3/03/2026 | OR-22 | Gymnodinium/Karenia group | 240 | 250,000 |  |
| | | Pseudo-nitzschia "delicatissima" group | 9,680 | 500,000 | |
| | OR-7 | Gymnodinium/Karenia group | 160 | 250,000 | - |
| | | Pseudo-nitzschia "delicatissima" group | 3,040 | 500,000 | |
| | ORR2 | Pseudo-nitzschia "delicatissima" group | 480 | 500,000 | - |
| | | *Trichodesmium erythraeum* | 80 | - | |
| 19/03/2026 | OR-15 | Pseudo-nitzschia "delicatissima" group | 24,640 | 500,000 | - |
| | OR-30 | Gymnodinium/Karenia group | 160 | 250,000 |  |
| | | Pseudo-nitzschia "delicatissima" group | 47,600 | 500,000 | |
| | ORR2 | Gymnodinium/Karenia group | 400 | 250,000 | - |
| | | Pseudo-nitzschia "delicatissima" group | 7,440 | 500,000 | |

Notes:

1. Green symbols indicate the Environmental Quality Criteria (EQC) were met. '-' indicates that a site was not a part of the OZE boundary.
2. Samples were analysed for one monitoring OZE boundary site, one Primary Contact site and one reference site per sampling occasion.
3. Compliance to the EQG only applies for OZE boundary sites (OR-17 to OR-32). Results for reference sites (ORR1 to ORR4) and Primary Contact management zone sites (OR-1 to OR-16) are not applicable to compliance assessment but are provided for comparison. The bolded site name indicates the OZE monitoring site analysed on each occasion.
4. Western Australian Shellfish Quality Assurance Program (WASQAP) Marine Biotoxin Monitoring and Management Plan (MBMMP; DoH 2025).
5. Limit of reporting = 80 cells/L
6. Phytoplankton species that do not have a guideline described in the WASQAP MBMMP (DoH 2025) but are described by the lab as being potentially toxic have been included in this table (e.g. *Trichodesmium erythraeum*).
7. *Alexandrium pseudogonyaulax* is not identified as a WASQAP MBMMP trigger species however it is listed under Category B species in the MBMMP (DoH 2025) which contains species that their status is "potential unclear or untested toxin producing species known to be present in Australian coastal waters" and therefore has been included in this table.
8. *Prorocentrum rhathymum* is not a WASQAP watch list species with a trigger criterion but is noted as "*Reportable for presence and cell density only, as no evidence to set up action levels" therefore it has been included in this table.

## 4.4 Toxic algae

There are two EQGs associated with compliance for toxic algae in marine recreational waters (Table 23). The first EQG is based upon total phytoplankton cell count and the levels of any DoH (2022) watch list species. The second EQC examines whether any cases of skin or eye irritation, or suspected algal poisoning in swimmers, have been reported by a medical professional to the DoH as potentially linked to toxic algae when phytoplankton counts are below 10,000 cells/mL.

Phytoplankton sampling was undertaken on 10 occasions over the 2025/26 summer monitoring period at one of the Primary Contact Management Zone fixed monitoring sites; the date and sampling site for each occasion are provided in (Table 24).

During the 2025-26 monitoring period, the densities of phytoplankton at the individual monitoring sites remained below 10,000 cells/mL (Table 24). The EQG for phytoplankton concentrations was therefore met. Historically, algal density has never exceeded 10,000 cells/mL at any site (Figure 27). No DoH algal watchlist species were detected at levels exceeding their trigger values during the 2025-26 extended summer monitoring period, meeting the EQG (DoH 2022; Table 25 and Figure 28). Additionally, Water Corporation did not receive any reports from DoH concerning skin or eye irritation, or potential algal poisoning in swimmers at Ocean Reef during the monitoring period, thus meeting the EQG (Figure 29).

