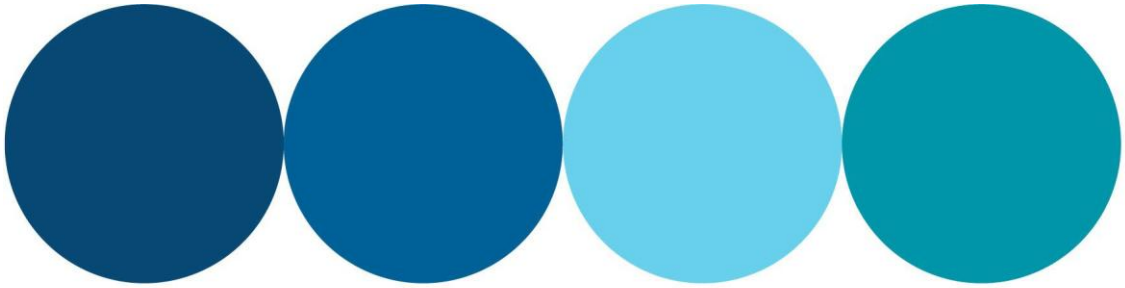
# Perth Long-term Ocean Outlet Monitoring (PLOOM) Program

## Subiaco Water Resource Recovery Facility

**2024 - 2025 Annual Report**



WATER CORPORATION

Document Management

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## Document history

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Hydrobiology WA Pty Ltd has prepared this report in accordance with our Integrated Management System, in compliance with ISO9001 and ISO45001.

## Status

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

# Contents

## Acronyms

| Acronym | Extension |
|---|---|
| ANZECC | Australian and New Zealand Environment and Conservation Council |
| ARMCANZ | Agriculture and Resource Management Council of Australia and New Zealand |
| CFU | Colony Forming Unit |
| CTWWC | Comprehensive Treated Wastewater Characterisation (CTWWC) |
| DO | Dissolved Oxygen |
| DoH | Western Australian Department of Health |
| DPIRD | Western Australian Department of Primary Industries and Regional Development |
| EPA | Environmental Protection Authority |
| EQC | Environmental Quality Criteria |
| EQMF | Environmental Quality Management Framework |
| EQO | Environmental Quality Objective |
| EQS | Environmental Quality Standard |
| HEPA | High Ecological Protection Area |
| LAC | Light Attenuation Coefficient |
| LEPA | Low Ecological Protection Area. Referred to as 'notional' for the Swanbourne ocean outlet |
| LoR | Limit of Reporting |
| MPN | Most Probable Number |
| NATA | National Association of Testing Authorities |
| NOEC | No Observed Effect Concentration |
| OZI | Observed Zone of Influence. These management zones are referred to as 'notional' for the Swanbourne ocean outlet |
| PLOOM | Perth Long-term Ocean Outlet Monitoring |
| RO | Reverse Osmosis |
| 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 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 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 Subiaco WRRF to the ocean via the Swanbourne outlet. A small area around the outlet, measuring 100 metres in radius, is designated as a notional Low Ecological Protection Area (or LEPA). Within this area, the Environmental Protection Authority (EPA) allows for changes to marine water quality. Outside the notional 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 involves testing marine water quality around the Swanbourne outlet to confirm it returns to the natural range expected in the HEPA to protect the environment and recreational users (swimmers, boaters and fishers). Water samples are collected within the notional LEPA, at the LEPA/HEPA boundary, and at reference sites representing background conditions and assessed against nationally-agreed criteria.

This annual report documents the findings of the 2024-2025 Swanbourne ocean monitoring as part of the PLOOM program. The compliance results are summarised in report card format below and 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

### 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 national guideline values. |
| Non-bioaccumulating toxicants | Some low levels of contaminants (e.g. detergents, metals and oils) may persist in wastewater after treatment at the WRRF and are possibly discharged at the outlet. Monitoring confirms they are not directly toxic or likely to accumulate in marine life. |  | Concentrations of non-bioaccumulating toxicants were below the national guideline values. |
| Total toxicity of the mixture (TTM) | TTM measures the potential for a combined, or cumulative, effect of ammonia, copper, and zinc in the TWW after it has been diluted into the ocean. It is used as an additional interpretative tool for estimating the potential toxicity of TWW. |  | The total toxicity of the mixture was below the national guideline value. |
| Whole of effluent toxicity (WET) testing | WET testing is another tool to test the potential toxicity of the TWW to marine life. WET testing is particularly useful for toxicants that occur in very low concentrations, or for which there are no national guidelines on safe levels. Direct tests on organisms determine the actual toxicity of the TWW demonstrate that the discharge is not harmful to the ocean environment. |  | The TWW plume is sufficiently diluted to achieve the No Ecological Effects Concentration at the management boundary. |

| 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 abundance. |  | Median chlorophyll-*a* concentration within the high ecological protection area (HEPA) did not exceed the 80$^{th}$ percentile of reference site concentrations |
| Light attenuation coefficient (LAC) | Increased phytoplankton can block (attenuate) light from reaching the bottom (impacting seagrass and macroalgae). |  | LAC did not exceed the 80$^{th}$ percentile of historical reference sites (0.094 m$^{-1}$). Light transmission to the sea floor was not reduced. |
| ***Phytoplankton biomass*** | | | |
| Phytoplankton biomass (measured as chlorophyll-*a*) | Phytoplankton are a naturally occurring part of the marine environment, but TWW contains nutrients (ammonia, nitrite, nitrate and orthophosphate) that can stimulate phytoplankton growth. Chlorophyll-*a* (Chl-*a*; the active constituent in phytoplankton) concentration is used as an indicator for phytoplankton abundance. |  | Phytoplankton biomass (measured as chlorophyll-*a*) exceeded three times the reference median on more than one occasion during non-river flow period but did not exceed in two consecutive years. |
| ***Physical & chemical stressors*** | | | |
| Organic enrichment | Organic matter in TWW is naturally decomposed by bacteria. Dissolved Oxygen (DO) concentration in water is used by the bacteria during the decomposition process. If the bacteria use more DO than they produce, the DO levels fall. Low DO levels can be harmful to marine life. DO concentration is assessed against the Environmental Protection Authority (EPA) guidelines. |  | DO remained >90% at all times at all sites near the outlet. DO levels near the outlet were similar to those at the reference sites. There was a very low risk of DO levels falling below critical levels. |
| Salinity | Salinity refers to the 'saltiness' of water. TWW is fresh whereas the ocean is saline. When TWW is |  | Measurements of salinity near the outlet were similar to the salinity at appropriate |

| Indicator | Indicator purpose | Result | Commentary |
|---|---|---|---|
| | discharged to the ocean, salinity will be reduced in an area around the outlet until the fresher water is fully mixed with the saline seawater. Low salinity water may cause stress to marine life. | | reference sites. Stress to marine life from low salinity is unlikely. |

## Seafood Safe for Human Consumption

Seafood safe for human consumption aims to confirm 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 outlet | The risk from bacteria to seafood safety is assessed using the indicator organism thermotolerant coliforms. |  | The relevant concentrations of TTC near the outlet 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 outlet was very low. |
| Shoreline TTC | |  | The relevant concentrations of TTC 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 contain species than can taint seafood. |  | Densities of potentially toxic phytoplankton species did not exceed relevant guidelines on any occasion. |

## Primary and Secondary Contact Recreation

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

| Indicator | Indicator purpose | Result | Commentary |
|---|---|---|---|
| ***Faecal indicator*** | | | |
| *Enterococci* spp. near the outlet | The risk from bacteria to recreation contact (swimming and boating) is assessed using the indicator organism *Enterococci* spp. |  | The relevant concentrations of *Enterococci* spp. near the outlet 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 outlet 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 seafood in the vicinity of the beaches 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 chlorophyll-a based guidelines for phytoplankton are well below a level that would be visible as an algal bloom. The highest total phytoplankton cell concentration in the notional HEPA was 1,428 cells/mL. There were no phytoplankton blooms during the monitoring period |

## Aesthetics

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

## Executive Summary

This report documents the findings of the 2024-2025 Swanbourne monitoring program. The report outlines the findings of three environmental monitoring programs:

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

To maintain consistency with other metropolitan ocean outfall monitoring programs, the Swanbourne ocean outlet is 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 Environmental Quality Management Framework (EQMF), which is applied to Western Australia's coastal waters (EPA 2016). Results are reported in the context of the 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 2024-2025 are summarised 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 |
|---|---|
| **Monitor**: EQG & EQS met (continue monitoring) | |
| **Investigate**: EQG not met (investigate against the EQS) | |
| **Action**: EQS not met (management response required) | |

Note:

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

***Environmental Quality Objective 'Maintenance of Ecosystem Integrity'***

There are several EQC relevant to the 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.

Toxicants in treated wastewater

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

- Concentrations of bioaccumulating toxicants (specifically, cadmium and mercury) must be below their respective ANZG (2018) 80% species protection guidelines prior to discharge and dilution with seawater. Concentrations of bioaccumulating toxicants were below their laboratory limits of reporting and the 80% species protection guidelines in all cases, thus meeting the EQG.
- Concentrations of non-bioaccumulating contaminants must not exceed the ANZG (2018) 99% species protection guideline at the notional Low Ecological Protection Area (hereafter LEPA) boundary (100 m radius from the diffuser). Initial dilution modelling for conditions on 19 January 2025 found that Swanbourne outlet was achieving a worst-case initial dilution of 1:131. This was sufficient to dilute all contaminants to concentrations below their respective 99% species protection guidelines. EQG 2 for toxicants in TWW was therefore met.
- 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 0.63, which is lower than the guideline and EQG 3 was met.
- The highest concentration of TWW at which there is no statistically significant observed effect on fertilisation of sea urchin gametes exposed to different concentrations of TWW (NOEC) must be greater than 1.0% TWW concentration. The lowest NOEC from tests undertaken in January 2025 and March 2025 was 12.5% and EQG 4 was met.

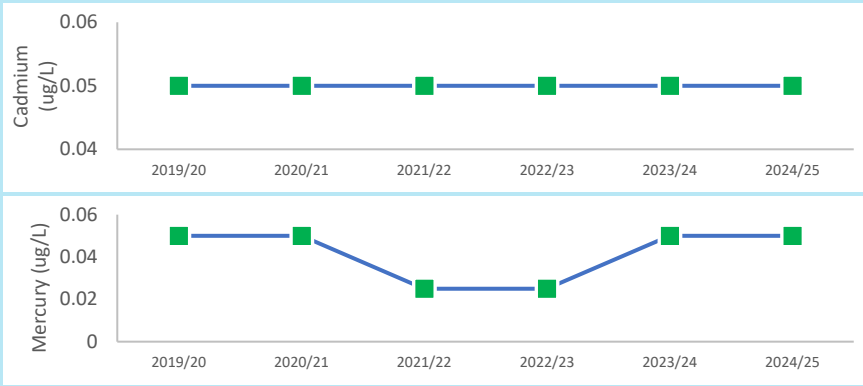
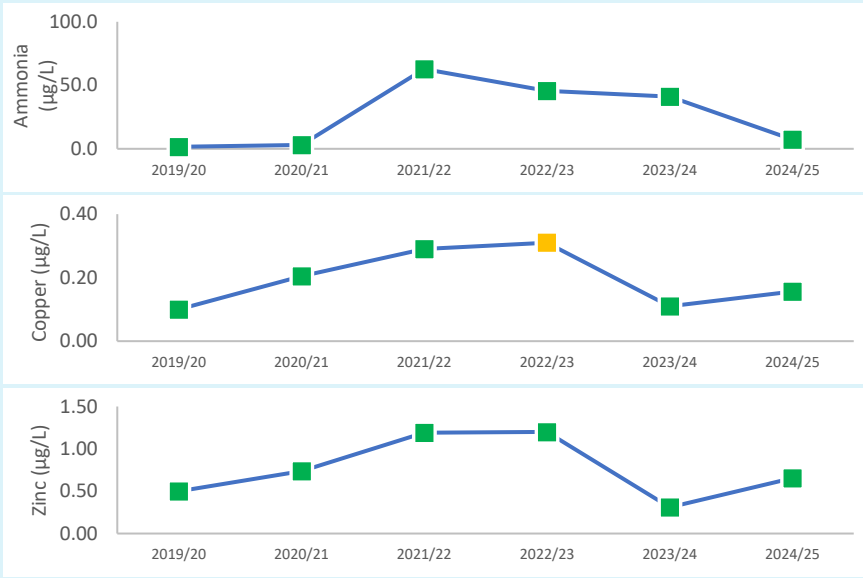
Water quality monitoring – receiving environment

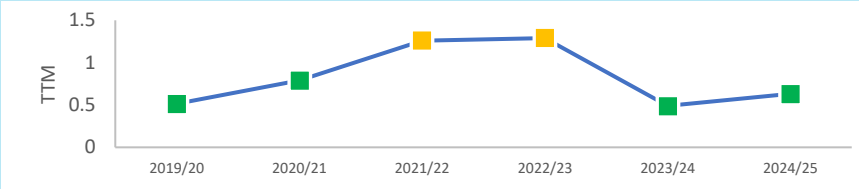
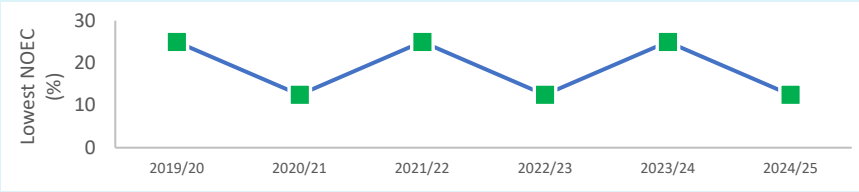
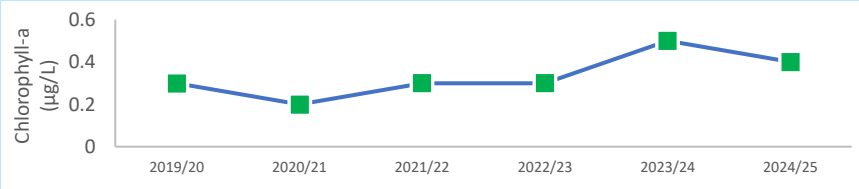
Ocean sampling was conducted between December 2024 and March 2025 at fixed distance intervals down-current (determined using a drogue) of the outlet. There are six Environmental Quality Guidelines (EQGs) based on chlorophyll-a concentration (a measure of phytoplankton biomass), water temperature, salinity, dissolved oxygen and light attenuation coefficient:

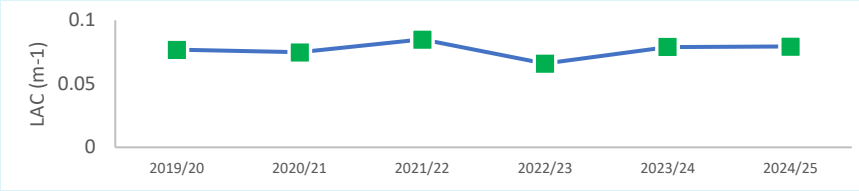
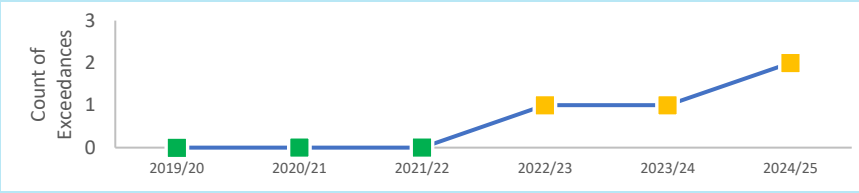
- The median chlorophyll-a concentration in the notional HEPA (i.e., 100 m and greater from the diffuser) during the non-river flow period must not exceed the 80$^{th}$ percentile of historical reference site data. Median chlorophyll-*a* concentration within the high ecological protection area (HEPA; 0.4 µg/L) was lower than the 80$^{th}$ percentile of historical reference site concentrations (0.5 µg/L) and the EQG was met.
- The median light attenuation coefficient in the notional HEPA must not exceed the 80$^{th}$ percentile of historical reference site data. Median LAC within the HEPA (0.079 m$^{-1}$) was lower than the 80$^{th}$ percentile of historical reference sites (0.094 m$^{-1}$) and the EQG was met.