**Table 23 Environmental Quality Criteria for toxic algae**

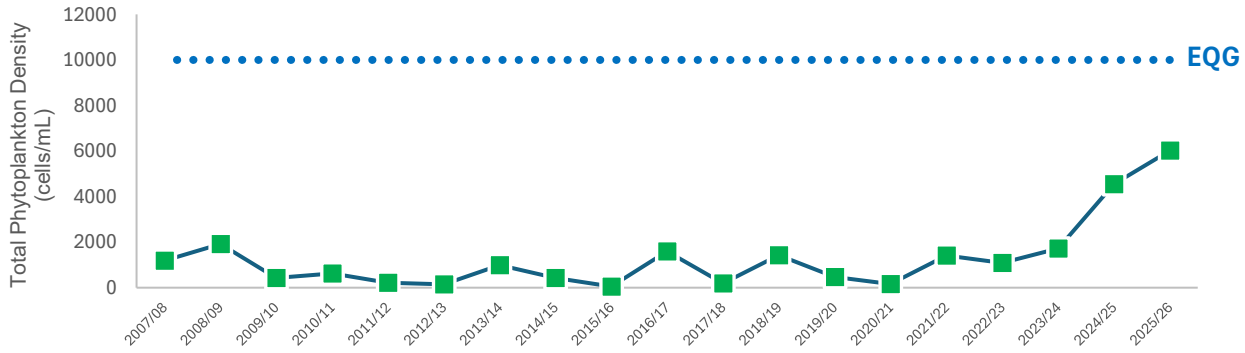
| | |
|---|---|
| **EQG 1** | Total phytoplankton cell count for the area of concern (either from one sampling run or from a single site over agreed period of time) should not exceed 10,000 cells/mL during normal plant operating conditions or detect DoH watch list species exceeding their trigger levels:<br>Cyanobacteria<br>• *Lyngbya majuscula* (any detection)<br>• *Trichodesmium* spp. (≥ 5,000 cells/mL)<br>Dinoflagellates<br>• *Alexandrium* spp. (≥ 1 cells/mL)<br>• *Karenia brevis* (≥ 5 cells/mL)<br>• *Karenia* spp. (≥ 50 cells/mL)<br>• *Pfiesteria* spp. (any detection) |
| **EQG 2** | There should be no reports of skin or eye irritation or potential algal poisoning in swimmers considered by a medical practitioner as potentially resulting from toxic algae when less than 10,000 cells/mL is present in the water column. |
| **EQS 1** | The phytoplankton cell count from a single site should not exceed 50,000 cells/mL or exceed DoH watch list action levels and there should be no visual presence of algal scums or relatively widespread visible presence of *Lyngbya majuscula* filaments (NHMRC 2008). |

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

**Table 24 Estimated phytoplankton total cell densities collected at one of the fixed monitoring sites for contact recreation down-current of the Ocean Reef outlets**

| Date | Site | Total phytoplankton density (cells/mL)[2] | Compliance[1] |
|---|---|---|---|
| 5/11/2025 | OR15 | 6,015 | |
| 18/11/2025 | OR13 | 17 | |
| 3/12/2025 | OR7 | 2 | |
| 17/12/2025 | OR7 | 487 | |
| 6/01/2026 | OR7 | 206 | |
| 19/01/2026 | OR11 | 22 | |
| 2/02/2026 | OR15 | 121 | |
| 16/02/2026 | OR7 | 53 | |
| 3/03/2026 | OR7 | 31 | |
| 19/03/2026 | OR15 | 180 | |

Notes:
1. Green symbols indicate the Environmental Quality Guideline (EQG) was met.
2. Cell density has been converted from cells/L used in laboratory reports to cells/mL for assessment against the guidelines.




Note:
1. Environmental Quality Criteria (EQC): Green symbols indicate the Environmental Quality Guideline (EQG) was met.
2. Blue dotted line represents 10,000 cells/mL. Total phytoplankton cell count per survey must not exceed 10,000 cells/mL to meet the EQG.
3. Cell density has been converted from cells/L used in laboratory reports to cells/mL for assessment against the guidelines

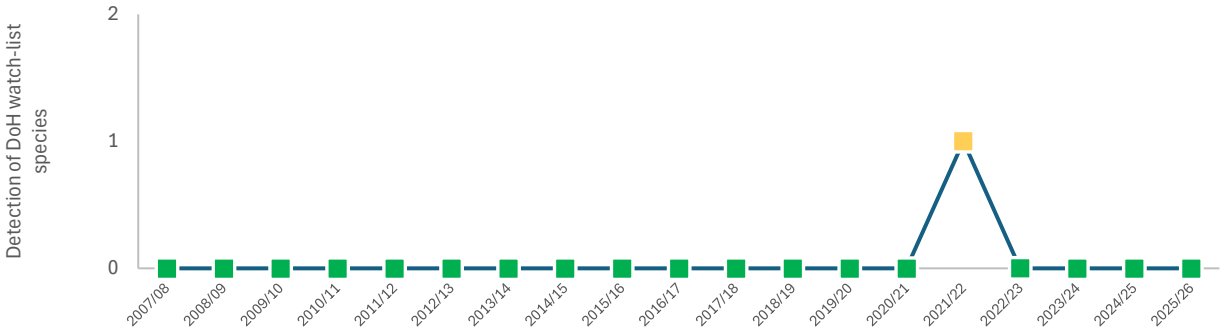
**Figure 27 Historical compliance of total phytoplankton cell densities**

**Table 25 Estimated cell densities of DoH (2022) watch-list phytoplankton species at Ocean Reef outfall sites.**

| Date | Site | Species | Estimated density (cells/mL)[4] | DoH Guideline[2,3] (cells/mL) | Compliance[1] |
|---|---|---|---|---|---|
| 5/11/2025 | OR | No watch-list species detected | - | - | |
| 18/11/2025 | OR-30 | *Alexandrium pseudogonyaulax* | 0.08 | 1 | |
| 3/12/2025 | OR | No watch-list species detected | - | - | |
| 17/12/2025 | OR | No watch-list species detected | - | - | |
| 6/01/2026 | ORR3 | *Trichodesmium* spp. | 0.16 | 5,000 | |
| 19/01/2026 | OR | No watch-list species detected | - | - | |
| 2/02/2026 | OR | No watch-list species detected | - | - | |
| 3/03/2026 | ORR2 | *Trichodesmium erythraeum* | 0.08 | 5,000 | |
| 19/03/2026 | OR | No watch-list species detected | - | - | |

Notes:

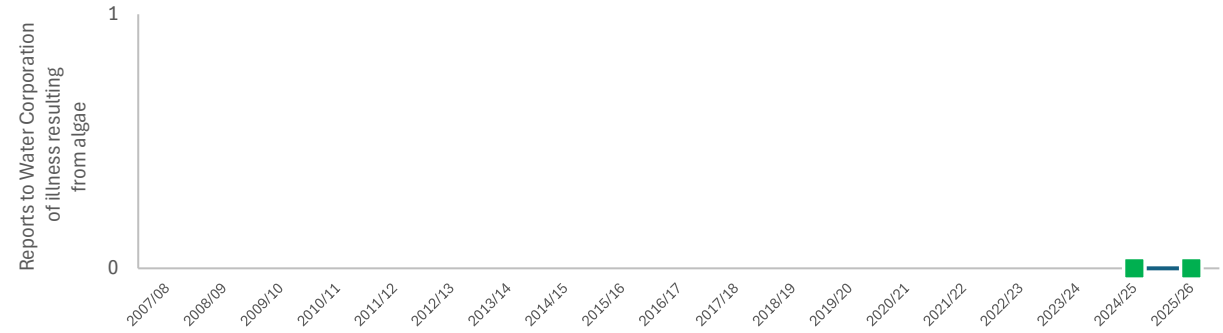
1. Green symbols indicate the Environmental Quality Criteria (EQC) were met.
2. Department of Health watch-list species (DoH 2022).
3. Cell density has been converted from cells/L used in laboratory reports to cells/mL for assessment against the guidelines.
4. Limit of reporting = 80 cells/L (0.08 cells mL)




Note:

1. Environmental Quality Criteria (EQC): Green symbols indicate the Environmental Quality Guideline (EQG) was met; amber symbols represent an exceedance of the EQG. To meet the EQG, DoH (2022) watch-list phytoplankton species concentrations must not be detected at concentrations exceeding their trigger levels:

**Figure 28 Historical compliance of concentrations of watch-list phytoplankton species**




Note:

1. Environmental Quality Criteria (EQC): Green symbols indicate the Environmental Quality Guideline (EQG) was met. To meet the EQG, there should be no reports of skin or eye irritation or potential algal poisoning in swimmers considered by a medical practitioner as potentially resulting from toxic algae when less than 10,000 cells/mL is present in the water column
2. Monitoring for this EQC commenced in the 2024/25 summer monitoring period.