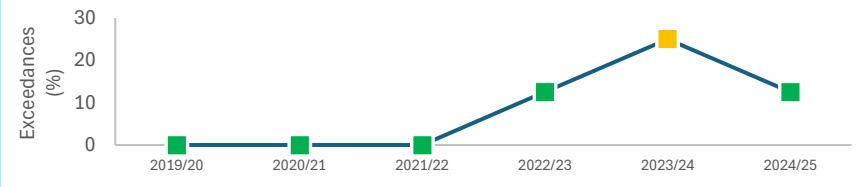
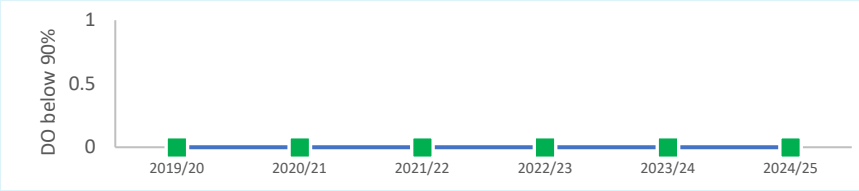
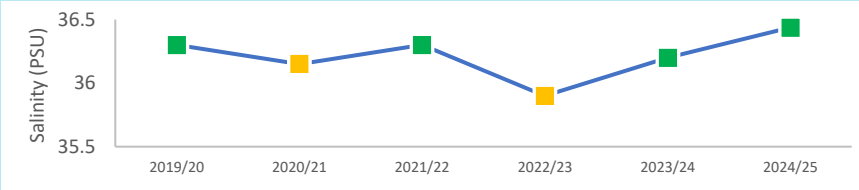
- Median phytoplankton biomass, measured as chlorophyll-*a* must not exceed three times the median chlorophyll-*a* concentration of reference sites (0.9 µg/L) on any occasion. Median chlorophyll-*a* concentrations exceeded this value on two occasions, therefore the EQG1 was not met, triggering assessment against the EQS1.
    - Median phytoplankton biomass measured as chlorophyll–a must not exceed three times median chlorophyll–a concentration of reference sites, on more than one occasion during non-river flow period and in two consecutive years. Median chlorophyll-*a* concentrations exceeded this value on two occasions but not in two consecutive years, therefore the EQS1 was met.
- Median phytoplankton biomass measured as chlorophyll-*a* at any site must not exceed three times the median chlorophyll-*a* concentration of historical reference sites (0.9 µg/L), on 25% or more occasions. Phytoplankton biomass, measured as chlorophyll-*a*, exceeded this value on one (12.5% of) occasion at all four notional HEPA sites, therefore the EQG was met.
- 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 no less than 6 of the 8 scheduled sampling events during the summer monitoring period. Dissolved oxygen saturation within the notional HEPA was above 90% saturation at all times and the EQG was met.
- Median salinity (0.5 m below the water surface) at an individual site over any period is not to deviate beyond the 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 notional HEPA (at 100, 350, 1000, and 1500 m from the outlet) 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 and the ANZG (2018) 80% species protection guidelines (36 and 1.4 µg/L, respectively). | |  |
| | Non-bioaccumulating toxicants and initial dilution | EQG 2 | Initial dilution on 19/01/2025 (1:131) was sufficient to reduce non-bioaccumulating contaminant concentrations to below their ANZG (2018) 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 (0.63) was below the ANZG (2018) guideline of 1.0 | |  |
| | Whole of Effluent Toxicity (WET) | EQG 4 | The lowest NOEC[3] during the reporting period was 12.5%. Only 8 dilutions with background seawater are required to achieve this NOEC[3], which is lower than the worst-case dilutions achieved at the notional LEPA[2] boundary during the monitoring period (1:131). | |  |
| Nutrient enrichment | Chlorophyll-*a* | EQG 1 | Median chlorophyll-a concentration within the high ecological protection area (HEPA[2]; 0.4 µg/L) was lower than the 80th percentile of historical reference site concentrations (0.5 µg/L). | |  |

| Environmental Quality Indicator | | EQC | Comments | Compliance[1] | 6-year compliance trend (including current year) |
|---|---|---|---|---|---|
| | Light Attenuation Coefficient (LAC) | EQG 2 | Median LAC within the notional HEPA[2] (0.079 $m^{-1}$) was lower than the 80th percentile of historical reference sites (0.094 $m^{-1}$). | |  |
| Phytoplankton blooms | Phytoplankton biomass (measured as chlorophyll-*a*) | EQG 1 | Median chlorophyll-a concentrations exceeded three times the median of reference sites on two occasions (4 December 2025, 5 February 2025). | |  |
| | | EQS 1 | Median chlorophyll-a concentration exceeded three times the median of reference sites on two occasions in the 2024-25 non-river flow period and but only once in the 2023-24 non-river flow period, therefore the EQS was met. | |  |

| Environmental Quality Indicator | | EQC | Comments | Compliance[1] | 6-year compliance trend (including current year) |
|---|---|---|---|---|---|
| | | EQG 2 | Phytoplankton biomass, measured as chlorophyll-a, exceeded three times the median chlorophyll-a concentration of historical reference sites (0.9 µg/L) on 12.5% of occasions. | |  |
| Physical-chemical stressors | Organic enrichment | EQG 1 | Dissolved oxygen saturation within the notional HEPA[2] was maintained above 90% saturation at all times. | |  |
| | Salinity | EQG 2 | Median salinity was between the 20th and 80th percentiles of the natural salinity range within the notional HEPA[2] (at 100, 350, 1,000, and 1500 m from the outlet). | |  |

Notes:

1. Green symbols indicate the Environmental Quality Guideline (EQG) was met; amber symbols represent an exceedance of the EQG.
2. LEPA = Low Ecological Protection Area (notional); 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.

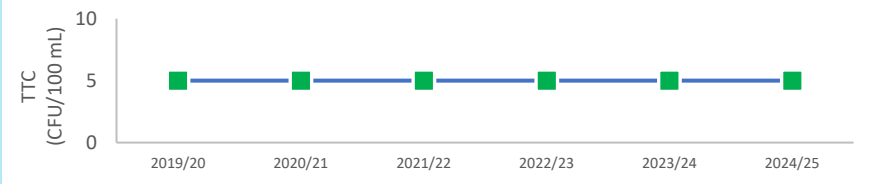
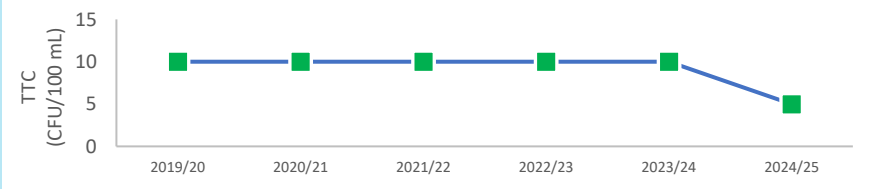
### Environmental Quality Objective 'Maintenance of Seafood Safe for Human Consumption'

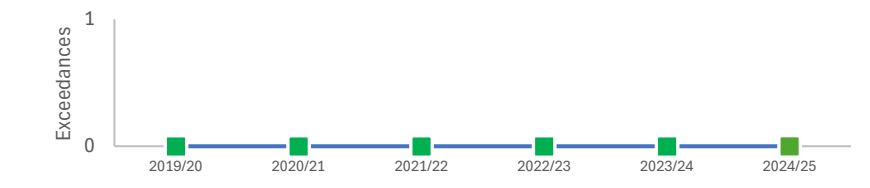
There are two EQC for the EQO 'Maintenance of the Seafood Safe for Human Consumption': the first is based on in water concentrations of thermotolerant coliforms (TTC), and the second is based on in-water concentrations of toxic phytoplankton species (to monitor for algal biotoxins):

- To meet the EQG for TTC at the boundary of the notional Seafood Management Observed Zone of Influence (OZI), median TTC concentrations are not to exceed 14 CFU/100 mL and no more than 10% of TTC concentrations should exceed 21 CFU/100 mL. The median TTC concentration from two sampling seasons (2023-24 and 2024-2025)[1] was at the limit of reporting, <10 CFU/100 mL, and below the 14 CFU/100 mL guideline, meeting the EQG. The percentage of samples with TTC concentrations exceeding 21 CFU/100 mL was below the 10% criteria, meeting the EQG.
- Water Corporation conducts additional TTC monitoring along the shoreline. These results are informally assessed against the EQC. To meet the informal EQG for TCC at the shoreline, median TTC concentrations at shoreline monitoring sites should not exceed 14 CFU/100 and no more than 10% of TTC concentrations should exceed 21 CFU/100 mL. The median TTC concentration from three sampling seasons (2022-23, 2023-24 and 2024-2025)[1] was at the limit of reporting, <10 CFU/100 mL, and below the 14 CFU/100 mL guideline, meeting the informal EQG. The percentage of samples with TTC concentrations exceeding 21 CFU/100 mL was below the 10% criteria, meeting the informal EQG.
- To meet the EQG for algal biotoxins, concentrations of potentially toxic algae at sites at the boundary of the notional Seafood Management OZI must not exceed the Western Australian Shellfish Quality Assurance Program (WASQAP; DoH 2025) concentrations. There were no exceedances of the relevant WASQAP guidelines on any occasion, meeting the EQG for toxic phytoplankton species.

[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 Seafood Safe for Human Consumption'

| Environmental Quality Indicator | | EQC | Comments | Compliance[1] | 6-year compliance trend (including current year)[7] |
|---|---|---|---|---|---|
| Microbiological contaminants (outlet sites) | Thermotolerant coliforms (TTC)[2,3] | EQG 1 | Median[2] TTC concentrations derived from 120 samples collected over the 2022-24 to 2024-25 sampling seasons was at the limit of reporting[6] (<10 CFU/100 mL) and below the 14 CFU/100 mL criteria. | |  |
| | | | The percentage of TTC samples with concentrations exceeding 21 CFU/100 mL was 7%, below the 10% criteria. | |  |
| Microbiological contaminants (additional shoreline sites)[5] | | EQG 2 | Median[2] TTC concentrations derived from 128 shoreline samples collected over the 2023-24 to 2024-25 sampling seasons was at the limit of reporting[6] (<10 CFU/100 mL) and below the 14 CFU/100 mL criteria. | |  |

| Environmental Quality Indicator | | EQC | Comments | Compliance[1] | 6-year compliance trend (including current year)[7] |
|---|---|---|---|---|---|
| | | | The percentage of TTC samples with concentrations exceeding 21 CFU/100 mL was 2%, below the 10% criteria. | |  |
| Algal biotoxins | Toxic phytoplankton species | EQG 1 | During the 2024-2025 monitoring period, there were no possible instances of toxic phytoplankton exceeding the WASQAP[4]. | |  |

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. Marine Biotoxin Monitoring and Management Plan 2025 version 5: Western Australian Shellfish Quality Assurance Program (WASQAP) (DoH 2025)
5. Additional Shoreline Monitoring commenced in the 2011-12 sampling season. Shoreline sites are informally 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.
7. Previous years assessed TTC concentrations as 90$^{th}$ percentiles. From the 2023-24 monitoring period onwards, TTC concentrations are instead assessed as the percentage of samples with concentrations >21 CFU/100 mL.

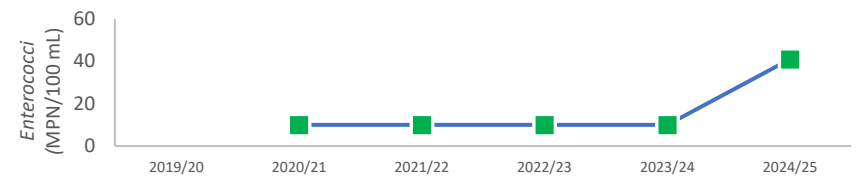
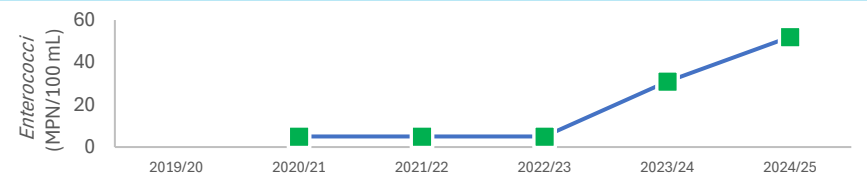
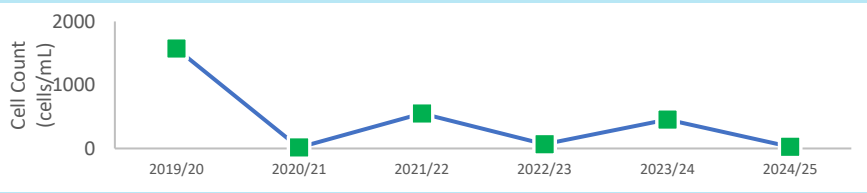
**Environmental Quality Objective 'Maintenance of Primary and Secondary Recreation'**

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.

- To meet the faecal indicators EQGs, the 95$^{th}$ percentile value for *Enterococci* spp. concentrations outside the notional Contact Recreation Management OZI boundary 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 based on pooled data from three sampling seasons (2022–2023, 2023–2024 and 2024-2025)[2] was <10 MPN/100 mL, meeting the EQGs for both primary (EQG 1) and secondary (EQG 2) contact recreation.
- Water Corporation conducts additional *Enterococci* spp. monitoring along the shoreline. These results are informally assessed against the EQC. To meet the informal *Enterococci* spp. EQGs, the 95$^{th}$ percentile value of *Enterococci* spp. concentrations 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 (2023–24 and 2024-25)[2], was 52 MPN/100 mL, meeting the EQGs for both primary (EQG 1) and secondary (EQG 2) contact recreation.
- To meet the algal biotoxin EQG, total phytoplankton cell concentration at any site must not exceed 10,000 cells/mL. The highest median total phytoplankton cell concentration was 1,428 cells/mL and the EQG was met.
- To meet the toxic algae EQG 2, there were no reports of skin or eye irritation or potential algal poisoning (via Department of Health) 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. There were no reports during the 2024-25 monitoring period, and EQG 2 was met.

[2] *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) | *Enterococci* spp.[3] | EQG 1<br>EQG 2 | The 95th percentile of *Enterococci* spp. concentrations near the outlet sites (<10 MPN/100 mL) was lower than the primary and secondary contact EQGs (200 and 2,000 MPN/100 mL, respectively). | |  |
| Faecal indicators (additional shoreline sites)[2] | | EQG 1<br>EQG 2 | The 95th percentile of *Enterococci* spp. concentrations at the shoreline (52 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 2024-25 monitoring period, there were no median 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 | During the 2024-25 monitoring period[4], there were no reports from the Department of Health to Water Corporation about any skin or eye irritation or potential algal poisoning in swimmers on any occasion. | |  |



Notes:

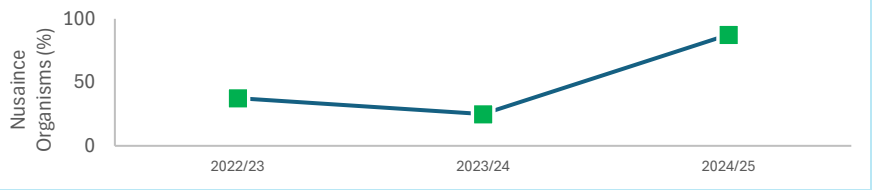
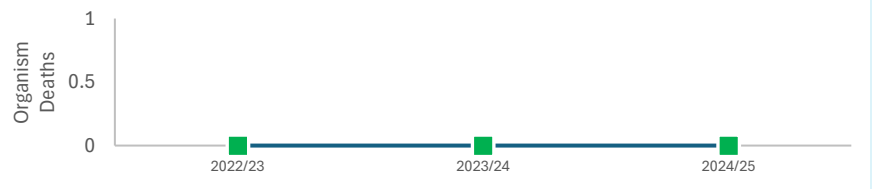
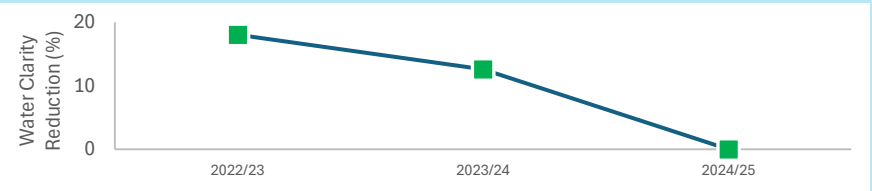
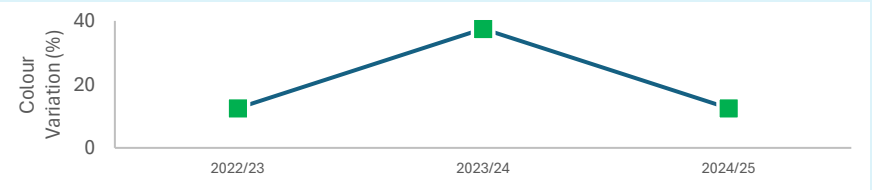
1. Green symbols indicate the Environmental Quality Guideline (EQG) was met.
2. Additional Shoreline Monitoring commenced in the 2011-12 sampling season. Shoreline sites are informally assessed against the EQC.
3. Monitoring for *Enterococci* spp. concentrations commenced in the 2020-21 sampling season.
4. This is the first monitoring period (2024/25) in which the Department of Health reports have been included in the compliance trends.

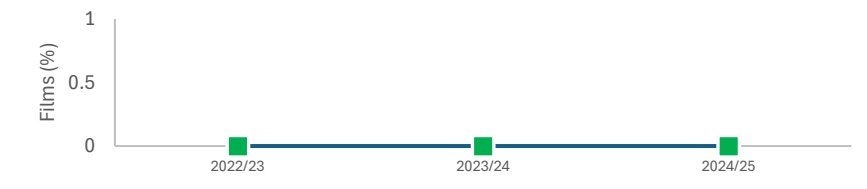
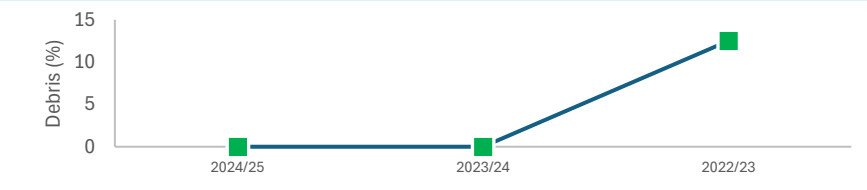
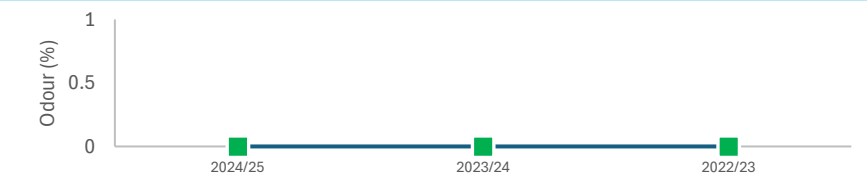
### Environmental Quality Objective 'Maintenance of Aesthetic Values'

The EQO 'Maintenance of Aesthetic Values' is to confirm that Perth's coastal waters are aesthetically pleasing and that the aesthetic value is protected. There are a series of EQGs that confirm this EQO is being met:

- Macrophytes, phytoplankton scums, filamentous algal mats, blue-green algae, and sewage fungus should not be present in excessive amounts. Seagrass fronds were observed on 7 of the 8 sampling events but were not present in excessive amounts nor considered nuisance organisms at the densities observed by the field scientists. Therefore, 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%. Measurements of light attenuation determined that the natural visual clarity of the water was reduced by ~9% (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 (brown tones) on one out of eight (12.5%) sampling occasions 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. No noticeable odour was detected on any sampling occasion and the EQG was met.

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

| Environmental Quality Indicator | EQC | Comments | Compliance[1] | 3-year compliance trend (including current year)[2] |
|---|---|---|---|---|
| Nuisance organisms | EQG | Seagrass fronds were observed on 7 of the 8 sampling events but were not present in excessive amounts nor considered nuisance organisms at the densities observed by the field scientists. Therefore, the EQG was met. | |  |
| Faunal deaths | EQG | There were no instances of dead marine organism observed and the EQG was met. | |  |
| Water clarity | EQG | Measurements of light attenuation determined that the natural visual clarity of the water was reduced by ~9%, which is less than the 20% EQG threshold. The EQG was therefore met. | |  |
| Colour | EQG | There was a noticeable colour variation (described by the field scientists as 'brown tones') on one (12.5% of) sampling occasions. Colour variation was not changed by ten points on the Munsell scale over the long-term and the EQG was met. | |  |

| Environmental Quality Indicator | EQC | Comments | Compliance[1] | 3-year compliance trend (including current year)[2] |
|---|---|---|---|---|
| Surface films | EQG | No surface films or oil were recorded on any sampling event. | |  |
| Surface debris | EQG | No floating debris or matter was visible on the surface on any sampling occasion. | |  |
| Odour | EQG | No noticeable odour was detected on any sampling occasion. | |  |

Notes:

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

# 1 Introduction

## 1.1 Document purpose

This annual report documents the findings of the 2024–2025 Swanbourne 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).

## 1.2 Wastewater treatment plant infrastructure and discharge

The Subiaco Water Resource Recovery Facility (WRRF) treats predominantly domestic wastewater from the central Perth area. The treated wastewater (TWW) comprises ~95% domestic wastewater and less than 5% industrial wastewater. The Subiaco WRRF discharges ~56 ML/day of secondary TWW to the ocean through a sub-marine ocean outlet (~11 m depth) offshore from Swanbourne Beach (Figure 1).


**Figure 1 Location of the Subiaco WRRF and Swanbourne ocean outlet**

## 1.3 Potential stressors in treated wastewater

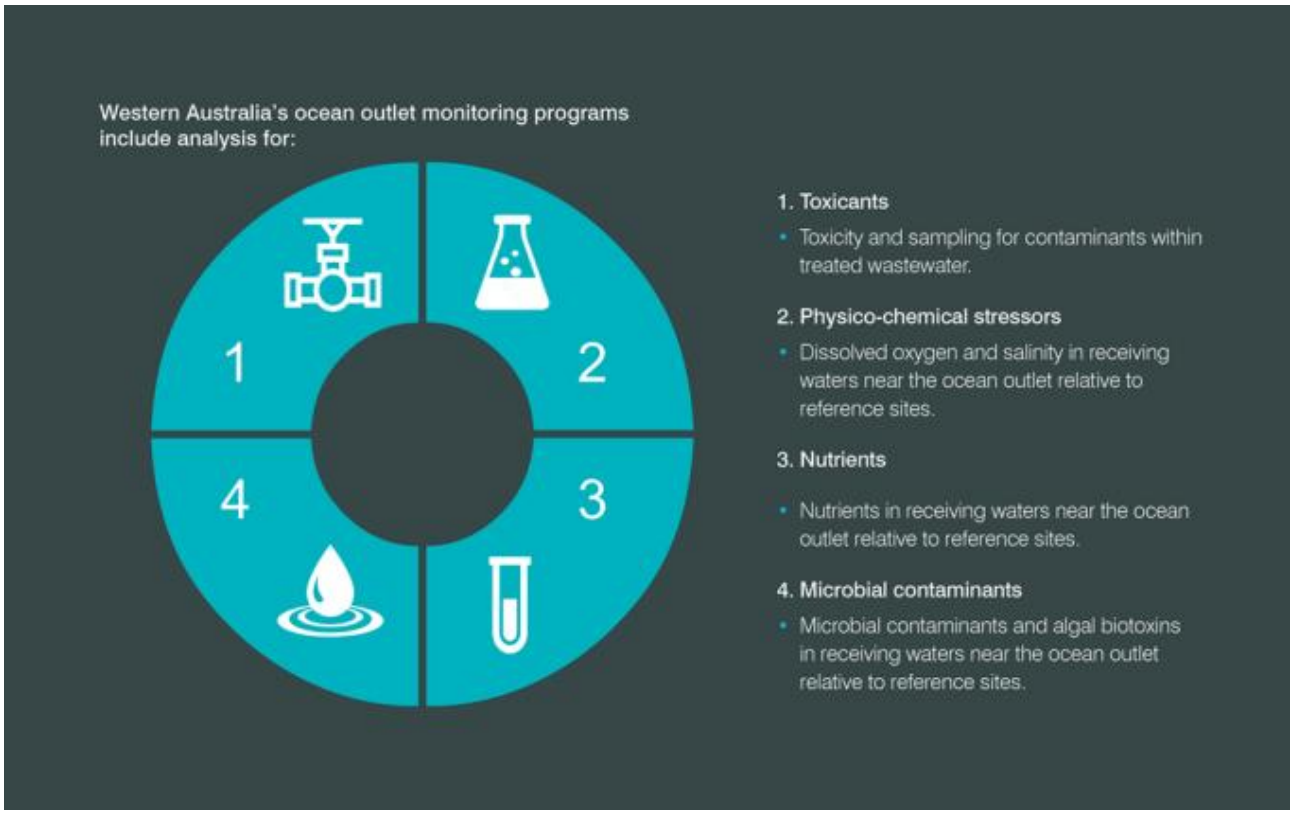



**Figure 2 Potential stressors in treated wastewater**

### 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 by which microorganisms use oxygen. If more dissolved oxygen (DO) is consumed than is produced, DO levels decline. Measurements of DO saturation in receiving waters near the outlet, relative to measurements at reference sites, provide an indication of the risk posed by deoxygenation.

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

### 1.3.3 Nutrients

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

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

### 1.3.4 Microbial contaminants

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

## 1.4 Environmental management approach

To maintain consistency with other metropolitan ocean outlet monitoring programs, the Swanbourne ocean outlet (Figure 3) is part of the Perth Long-term Ocean Outlet Monitoring (PLOOM) program.


**Figure 3 Aerial image of Swanbourne ocean outlet**

## 1.5 Environmental Quality Management Framework (EQMF)

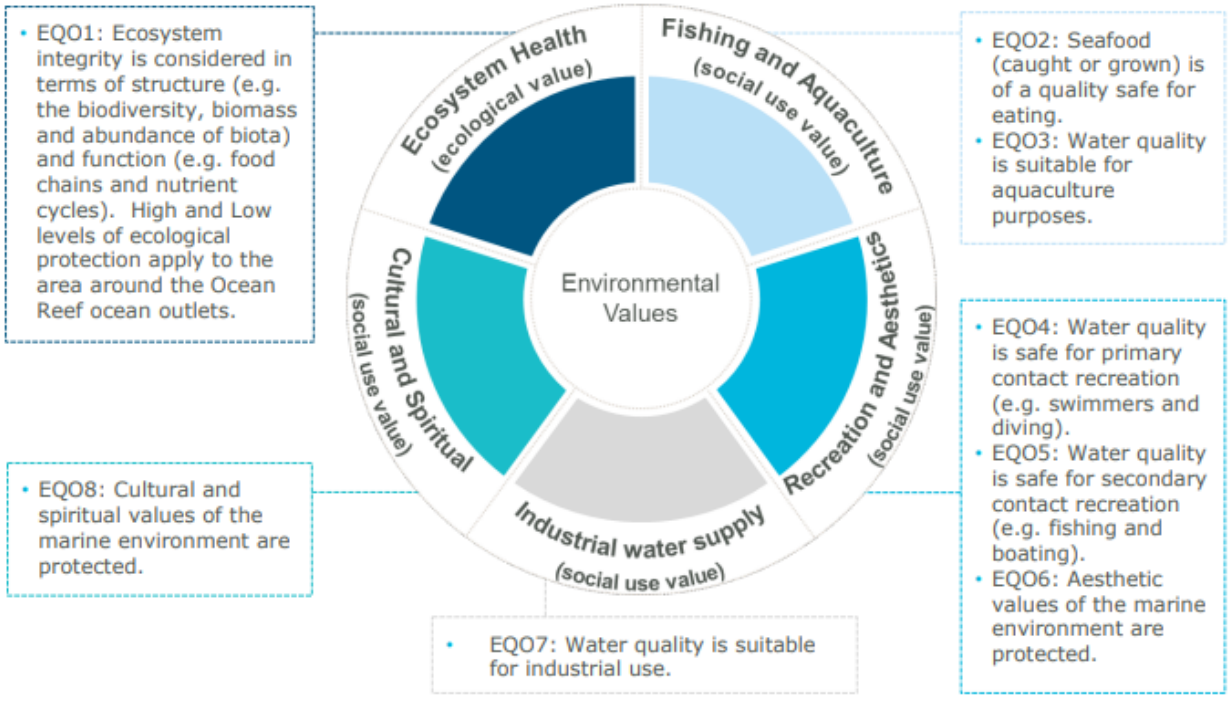
The ocean monitoring program is consistent with the approach advocated under the State Government's EQMF, which is applied to Western Australia's coastal waters (EPA 2016).