**Figure 29 Reports from DoH of skin or eye irritation, or potential algal poisoning in swimmers (when less than 10,000 cells/mL are present in the water column)**

## 4.5 Toxic chemicals

The recreational guidelines for toxic chemicals (EPA 2017) are relatively high (less conservative) compared to the ANZG guidelines for ecosystem protection. An initial assessment for toxic chemicals was made against the ANZG (2018) 99% species protection (i.e. most conservative) guidelines in the first instance, with no exceedances detected (i.e. Table 26), therefore the EQG was met.

Refer to Table 5 for a comprehensive summary of toxic chemicals as assessed against the ANZG (2018) guidelines.

**Table 26 Environmental Quality Guidelines for Toxic Chemicals in Primary Contact Recreation Area**

| | |
|---|---|
| **EQG** | Toxic chemicals are not to exceed the ANZG (2018) 99% species protection (most sensitive) guidelines. |
| **EQS** | Toxic chemicals are not to exceed human health guidelines. |

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

# 5 Shoreline Monitoring

## 5.1 Thermotolerant coliforms (TTC)

Water Corporation conducts TTC monitoring additional to that required by the MMP along the shoreline, as these sites are located outside the observed zone of influence (OZI). These results are informally assessed against the EQC.

Four additional shoreline sites were included in the 2025-26 monitoring program, as such, TTC were sampled at 12 shoreline monitoring sites ten times over the 2025-26 extended summer period (yielding a total of 120 samples). NHMRC (2008) guidelines and EPA (2005) recommend that a minimum of 100 samples is required for accurate assessment of the EQG. Due to the additonal monitoring sites in the 2025-26 period there was sufficient samples to not pool data from previous years.

**Table 27 Informal Environmental Quality Guideline for Thermotolerant Coliforms at shoreline monitoring sites**

| | |
|---|---|
| **EQG** | Median thermotolerant coliform (TTC) counts (rolling median consisting of 100 samples) at shoreline monitoring sites are not to exceed 14 CFU/100 mL and the estimated 90$^{th}$ percentile concentration will not exceed 21 CFU/ 100 mL as measured using the membrane filtration method during normal plant operating conditions. |

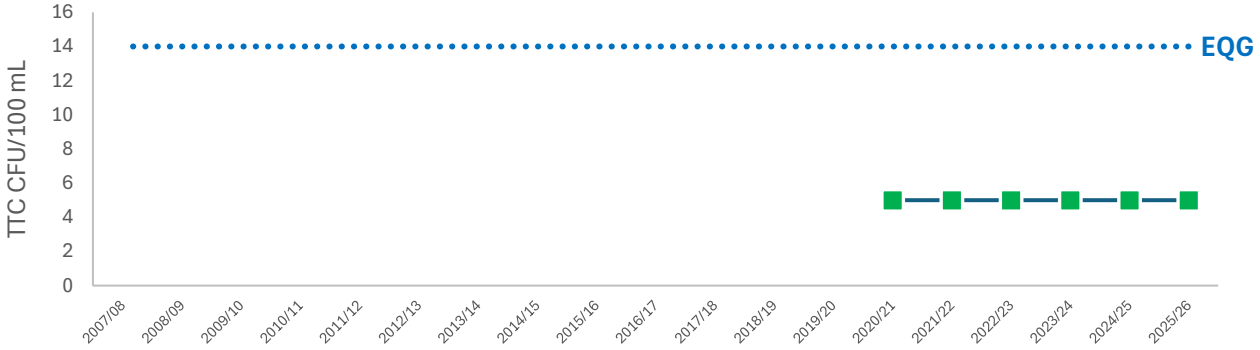
Notes:
EQG = Environmental Quality Guideline.

The shoreline sites are not formally assessed against the EQC, but the median and 90$^{th}$ percentile TTC concentrations derived from 120 samples were at the limit of reporting (<10 CFU/100 mL; Table 28) and less than the 14 and 21 CFU/100 mL criteria, respectively meeting the EQG criteria (Table 27, Figure 30 and Figure 31).