The EQMF is based on:

- Identifying Environmental Values (EVs) (Figure 4).
- Establishing and spatially defining Environmental Quality Objectives (EQOs) that need to be maintained to confirm the associated EVs are protected (Figure 4).
- Monitoring and managing to confirm 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 (EQGs)** 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 (EQSs)** 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 4 Environmental Values and Environmental Quality Objectives (EQO) for the marine waters of Western Australia**

The compliance results for 2024-2025 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 5). A notional Low Ecological Protection Area (LEPA) has been established around the Swanbourne outlet, as per technical guidance (EPA 2016). The notional LEPA occupies the area within a 100 m radius of the diffuser (Figure 6). Waters outside the notional LEPA are designated a High Ecological Protection Area (HEPA; Figure 6).

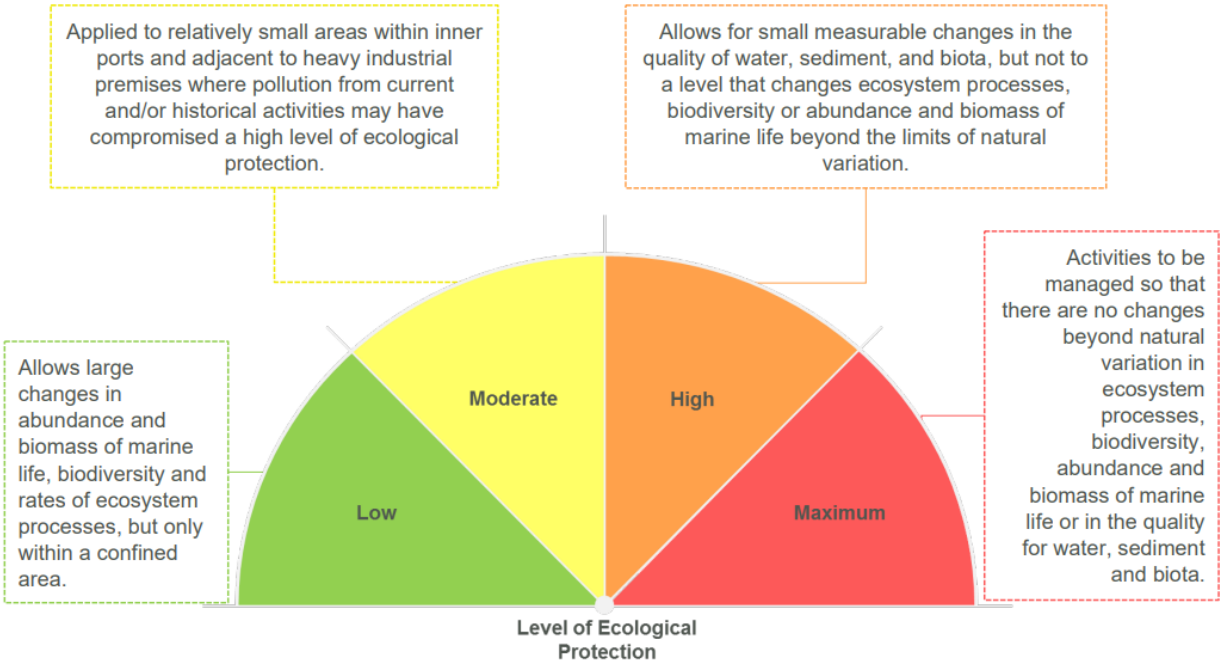



**Figure 5 Level of Ecological Protection**

### 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 outlet where EQO 2 may not be achieved, and seafood may be unsafe to eat.

Formal management zones have not been established for the Swanbourne outlet. However, a notional Seafood Management Observed Zone of Influence (OZI) has been established based on microbiological data from ten years of historical monitoring records (Figure 6). The Seafood Management OZI 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 outlet, where water quality may not be suitable for swimming. A notional Contact Recreation Management Observed Zone of Influence (OZI) has been developed for the Swanbourne outlet encompassing the management area for primary and secondary contact recreation (Figure 6). As the EQO for maintenance of primary contact recreation uses a higher water quality standard than secondary contact recreation, it is assumed that if the primary contact criteria are met, then the secondary contact criteria are also met by default.

### 1.5.4 Maintenance of Aesthetic Value EQO

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

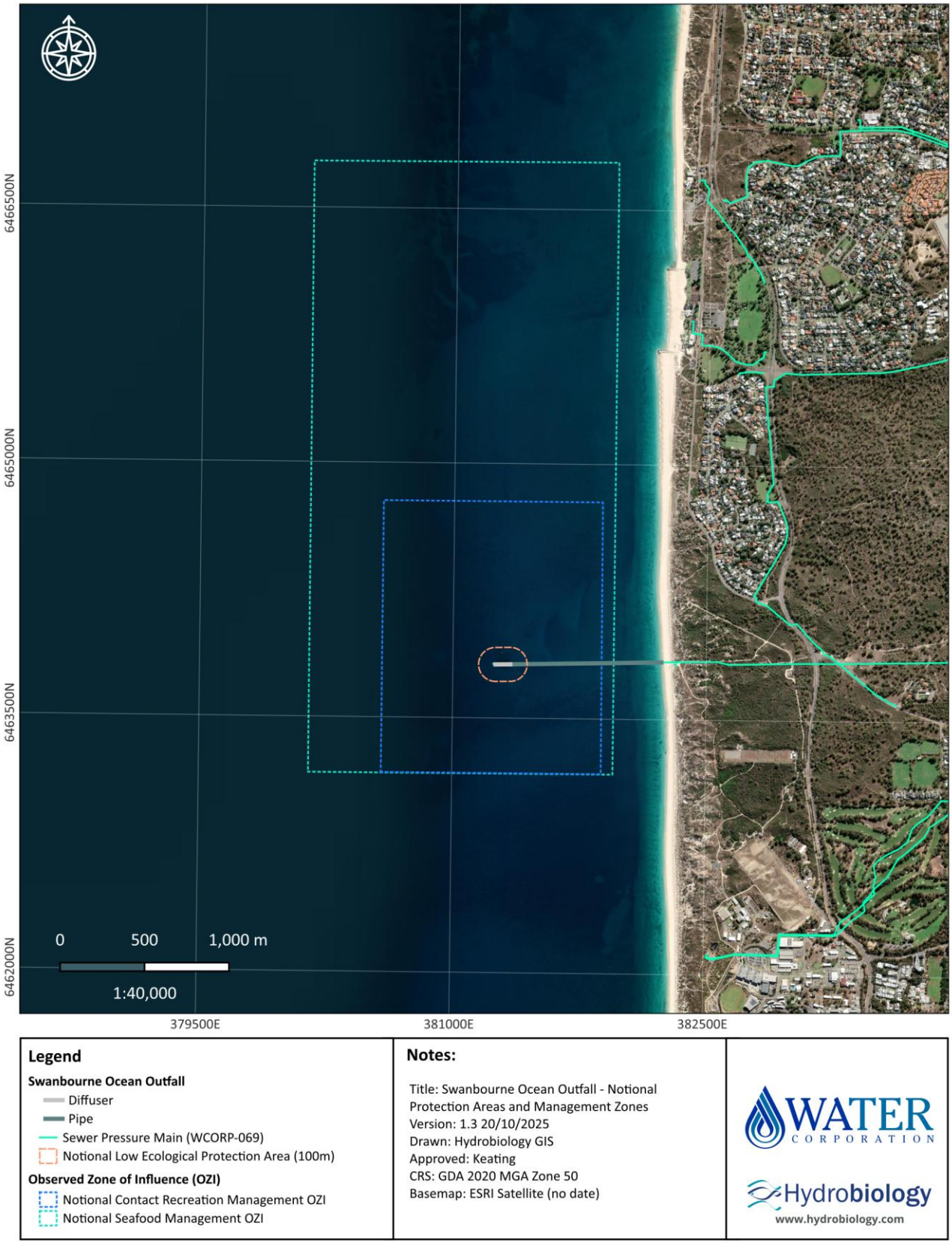



**Figure 6 Swanbourne ocean outlet notional protection area and management zones**

# 2 Toxicants in treated wastewater

## 2.1 Comprehensive treated wastewater characterisation (CTWWC)

TWW (final effluent) from the Subiaco WRRF was analysed for a suite of potential contaminants of concern (Figure 7):

- 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.

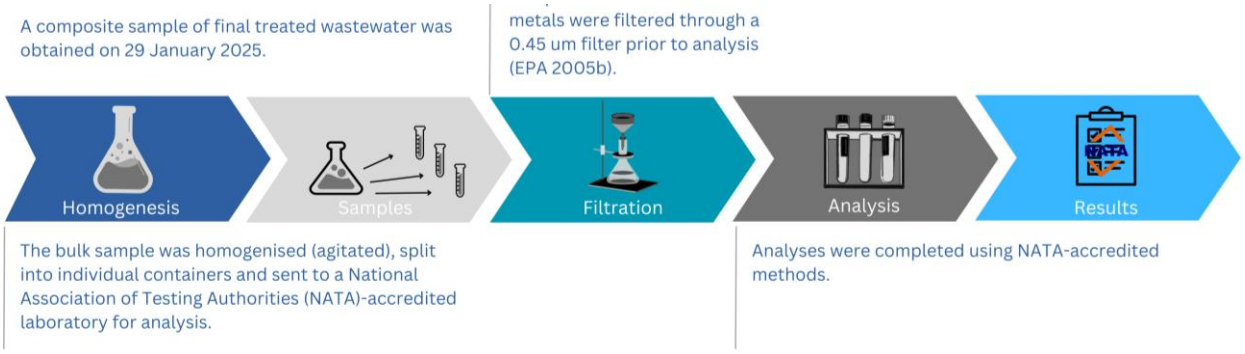



**Figure 7 Treated wastewater sampling and analysis process**

### 2.1.1 Bioaccumulating toxicants

Concentrations of bioaccumulating toxicants, cadmium and mercury, in the undiluted TWW sample were both below the limit of reporting (LoR; 0.1 µg/L) and the EQG (Table 2) for cadmium (36 µg/L) and mercury (1.4 µg/L) was met (Table 3). Concentrations of bioaccumulating toxicants in the discharge have been consistent since 2007-2008 (Figure 8).

**Table 2 Environmental Quality Guideline for bioaccumulating toxicants**

| | |
|---|---|
| **EQG[1] 1** | Concentrations of bioaccumulating contaminants in the treated wastewater stream will not exceed the ANZG (2018) 80% species protection guidelines. |

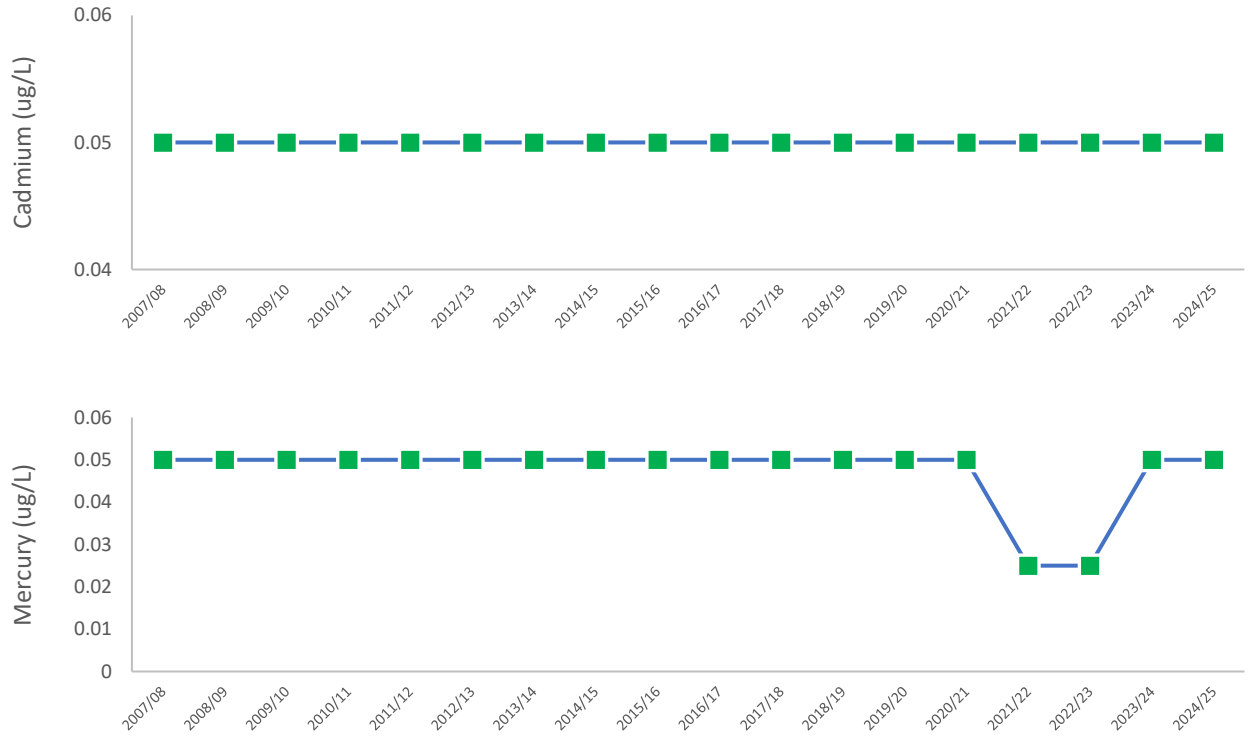
Note:
1. EQG = Environmental Quality Guideline

## Table 3 Bioaccumulating toxicants in the Swanbourne treated wastewater stream

| Toxicant | Swanbourne TWW[2] concentration (µg/L) | ANZG (2018) 80% species protection guideline (µg/L)[1] |
|---|---|---|
| Cadmium | <0.1 | 36 |
| Mercury | <0.1 | 1.4 |

Notes:

1. Assessment against ANZG (2018) guidelines. The bioaccumulating toxicants cadmium and mercury must meet the 80% species protection guidelines at the diffuser (i.e. prior to initial dilution), and therefore a diluted concentration was not calculated.
2. TWW = Treated wastewater




Note:

1. Green symbols indicate the Environmental Quality Guideline (EQG) was met.
2. Cadmium and mercury concentrations below the detection limit are assigned a value half that of the laboratory Limit of Reporting (LoR) for reporting purposes (i.e. concentrations below the detection limit of 0.1 µg/L are assigned a value of 0.05 µg/L).
3. The LoR for mercury in the 2021/22 and 2022/23 monitoring seasons (0.05 µg/L) was different to previous years (0.1 µg/L) due to a change in laboratory.