**Table 28 Median and 90th percentile thermotolerant coliform concentrations at the shoreline monitoring sites of the Ocean Reef outlets for the 2025-2026 period and comparison to the EQG**

| Sampling Period | Median (CFU/100 mL)[2,4] | 90$^{th}$ percentile[2,4] | Compliance[1,3] |
|---|---|---|---|
| Nov 2025 – Mar 2026 | <10 CFU/100 mL | <10 CFU/100 mL | |

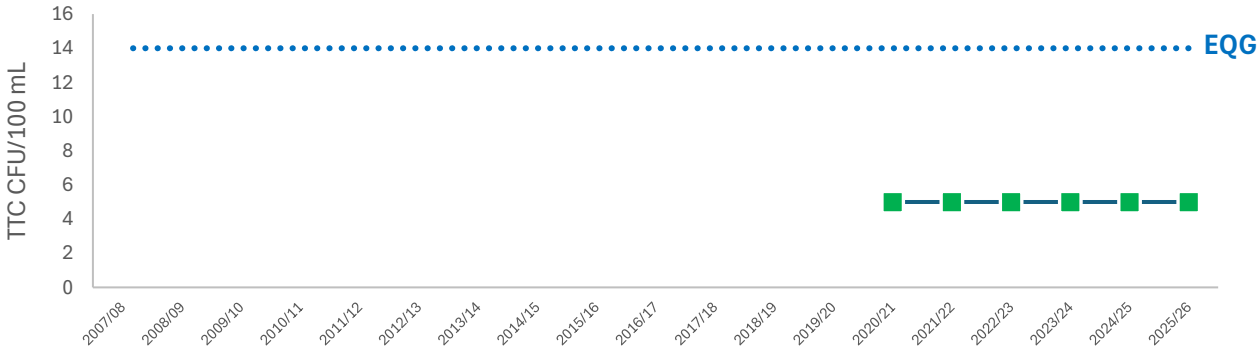
Notes:
1. Green symbols indicate the Environmental Quality Criteria (EQC) were met.
2. Previous monitoring seasons pooled data across several surveys to meet the 100-sample requirement, with the additional sampling occasions and sites there was no requirement to pool data.
3. CFU = Colony Forming Unit
4. Thermotolerant coliform results below the analytical limit of reporting (<10 CFU/100 mL) were halved (= 5 CFU/100 mL) to calculate the median and 90$^{th}$ percentile.
5. The shoreline sites are not formally assessed against the EQG.




Notes:

1. Environmental Quality Criteria (EQC): Green symbols indicate the Environmental Quality Guideline (EQG) was met.
2. Shoreline monitoring first assessed in 2019-2020.
3. Thermotolerant coliform results below the analytical limit of reporting (<10 CFU/100 mL) were halved (= 5 CFU/100 mL) to calculate the median and 90$^{th}$ percentile.
4. Blue dotted line indicates the EQG. To meet the EQG, median TTC concentration must not exceed 14 CFU/100 mL, noting that the shoreline sites are not formally assessed against the EQG.

**Figure 30 Historical compliance of median thermotolerant coliform concentrations at the shoreline monitoring sites**




Notes:

1. Environmental Quality Criteria (EQC): Green symbols indicate the Environmental Quality Guideline (EQG) was met.
2. Shoreline monitoring first assessed in 2019-2020.
3. Thermotolerant coliform results below the analytical limit of reporting (<10 CFU/100 mL) were halved (= 5 CFU/100 mL) to calculate the median and 90$^{th}$ percentile.
4. Blue dotted line indicates the EQG. To meet the EQG, the 90$^{th}$ percentile of TTC concentration must not exceed 21 CFU/100 mL, noting that the shoreline sites are not formally assessed against the EQG.

**Figure 31 Historical compliance of the 90$^{th}$ percentile of thermotolerant coliform concentrations at the shoreline monitoring sites**

## 5.2 *Enterococci* spp.

Water corporation conducts faecal indicator (*Enterococci* spp.) monitoring additional to that required by the MMP along the shoreline. These results are informally assessed against the EQS.

Samples were collected ten times at 12 monitoring sites across the 2025-26 extended summer monitoring period (yielding a total of 120 samples) for faecal indicator analyses. NHMRC (2008) guideline and EPA (2005) recommend that a minimum of 100 samples over the monitoring period are required for accurate assessment of the EQC. Due to the additonal monitoring sites in the 2025-26 period there was sufficient samples to not pool data from previous years.