## Figure 8 Historical compliance of concentrations of the bioaccumulating toxicants cadmium and mercury

### 2.1.2 Non-bioaccumulating toxicants

The EQG for non-bioaccumulating toxicants is presented in Table 4. Contaminant concentrations after the initial dilution of 1:131 were below the ANZG (2018) 99% species protection guidelines, and the EQG for non-bioaccumulating toxicants was met (Table 5). Modelling predicted an average initial dilution of 1:131 at the Swanbourne ocean outlet as a conservative estimate of the dilution expected at the notional LEPA boundary (Figure 9; as applied to the 2024/25 results for ammonia, copper and zinc (Figure 10).

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

| | |
|---|---|
| **EQG[1] 1** | Treated wastewater contaminant concentration corrected for minimum dilution at the notional LEPA[1] boundary will ensure the ANZG (2018) 99% species protection guidelines for toxicants are being achieved at the boundary of the LEPA[1] (i.e. a high level of protection is met beyond a 100 m radius of the diffuser). |

Note:

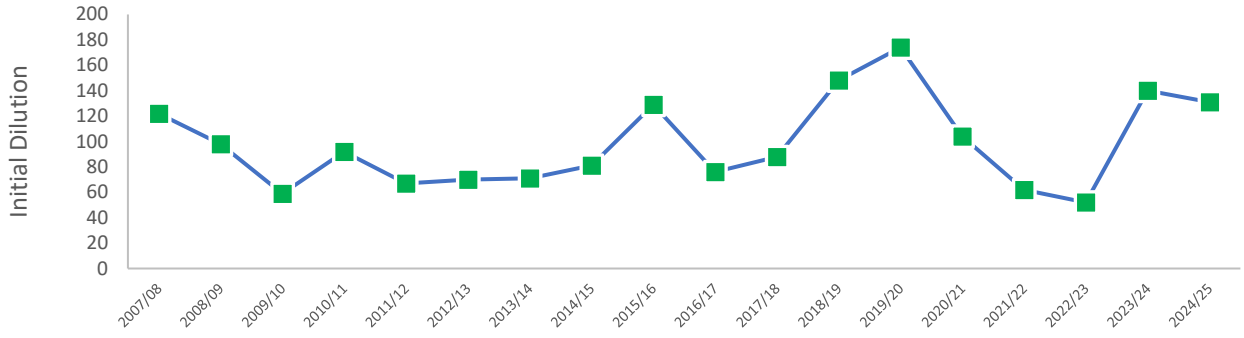
1. EQG = Environmental Quality Guideline; LEPA = Low Ecological Protection Area (notional)

**Table 5 Non-bioaccumulating toxicants in the Swanbourne treated wastewater 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)[1,5,7] |
|---|---|---|---|
| **Nutrients** | | | |
| Ammonia-N | 760 | 7.3 | 500 |
| **Dissolved metals (0.45 µm filtered)** | | | |
| Chromium VI* | <1 | - | 0.14 (Cr VI) |
| Copper* | 10 | 0.16 | 0.3 |
| Lead* | <1 | - | 2.2 |
| Nickel* | 1 | 0.008 | 7 |
| Silver* | <1 | - | 0.8 |
| Zinc* | 66 | 0.65 | 3.3 |
| **Organophosphate pesticides** | | | |
| Chlorpyrifos[5] | <0.02 | - | 0.0005 |
| **Organochlorine pesticides** | | | |
| Endrin | <0.01 | - | 0.004 |
| Endosulfan sulfate[6] | <0.01 | - | 0.005 |
| **BTEX** | | | |
| Benzene | <1 | - | 500 |
| **Polyaromatic hydrocarbons (PAHs)** | | | |
| Naphthalene | <0.02 | - | 50 |
| Benzo(g,h,i)perylene | <0.02 | - | 50 |

Notes:

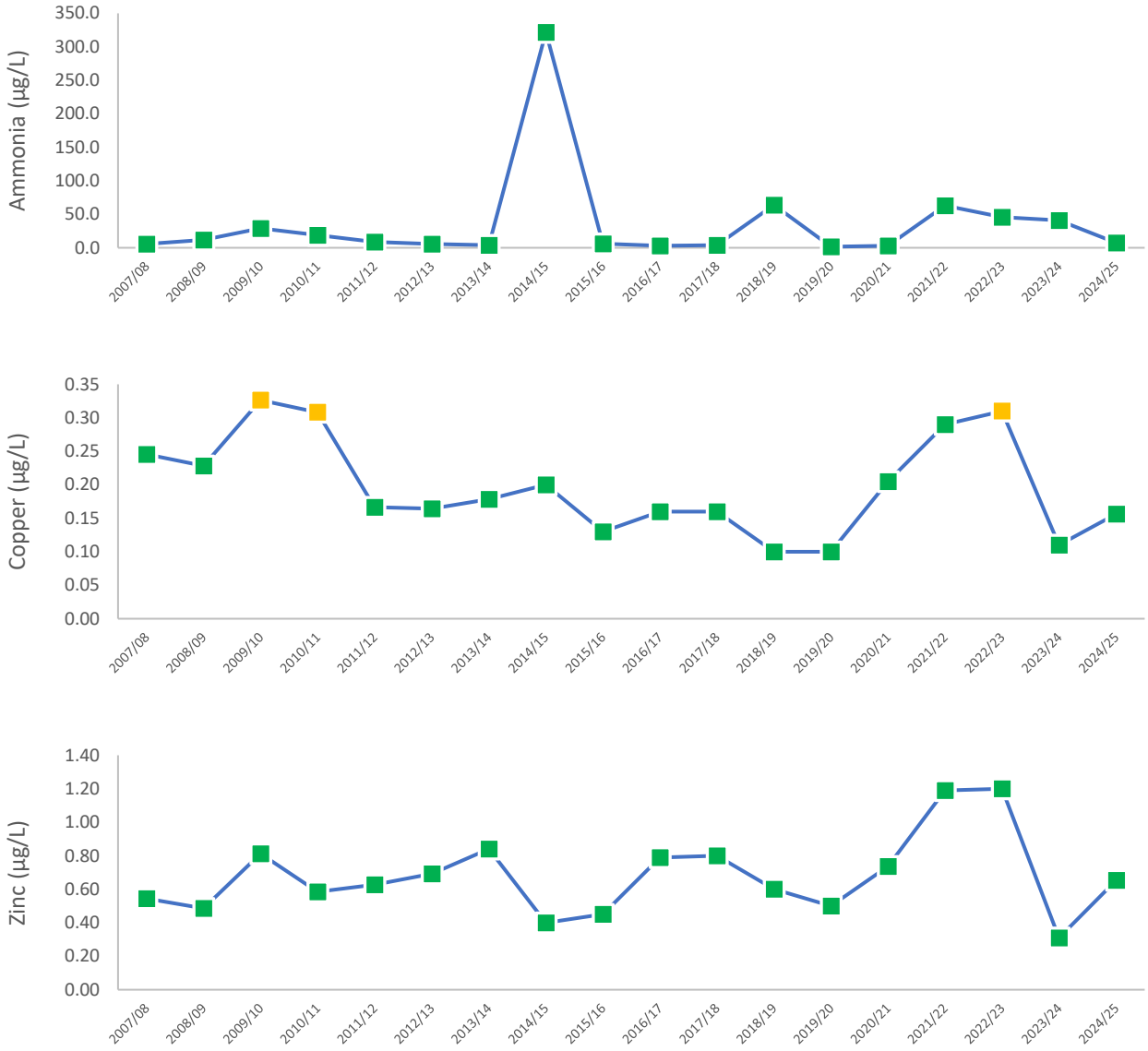
1. Assessment against EPA (2017) 99% species protection guidelines was undertaken only for those toxicants where guideline levels were available.
2. TWW = Treated wastewater
3. Initial dilution = 1:131 (predicted average value for Swanbourne outlet). Contaminant dilution calculations were not performed (–) on any toxicants where TWW concentrations were below the analytical limit of reporting.
4. The trigger values for non-bioaccumulating toxicants are from ANZG (2018). The EPA has provided advice that in WA waters where a high level of protection applies, the 99% species protection levels should be used.
5. Analytical limits for Chlorpyrifos were not low enough to confirm exceedance of, or compliance with, the ANZG (2018) guidelines. Until detection limits required for direct comparison can be attained by commercial laboratories, WET testing will provide a test of the toxicity of the treated wastewater stream.
6. Trigger values are for endosulfan, not endosulfan sulfate (ANZG 2018).
7. *= dissolved metals 0.45 µm filtered.




Note:

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

**Figure 9 Historical Compliance of initial dilution calculations**




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. Contaminant dilution calculations were applied to these toxicants in line with the annual predictions presented in Figure 9.

**Figure 10 Historical compliance of concentrations of non-bioaccumulating toxicants**

### 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. Following initial dilution, the combined TTM of ammonia, copper and zinc (0.63) was less than the ANZG (2018) guideline value of 1.0, and the EQG for TTM was met (Table 6, Table 7). The TTM EQG has been exceeded on five occasions since 2009/10, but there was no evidence of an increasing trend over time (Figure 11).

**Table 6 Environmental Quality Guideline for the total toxicity of the mixture**

| | |
|---|---|
| **EQG[1] 1** | The total toxicity of the mixture (TTM)[1,2,3] for the additive effect of ammonia, copper and zinc, calculated as per ANZG (2018), will not exceed the trigger value of 1.0 |

Notes:

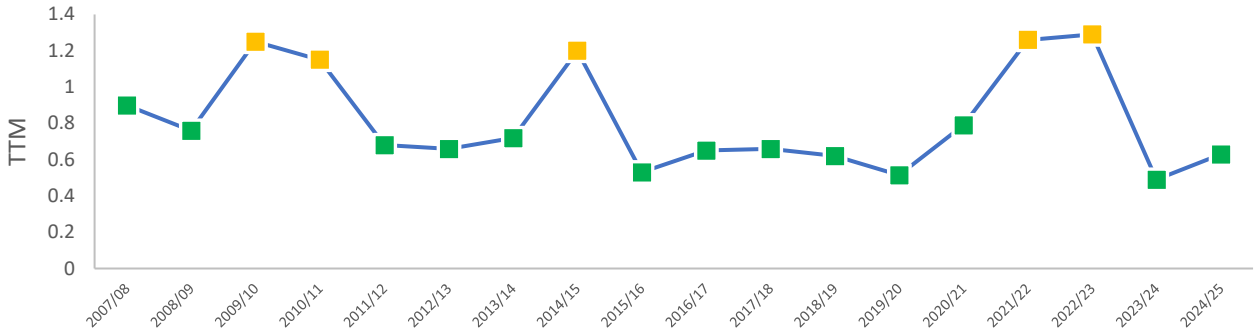
1. EQG = Environmental Quality Guideline; TTM = total toxicity of the mixture.
2. TTM = Σ(Ci/EQGi) where Ci is the concentration of the relevant component (i) in the mixture and its associated EQG for that component.
3. Assessment is based on bioavailable concentrations of metals in the treated wastewater (i.e. concentrations after filtering through a 0.45 µm filter).

**Table 7 Total toxicity of treated wastewater at the edge of the initial mixing zone associated with the Swanbourne ocean outlet**

| Toxicant | TWW[2] concentration (µg/L) | Background concentration (µg/L)[1] | Dilution | Concentration after dilution (µg/L) | Contaminant concentration/guideline (µg/L) | TTM[3] |
|---|---|---|---|---|---|---|
| Ammonia | 760 | 1.5 | 1:131 | 7.29 | 0.01 | 0.63 |
| Copper[4] | 10 | 0.08 | | 0.14 | 0.52 | |
| Zinc[4] | 66 | 0.15 | | 0.29 | 0.09 | |

Notes:

1. Background concentrations for copper and zinc from McAlpine et al. (2005); Perth marine waters (pp.19). Surface background concentrations for ammonia calculated as median of reference site data from 2003–2023.
2. Guideline values are from Table 5.
3. TTM = total toxicity of the mixture = [ammonia]/guideline + [copper]/guideline + [zinc]/guideline, TWW = treated wastewater
4. Assessment is based on bioavailable concentrations of metals in the treated wastewater (i.e. concentrations after filtering through a 0.45 µm filter).




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 11 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 salt-adjusted dilutions (1.0, 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; Table 8).

In January 2025, sea urchin fertilisation was significantly lower in samples exposed to 50% and 100% TWW dilutions compared to the artificial seawater control (Figure 12). In March 2025, sea urchin fertilisation was significantly lower in samples exposed to 25%, 50% and 100% TWW dilutions compared to the artificial seawater control (Figure 12). For both sampling dates, the NOEC was greater than 1% TWW and the EQG for WET testing (Table 8) was met (Figure 13).

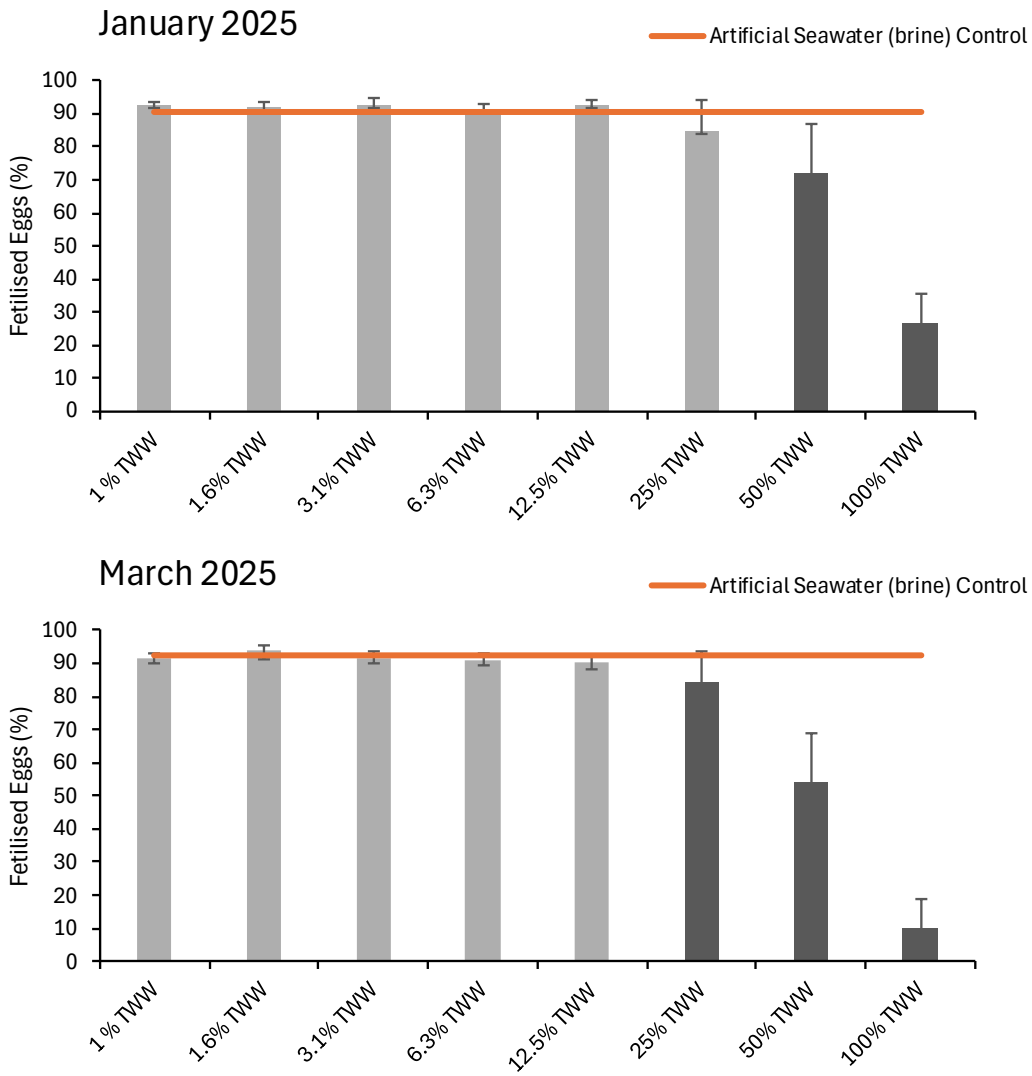
**Table 8 Environmental Quality Guideline for whole of effluent toxicity testing**

| | |
|---|---|
| **EQG[1] 1** | The EQG[1] for WET[1] will be exceeded where:<br>$$\frac{TDA}{DRNOEC} \leq 1.0$$<br>Where TDA[1] is Typical Dilutions Achieved (constant based on 200-fold dilution) and DRNOEC[1] is the number of Dilutions Required to achieve the NOEC[1].<br>Where this EQG[1] is breached an investigation into the EQS[1], comprising of the full suite of WET[1] tests (minimum of five species from four other tropic groups), will be triggered. |

*Source: BMT Oceanica 2014*

Note:

1. EQG = Environmental Quality Guideline; EQS = Environmental Quality Standard; WET = Whole of Effluent Toxicity; TDA = Typical Dilutions Achieved; DRNOEC = Dilutions Required to achieve the No Observed Effects Concentration.