**Table 29 Informal Environmental Quality Guidelines (*Enterococci* spp.) for contact recreation**

| | |
|---|---|
| **EQG** | The 95th percentile concentration of *Enterococci* spp. (rolling Hazen 95th percentile consisting of 100 samples) taken over the bathing season are not to exceed 200 MPN/100 mL, at the shoreline monitoring sites during normal plant operating conditions. |

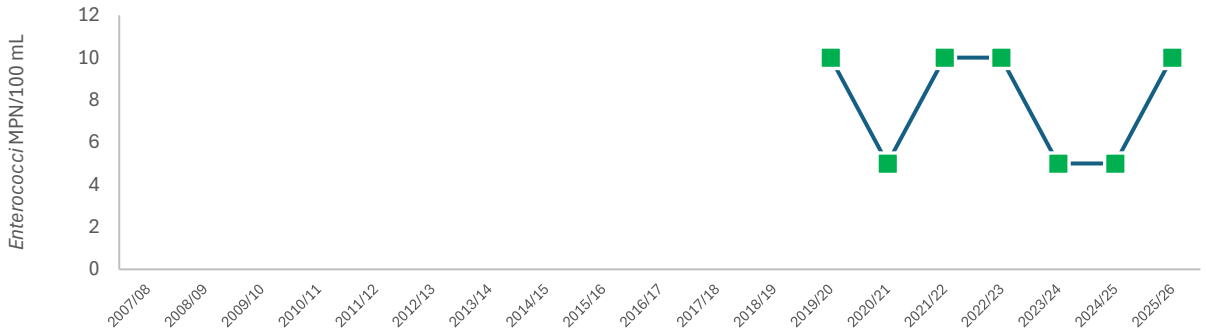
Notes:
1. EQG = Environmental Quality Guideline
2. Primary contact recreation = activities where humans are in direct contact with the water (e.g. swimming, snorkelling and diving).
3. Secondary contact recreation = activities where humans are in secondary contact with the water (e.g. boating and fishing).

Shoreline sites are not formally assessed against the EQG, however the 95th percentile of *Enterococci* spp. concentrations at the shoreline monitoring sites for the Ocean Reef ocean outlets was 10 MPN/100 mL (Figure 32) and met the primary contact recreation EQG (<200 MPN/100 mL; Table 29 and Table 30).

**Table 30 The 95th percentile of *Enterococci* spp. concentrations at the shoreline monitoring sites for the Ocean Reef outlets for 2023 – 25 and comparison to the EQG**

| Sampling period | 95th percentile[2,3,4] | Compliance (EQC)[1,5,6] |
|---|---|---|
| Dec 2025 – Mar 2026 | 10 MPN/100 mL | |

Notes:
1. Green symbols indicate the Environmental Quality Criteria (EQC) were met.
2. Previous monitoring seasons pooled data across several surveys to meet the 100 sample requirement, with the additional sampling occasions and sites there was no requirement to pool data
3. MPN = most probable number of *Enterococci* spp.
4. *Enterococci* spp. concentrations below the analytical limit of reporting (<10 *Enterococci* spp. MPN/100 mL) were halved (= 5 MPN/100 mL) to calculate the 95th percentile.
5. Environmental Quality Criteria (EQC) based on EPA (2017) water quality guidelines for recreation waters.
6. The shoreline sites are not formally assessed against the EQG.




Note:

1. Environmental Quality Criteria (EQC): Green symbols indicate the Environmental Quality Guideline (EQG) was met.
2. Shoreline Monitoring commenced in the 2020-21 sampling season.
3. To meet the EQG, the 95th percentile *Enterococci* spp. concentration must be <200 MPN/100 mL noting that shoreline sites are not formally assessed against the EQG.

**Figure 32 Historical compliance of 95th percentile shoreline *Enterococci* spp. concentration at the shoreline monitoring sites**

# 6 Aesthetics and Fish tainting substances

## 6.1 Aesthetic Monitoring

The Environmental Quality Criteria for aesthetic quality (Table 31) was assessed on each field sampling event via a questionnaire completed by field environmental scientists on ten occasions during the non-river flow period. On each occasion, the questionnaire was completed at one location on the recreation contact boundary down-current of the ocean outlets. Water clarity around the outlets (mean LAC at 350 m from the diffuser, pooled from all days) was compared against water clarity at a greater distance from the outlets (mean LAC at 1,500 m from the diffuser, pooled from all days) to assess whether aesthetic differences exist. Water Corporation also maintains a complaints' register for the Ocean Reef PLOOM program.