Notes:

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

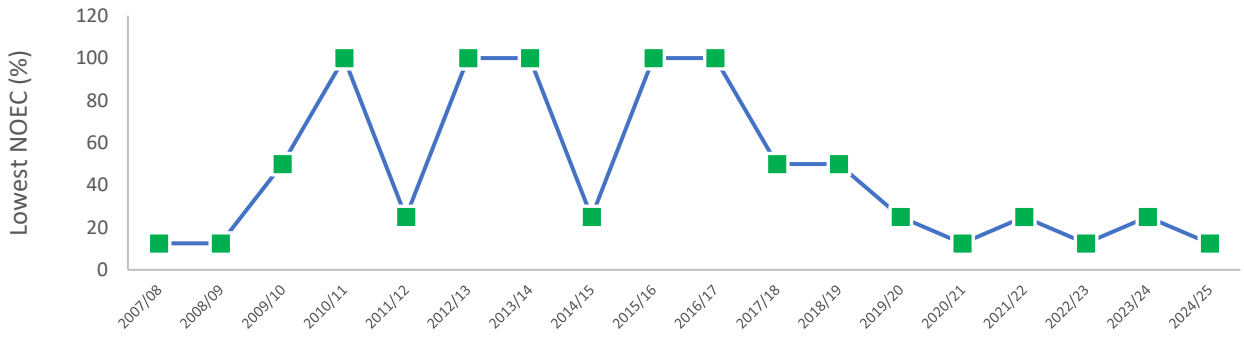
**Figure 12 Comparison of whole effluent toxicity TWW dilution results to artificial seawater control for Swanbourne treated wastewater**

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

| Indicator | January 2025 | March 2025 |
|---|---|---|
| NOEC[1] (%) | 25 | 12.5 |
| Dilutions required to meet the NOEC[1] | 4 | 8 |
| Dilutions required/dilution achieved | 0.03 | 0.06 |
| Under ≤1 | Yes | Yes |

Note:

1. NOEC = No Observed Effect Concentration




Note:

1. Environmental Quality Criteria (EQC): Green symbols indicate the Environmental Quality Guideline (EQG) was met.
2. NOEC = No Observed Effect Concentration

### Figure 13 Historical No Observed Effect Concentration

# 3 Water quality monitoring – receiving environment

Nutrients, phytoplankton biomass and physical and chemical stressors were monitored on eight occasions from early December 2024 to late March 2025 (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 for the Swanbourne ocean outlet between December 2024 and March 2025**

| Sampling Event | Sampling Month | Date |
|---|---|---|
| 1 | December | 4/12/2024 |
| 2 | December | 13/12/2024 |
| 3 | January | 08/01/2025 |
| 4 | January | 29/01/2025 |
| 5 | February | 05/02/2025 |
| 6 | February | 19/02/2025 |
| 7 | March | 04/03/2025 |
| 8 | March | 21/03/2025 |

**Table 11 Weather and current grid during water quality monitoring near the Swanbourne ocean**

| Date | Wind direction[1,2,3] | Wind strength (knots)[3] | Cloud cover (%) | Current grid[2] |
|---|---|---|---|---|
| 4/12/2024 | WSW | 10 to 14 | 30 - 90 | SE |
| 13/12/2024 | NNE – NW - WNW | 0 to 5 | 50 - 90 | SE |
| 08/01/2025 | S - SSW | 8 to 14 | 10 | E |
| 29/01/2025 | E | 8 to 14 | 5 -10 | SW |
| 05/02/2025 | SW – E - ESE | 3 to 18 | 0 - 20 | SW |
| 19/02/2025 | E - NE | 4 to 12 | 5 | NW |
| 04/03/2025 | S - SSE | 13 to 16 | 20 - 30 | N |
| 21/03/2025 | SE - SW | 1 to 6 | 0 | SE |

Notes:

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

## 3.1 Nutrient Enrichment

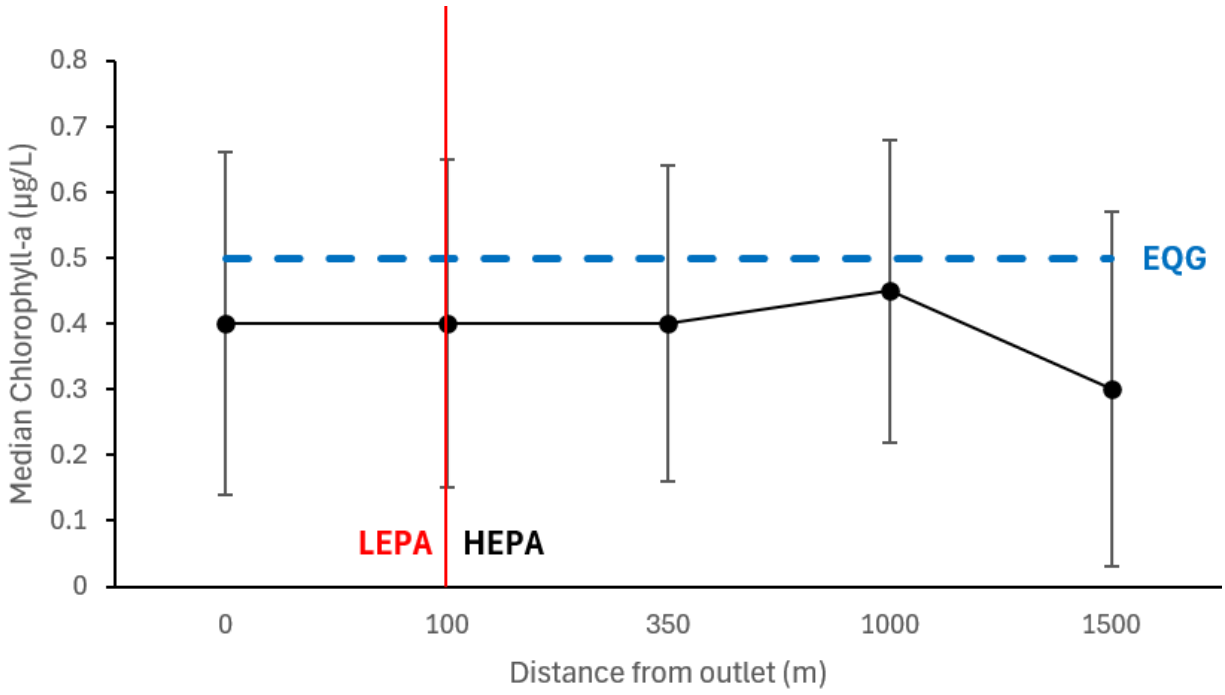
The median chlorophyll-*a* concentration in the Swanbourne notional HEPA (100, 350, 1,000 and 1,500 m) in 2024-25 was 0.4 µg/L and was lower than the 80th percentile of historical reference site data (0.5 µg/L; Figure 14), meeting the EQG (Table 12; Figure 15).

**Table 12 Environmental Quality Guidelines for nutrients**

| | |
|---|---|
| **EQG[1]1** | The median chlorophyll–*a* concentration in the HEPA[1] (100 m and greater from the diffuser) during the non-river flow period is not to exceed the 80th percentile of reference site data. |
| **EQG[1]2** | The median light attenuation coefficient in the notional HEPA[1] during the non-river flow period is not to exceed the 80th percentile of reference site data. |

Note:

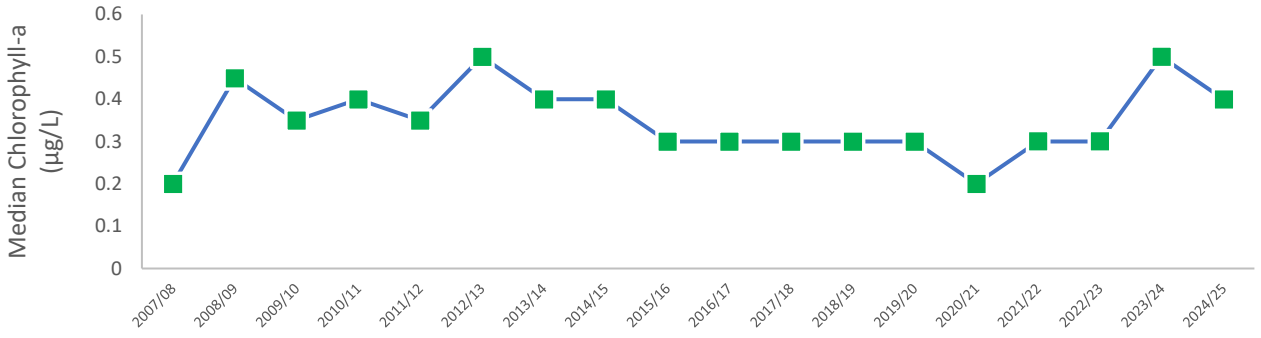
1. EQG = Environmental Quality Guideline; HEPA = High Ecological Protection Area




Notes:

1. Error bars represent ± 95% confidence intervals; n = 8.
2. Dark blue dashed line = Environmental Quality Guideline (EQG) is the 80th percentile of reference site data (0.5 µg/L chlorophyll-*a*).
3. LEPA = Low Ecological Protection Area (notional); HEPA = High Ecological Protection Area
4. Data were pooled across eight sampling events (n = 8) over December 2024 to March 2025.

**Figure 14 Median chlorophyll–*a* concentration down-current of the Swanbourne outlet during the summer monitoring period**

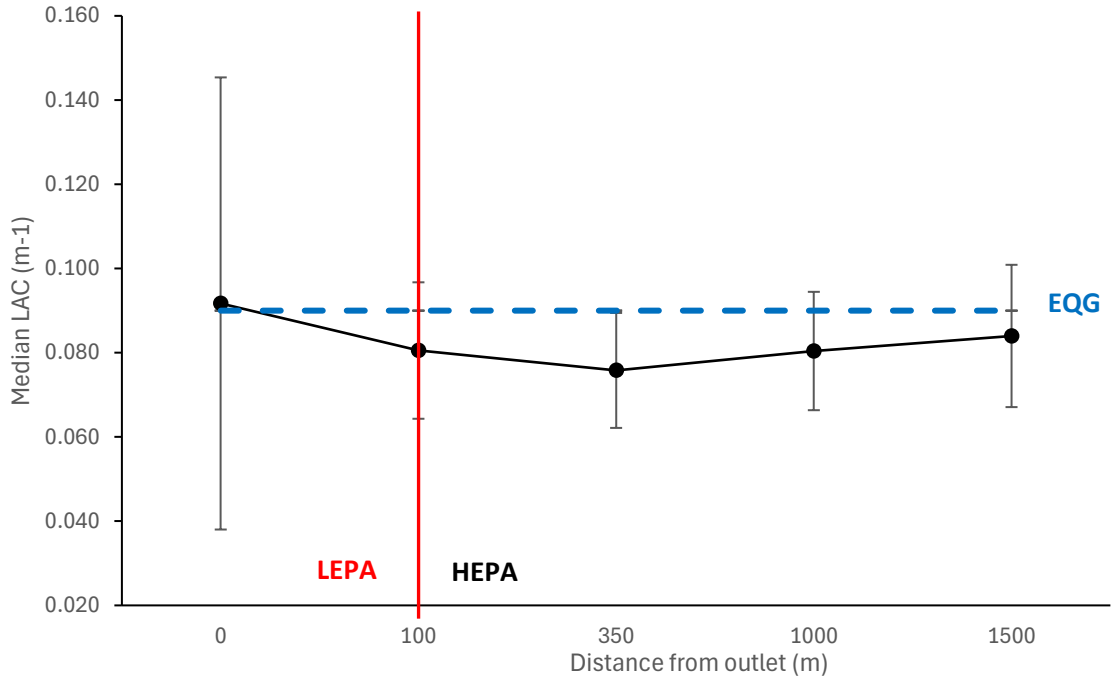



Note:

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

**Figure 15 Median chlorophyll-a concentration**

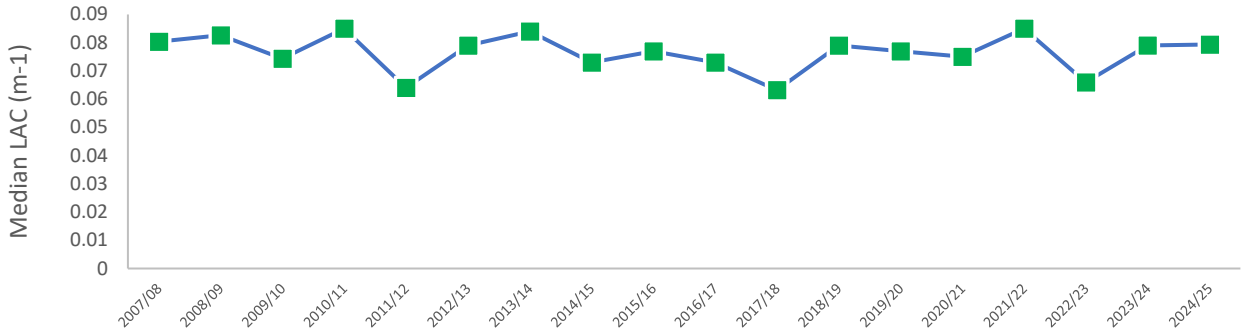
The median light attenuation coefficient (LAC) in the Swanbourne notional HEPA (100, 350, 1,000 and 1,500 m) was 0.079 $m^{-1}$ and was less than the 80$^{th}$ percentile of reference site data (0.09 $m^{-1}$; Figure 16), meeting the EQG (Table 12; Figure 17).




Notes:

1. Error bars represent ± 95% confidence intervals; n = 8.
2. Dark blue dashed line = Environmental Quality Guideline (EQG) is the 80$^{th}$ percentile of reference site data (0.094 $m^{-1}$).
3. LEPA = Low Ecological Protection Area (notional); HEPA = High Ecological Protection Area
4. Data were pooled across eight sampling days (n = 8) over December 2024–March 2025.

**Figure 16 Median light attenuation coefficient at fixed distances down current of the Swanbourne outlet during the summer monitoring period**




Note:

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

**Figure 17 Median light attenuation coefficient**

## 3.2 Phytoplankton biomass

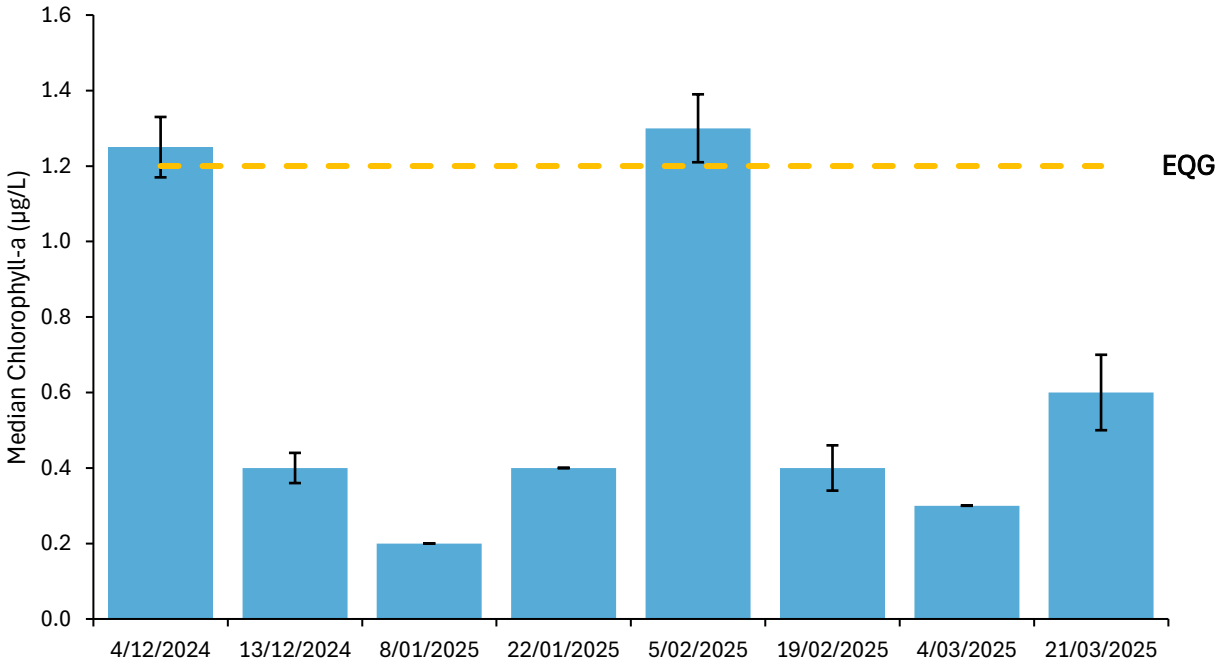
Median phytoplankton biomass (measured as median chlorophyll-*a* concentration) within the notional HEPA exceeded three times the median of reference sites (1.2 µg/L; Figure 18) on two sampling occasions during the summer monitoring period and EQG1 (Table 13) was not met. Median phytoplankton biomass (chlorophyll-*a* concentration) within the HEPA also exceeded three times the reference site median, on more than one occasion during the non-river flow period (Figure 19) but not in two consecutive years and the EQS 1 was met (Figure 20).

**Table 13 Environmental Quality Guidelines for phytoplankton in receiving waters**

| | |
|---|---|
| **EQG[1] 1** | Median phytoplankton biomass, measured as chlorophyll–*a* is not to exceed 3 times the median chlorophyll–*a* concentration of reference sites, on any occasion during the non-river flow period. |
| **EQS[1] 1** | Median phytoplankton biomass measured as chlorophyll–*a* does not exceed three times median chlorophyll–*a* concentration of reference sites, on more than one occasion during non-river flow period and in two consecutive years. |
| **EQG[1] 2** | Phytoplankton biomass measured as chlorophyll–*a* at any site does not exceed 3 times the median chlorophyll–*a* concentration of reference sites, on 25% or more occasions during the non-river flow period. |
| **EQS[1] 2** | Phytoplankton biomass measured as chlorophyll–*a* at any site does not exceed three times the median chlorophyll–*a* concentration of reference sites, on 25% or more occasions during the non-river flow period and in two consecutive years. |

Note:

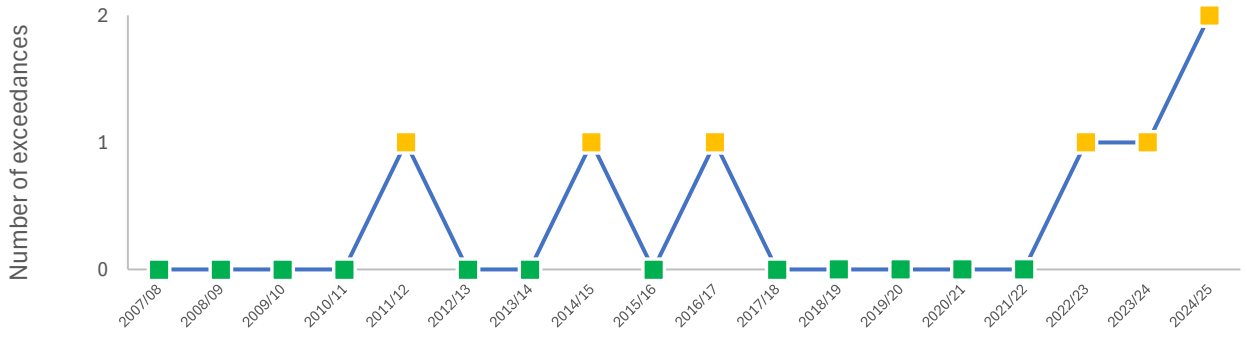
1. EQG = Environmental Quality Guideline; EQS = Environmental Quality Standard.




Notes:

1. Error bars represent ± 95% confidence intervals; n = 8.
2. Amber dashed line = Environmental Quality Guideline (EQG) is 3-times the median chlorophyll-*a* concentration of reference site data (1.2 µg/L chlorophyll-*a*).
3. Data pooled from fixed sites ≥ 100 m down-current of the outlets. Concentrations at 0 m are not included in the figure or EQC assessment, as the 0 m site is situated directly above the outlets within the notional Low Ecological Protection Area (LEPA).

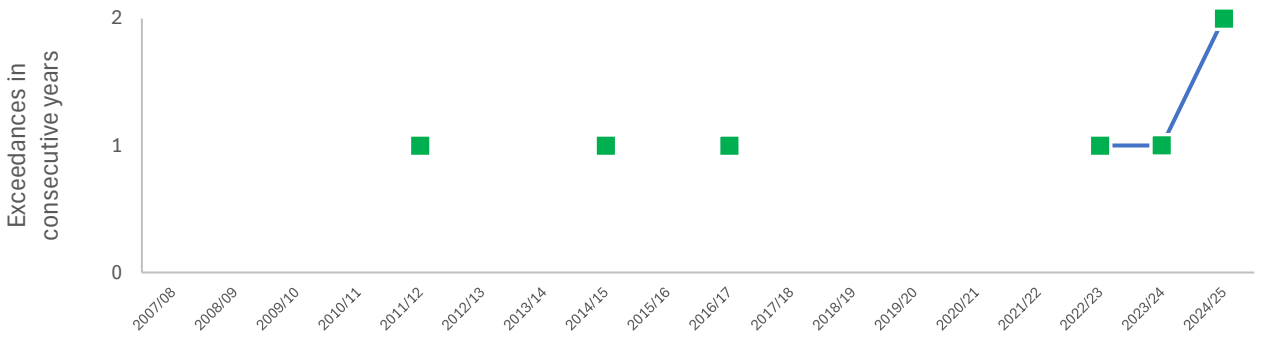
**Figure 18 Phytoplankton biomass (measured as median chlorophyll-a concentration) at fixed sites ≥ 100 m down-current of the Swanbourne outlet during the 2024-25 summer monitoring period**




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 19 Exceedance of three times the reference site median phytoplankton biomass (measured as median chlorophyll–*a* concentration) on any occasion**

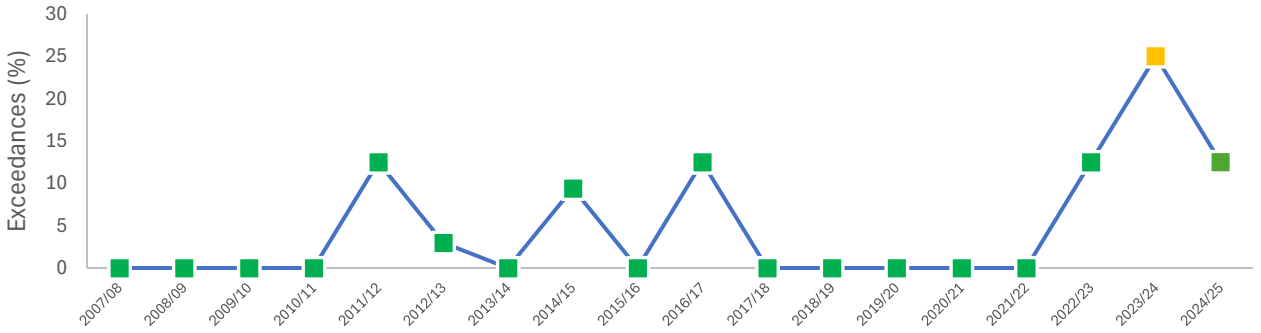



Note:

1. Environmental Quality Criteria (EQC): Green symbols indicate the Environmental Quality Standard (EQS) was met.

**Figure 20 Exceedance of three times the reference site median phytoplankton biomass (measured as median chlorophyll-a concentration) on more than one occasion in two consecutive years**

Phytoplankton biomass measured as chlorophyll–*a* at any site did not exceed 3 times the median chlorophyll–*a* concentration of reference sites, on 25% or more occasions during the non-river flow period, and therefore EQG2 was met (Figure 21).




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 21 Exceedance of three times the reference site median phytoplankton biomass (measured as chlorophyll-a concentration) on 25% or more occasions during the non-river flow period**

## 3.3 Physical-chemical stressors

### 3.3.1 Dissolved oxygen (DO)

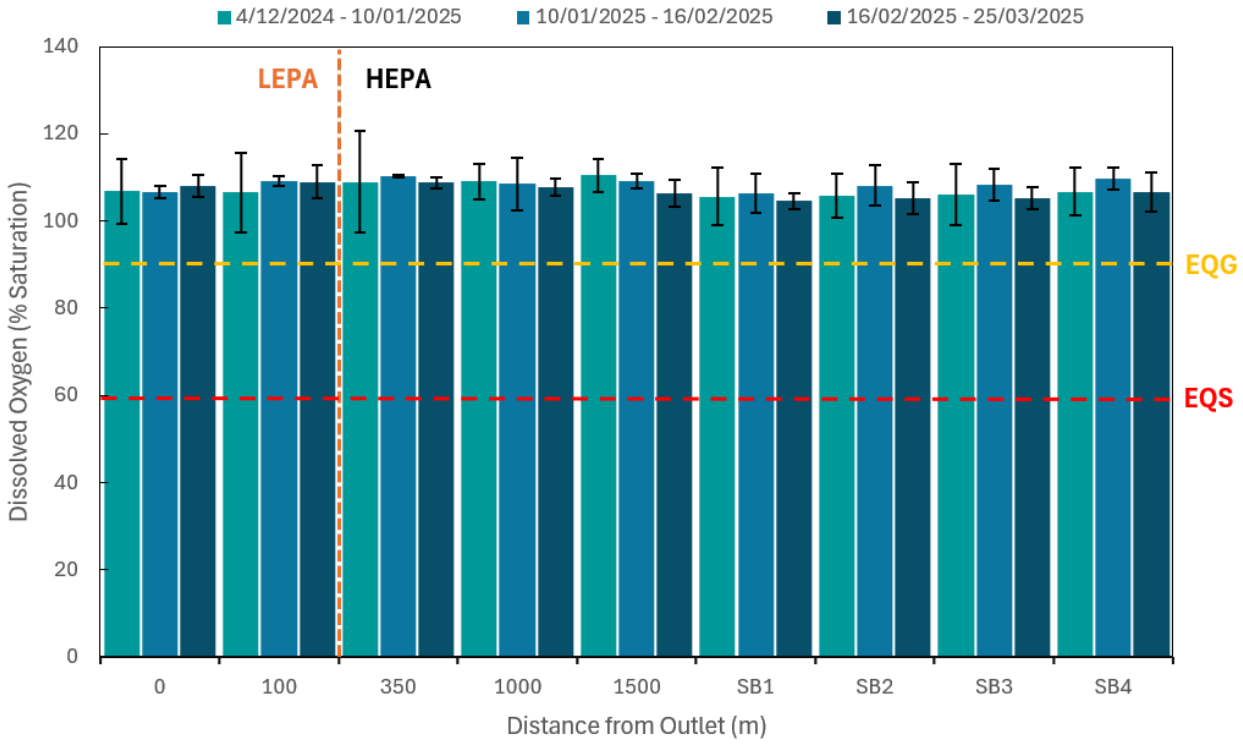
Table 14 presents the EQG and EQS for dissolved oxygen. The median of bottom (0 – 0.5 m) dissolved oxygen saturation was >90% at all sites and times throughout the summer survey period (Figure 22) and the EQG was met. Historically, DO has not fallen below 90% for any 6-week period at any time (Figure 23).