The results of the aesthetic monitoring are presented in Table 32. The field surveys found algae/plant material visible on the surface on 50% of occasions. No dead marine organisms were visible on any occasion. There was noticeable colour variation on 10% of occasions. There were no films, oil or floating debris on the surface on any sampling occasion. There was noticeable sewerage odour associated with the water recorded on two occasions, 19/01/2026 and 03/03/2026, representing 20% of occasions. There should be no objectionable odour on any sampling occasion and therefore the EQG for aesthetics was not met.

Mean LAC at 350 m from the ocean outlets (0.087 $m^{-1}$) was slightly higher than at 1,500 m distance from the outlet (Table 33). Overall water clarity was decreased by ~3% and therefore the EQG requirement that the natural visual clarity of the water should not be reduced by more than 20% was met.

An investigation into Beenyup WRRF treatment was undertaken to further assess the EQG exceedance and aesthetics captured during the monitoring event on the 3rd March 2026. The Beenyup WRRF treatment process can be used to evaluate ocean discharge quality prior to and on the day of the Ocean Reef ocean monitoring. The review of the operations found that Beenyup WRRF was in normal operation between Thursday 26th February 2026 to Tuesday 3rd March 2026 as evidenced by the AWRP online turbidity meter and Beenyup secondary TWW and Ocean Outfall composite samples. No 'Clean in Place' activities were performed, and the AWRP backwash was operating as expected. The bacterial indicators of TWW, TTC and *Enterococci* spp. results from the sampling undertaken on the 3rd of March 2026 were all within limits set in the MMP (see Section 4).

EQG for all other aesthetics were met within the criteria of the EQG for the monitoring season. Water Corporation received no direct complaints concerning aesthetics and the EQS was met. A recent independent report commissioned by the Department of Water and Environmental Regulation has shown there is no evidence that the TWW discharge is adversely affecting water quality at Mullaloo Beach (O2 Marine, 2025), which is approximately 2.5 km southeast of the ocean Beenyup WRRF's ocean outfalls.

### Table 31 Environmental Quality Criteria for Recreation and Aesthetics

| Indicator | Environmental Quality Criteria for Aesthetic Quality | |
|---|---|---|
| | 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 the marine receiving environment 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 Primary Contact Management Zone boundary during normal plant operating conditions. | There should be no detectable tainting of edible fish harvested outside the Seafood Management Zone boundary |

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

### Table 32 Aesthetic observations and measurements near the Ocean Reef ocean outlets from November 2025 to March 2026.

| Date | Site[1] | Algae/plant material? | Dead marine organisms? | Secci depth (m) | Colour variation? | Oil or other films? | Floating debris? | Odour? | Cotton buds? |
|---|---|---|---|---|---|---|---|---|---|
| 5/11/2025 | OR15 | Yes (macroalgae) | No | 5.0 | No | No | No | No | No |
| 18/11/2025 | OR13 | No | No | 9.0 | No | No | No | No | No |
| 3/12/2025 | OR7 | Yes (macroalgae) | No | 6.0 | No | No | No | No | No |
| 17/12/2025 | OR7 | Yes (macroalgae) | No | 6.0 | No | No | No | No | No |
| 6/01/2026 | OR7 | No | No | 6.0 | No | No | No | No | No |
| 19/01/2026 | OR11 | Yes (wrack) | No | 6.5 | No | No | No | Yes | No |
| 2/02/2026 | OR15 | No | No | 7.0 | No | No | No | No | No |
| 16/02/2026 | OR7 | Yes (seagrass) | No | 5.8 | No | No | No | No | No |
| 3/03/2026 | OR7 | No | No | 5.0 | Yes (green/turbid) | No | No | Yes | No |
| 19/03/2026 | OR16 | No | No | 6.0 | No | No | No | No | No |

Notes:
1. Aesthetic observations are taken at one of the fixed Primary Contact Management Zone sites each survey

**Table 33 Light attenuation coefficient at sites 350 m and 1500 m from the Ocean Reef ocean outlets from November 2025 to March 2026.**

| Date | Light attenuation coefficient (LAC; $m^{-1}$) | |
|---|---|---|
| | 350 m (site ORT-350 m) | 1,500 m (site ORT – 1500 m) |
| 5/11/2025 | 0.090 | 0.087 |
| 18/11/2025 | 0.086 | 0.083 |
| 3/12/2025 | 0.084 | 0.080 |
| 17/12/2025 | 0.078 | 0.077 |
| 6/01/2026 | 0.085 | 0.086 |
| 19/01/2026 | 0.071 | 0.076 |
| 2/02/2026 | 0.085 | 0.075 |
| 16/02/2026 | 0.093 | 0.077 |
| 3/03/2026 | 0.098 | 0.106 |
| 19/03/2026 | 0.099 | 0.097 |
| **Average** | **0.087** | **0.084** |

## 6.2 Fish tainting substances

The EQC for fish tainting substances states that the concentrations of contaminants in a 24-hour composite sample of TWW are not to exceed the ecological guidelines. These guidelines are not specified in the Beenyup Ocean Outlets Marine Environmental Management Plan. Fish tainting guideline values have been adapted from those applied to the Sepia Depression monitoring program (as adapted from EPA, 2017; Table 34).

All units have been converted to ug/L for consistency and a dilution factor of 1:238 (worst case) applied. Where a result was below detection limits (<), the limit was already below the guideline before dilution, thus no exceedance is reported. Results are presented in Table 35.

**Table 34 Environmental Quality Guidelines and Standards for Fish Tainting Substances**

| | |
|---|---|
| **EQG** | Concentrations of contaminants will not exceed the aesthetics guidelines for fish tainting substances at the Primary Contact Management Zone boundary during normal plant operating conditions. |
| **EQS** | There should be no detectable tainting of edible fish harvested outside the Seafood Management Zone boundary. |

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

**Table 35 Assessment of fish tainting substances**

| Fish tainting substances | Observed TWW Concentration (µg/L) | Concentration after 1:238 initial dilution (µg/L) | EPA (2017) guideline for fish tainting substances (µg/L) | Exceedance |
|---|---|---|---|---|
| **Metal and metalloids (µg/L$^{-1}$)** | | | | |
| Copper | 8 | 0.11 | 1,000 | No |
| Zinc | 88 | 0.51 | 5,000 | No |
| **Phenols (µg/L$^{-1}$)** | | | | |
| Phenol | <0.1 | *Below detection* | 300 | No |
| 2,4-dichlorophenol | <0.1 | *Below detection* | 0.3 | No |
| 2,4,6-trichlorophenol | <0.1 | *Below detection* | 2 | No |
| Pentachlorophenol | <0.02 | *Below detection* | 30 | No |
| **Chlorinated hydrocarbons (µg/L$^{-1}$)** | | | | |
| Hexachlorocyclopentadiene | <10 | *Below detection* | 1 | No |
| **Ethers (µg/L$^{-1}$)** | | | | |
| Nitrobenzene | <2 | *Below detection* | 30 | No |
| **BTEX (µg/L$^{-1}$)** | | | | |
| Toluene | <2 | *Below detection* | 250 | No |
| Ethylbenzene | <2 | *Below detection* | 250 | No |
| **PAHs (µg/L$^{-1}$)** | | | | |
| Naphthalene | <5 | 0.0210 | 1,000 | No |
| Acenaphthene | <0.02 | *Below detection* | 20 | No |

# 7 References


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# 8 Appendices

The following Appendices are available from Water Corporation on request:

**Appendix A. Methods**

**Appendix B. Monitoring Sites**

**Appendix C. Field Sheets**

**Appendix D. Nutrient Results**

**Appendix E. Microbiological Sites**

**Appendix F. Algal Taxonomy Results**

**Appendix G. DoH Toxic Algae Guidelines (2022)**

**Appendix H. DoH WASQAP MBMMP (2025)**

**Appendix I. MAFRL Physical Profiling**

**Appendix J. TWW Characterisation Chemistry Results**

**Appendix K. TWW Ecotoxicity Results**

**Appendix L. Initial Dilution Modelling**