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

| | |
|---|---|
| **EQG[1] 1** | Median dissolved oxygen in bottom waters (0–0.5 m above the sediment surface) must be greater than 90% saturation at any site for a defined period of not more than 6 weeks during the non-river flow period. |
| **EQS[2] 1** | Median dissolved oxygen in bottom waters (0–0.5 m above the sediment surface) must be greater than 60% saturation at any site for a defined period of not more than 6 weeks during the non-river flow period. |

Note:

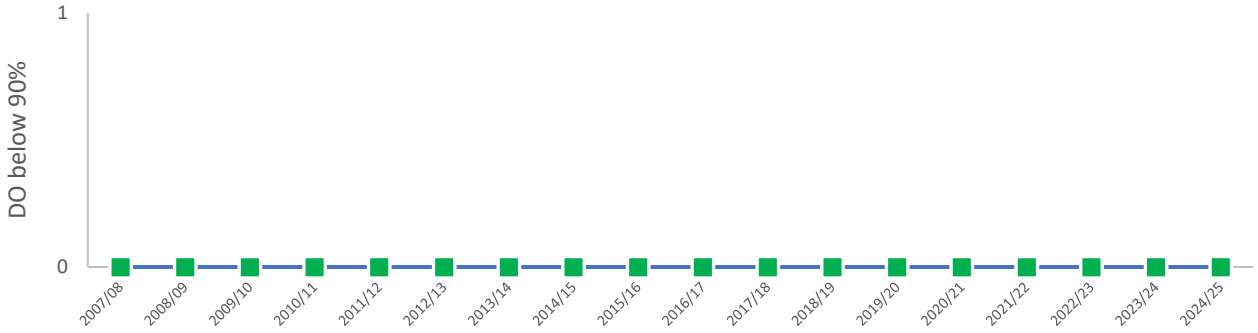
1. EQG = Environmental Quality Guideline.
2. EQS = Environmental Quality Standard




Notes:

1. Error bars ±95% confidence intervals (n = 40)
2. Dissolved oxygen (DO) measured 0–0.5 m above the seabed
3. Yellow dashed line = Environmental Quality Guideline (EQG) = 90% DO saturation; Red dashed line = Environmental Quality Standard (EQS) = 60% DO saturation.
4. LEPA = Low Ecological Protection Area (notional); HEPA = High Ecological Protection Area.
5. Reference site data (SB1–SB4) are provided for contextual purposes only.

**Figure 22 Median dissolved-oxygen (DO) saturation in bottom waters (0 - 0.5 m above the seabed) for all HEPA sites during the summer monitoring program.**




Note:

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

**Figure 23 Number of periods where DO was below 90% (EQG)**

### 3.3.2 Salinity

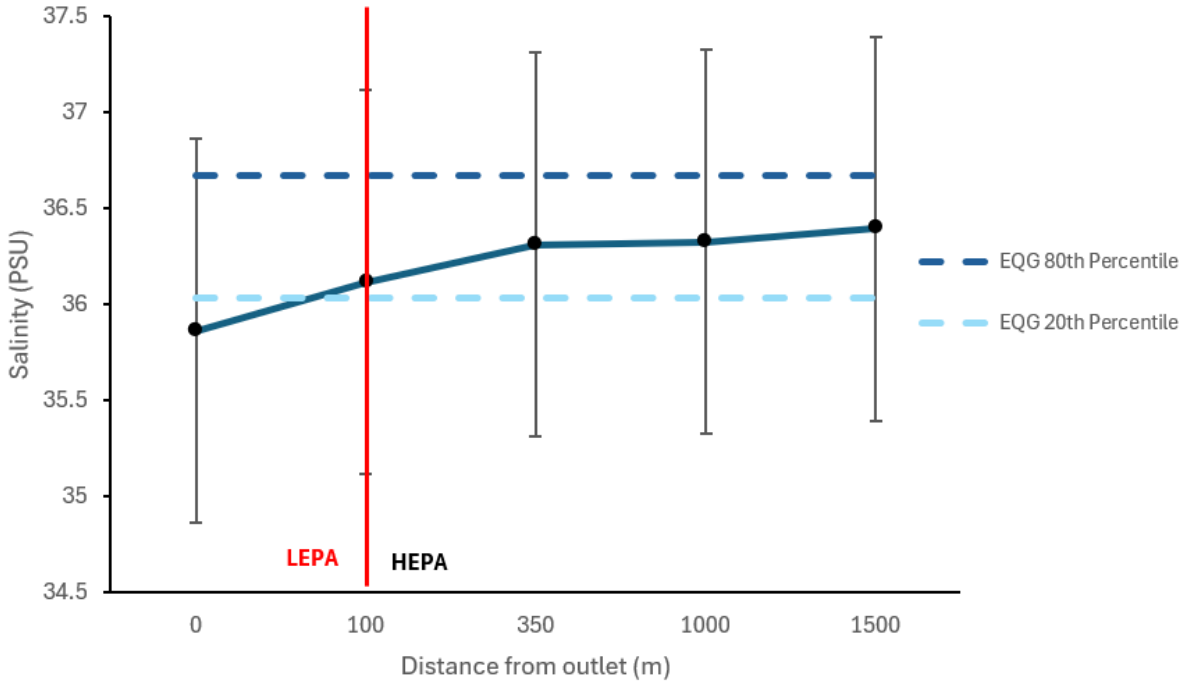
Median salinity was between the 20th and 80th percentile (36.04 and 36.67 PSU, respectively) of the natural salinity range at all HEPA sites across the summer monitoring period and therefore the EQG was met (Table 15; Figure 24). In the past, median salinity has deviated beyond the 20th and 80th percentile of the natural salinity range for the same period on four occasions (Figure 25).

**Table 15 Environmental Quality Guideline for salinity**

| | |
|---|---|
| **EQG[1] 1** | Median salinity (0.5 m below the water surface) at an individual site over any period is not to deviate beyond the 20th and 80th percentile of the natural salinity range[2] over the same period. |

Note:

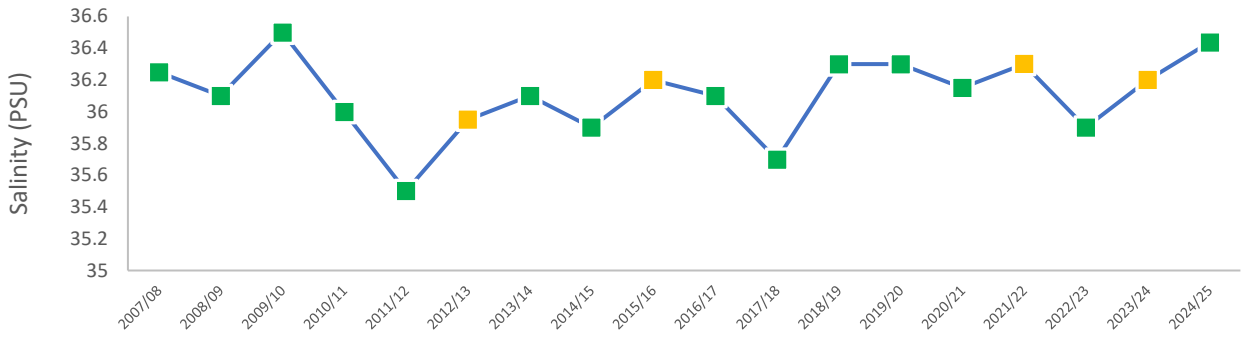
1. EQG = Environmental Quality Guideline
2. Natural salinity range refers to the salinity of the reference sites over the same period.




Notes:

1. Error bars ± 95% confidence intervals; n = 8.
2. Salinity measured ~0.5 m below the sea surface (closest measurement to 0.5 m depth taken for each distance, for each trip December 2024 – March 2025).
3. Dark blue dashed line = 80th percentile of reference sites over the same period; light blue dashed line = 20th percentile of reference sites over the same period.
4. LEPA = Low Ecological Protection Area (notional); HEPA = High Ecological Protection Area

**Figure 24 Median salinity down-current of the Swanbourne outlet 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 25 Median salinity down-current of the Swanbourne outlet**

# 4 Microbiological contaminants and algal biotoxins

## 4.1 Thermotolerant coliforms

TTC were sampled eight times over the 2024-2025 summer period (yielding a total of 40 samples). NHMRC (2008) and EPA (2005) guidelines require a minimum of 100 samples for accurate assessment of the EQC. Data from multiple years can be pooled where there are < 100 samples provided local pollution conditions have not changed (NHMRC 2008). Assuming conditions have not changed, data collected over three summers (2022-23, 2023-24 and 2024-25) were pooled to yield 120 samples.

The median concentration of TTC derived from three years of pooled samples was equal to the limit of reporting (< 10 CFU/100 mL; Table 17), meeting the EQG. Median concentration of TTC has never exceeded the limit of reporting (Figure 26). Over the three sampling periods, there were 8 instances where TTC concentration exceeded 21 CFU/100 mL, representing 6.7% of samples and thus were below the 10% criteria, meeting the EQG (Table 16 and Table 18).The percentage of samples exceeding 21 CFU/100 mL has never exceeded the 10% criteria for the past two monitoring seasons in which it has been assessed (Figure 27).

**Table 16 Environmental Quality Guideline for thermotolerant coliform concentrations**

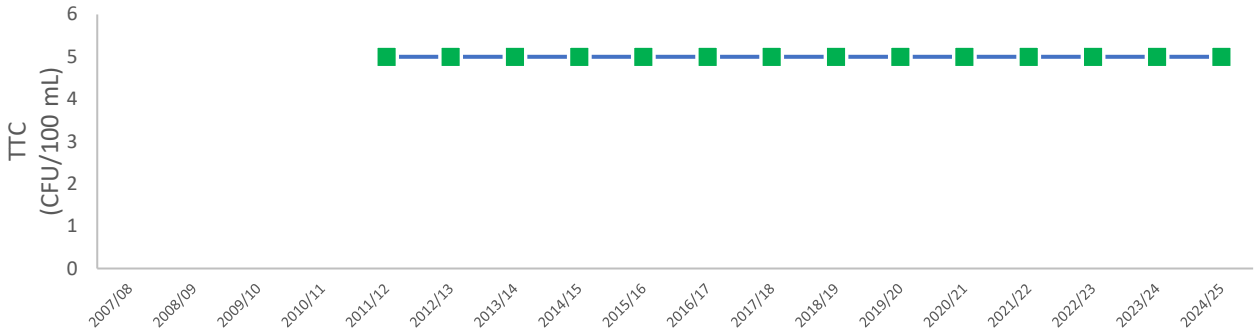
| | |
|---|---|
| **EQG[1] 1** | Median TTC[2,3] concentrations at sites at the boundary of the notional Seafood Management OZI[1] are not to exceed 14 CFU[2]/100 mL, with no more than 10% of the samples exceeding 21 CFU[2]/100 mL. |

Notes:
1. EQG = Environmental Quality Guideline.
2. OZI = Observed Zone of Influence; TTC = thermotolerant coliforms; CFU = Colony Forming Units
3. TTC concentrations are measured using the membrane filtration method.

**Table 17 Median thermotolerant coliform concentration at the boundary of the notional Seafood Management OZI for the Swanbourne outlet pooled over 2022–2025 sampling periods**

| Sampling period | Median | Compliance[1,2] |
|---|---|---|
| Dec 2022 – Mar 2023<br>Dec 2023 – Mar 2024<br>Dec 2024 – Mar 2025 | <10 CFU/100 mL |  |

Notes:
1. Green symbols indicate the Environmental Quality Criteria (EQC) were met.
2. 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.

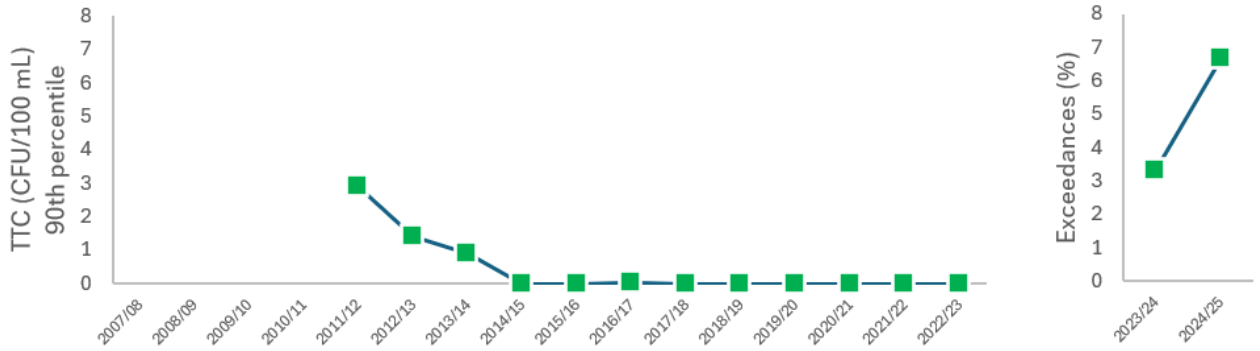
**Figure 26 Median thermotolerant coliforms**

**Table 18 Thermotolerant coliforms on the boundary of the Seafood Management Zone for Swanbourne outlet over 2022–2025 summer sampling periods that exceed 21 CFU/100 mL**

| Sampling season | Date | Site | TTC concentration (CFU/100 mL)[2] | Compliance[1] |
|---|---|---|---|---|
| Dec 2022 – Mar 23[3] | - | - | - | |
| Dec 2023 – Mar 24 | 11/01/2024 | SB22 | 30 | |
| | | SB23 | 60 | |
| | | SB24 | 100 | |
| | | SB25 | 70 | |
| Dec 2024 – Mar 25 | 4/12/2024 | SB18 | 100 | |
| | | SB19 | 100 | |
| | | SB31 | 210 | |
| | | SB32 | 80 | |
| Percentage of total samples (n = 120) > 21 CFU/100 mL = 7% | | | | |

Notes:

1. Green symbols indicate the Environmental Quality Criteria (EQC) were met.
2. TTC = thermotolerant coliforms; CFU = colony forming units
3. No TTC concentrations >21 CFU/100 mL recorded during the 2022-23 summer monitoring period.




Notes:

1. Green symbols indicate the Environmental Quality Criteria (EQC) were met.
2. Previous monitoring periods assessed the 90th percentile of TTC concentrations. Assessment of the percentage of samples with TTC concentrations >21 CFU/100 mL commenced in the 2023/24 monitoring period.

**Figure 27 Thermotolerant coliform concentrations (left, 2007/08 – 2022/23) and percentage exceedances (right, 2023/24 – 2024/25; refer to EQG 1)**

## 4.2 *Enterococci* spp.

Samples were collected eight times over the 2024-2025 summer monitoring period (yielding a total of 40 samples) for faecal indicator analyses. NHMRC (2008) guidelines and EPA (2005) require a minimum of 100 samples over the monitoring period for accurate assessment of the EQC. Data from multiple years can be pooled where there are less than 100 samples provided local pollution conditions have not changed (NHMRC 2008). Assuming conditions have not changed data from the past three summers (2022-23, 2023-24, and 2024–25) were pooled to yield 120 samples. The EQG for primary and secondary contact recreation are outlined in Table 19.

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

| | | |
|---|---|---|
| **Primary[1]** | **EQG[3] 1** | The 95th percentile bacterial content (*Enterococci* spp.) of marine waters should not exceed 200 MPN/100 mL. |
| **Secondary[2]** | **EQG[3] 1** | The 95th percentile bacterial content (*Enterococci* spp.) of marine waters should not exceed 2000 MPN/100 mL. |

Notes:

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

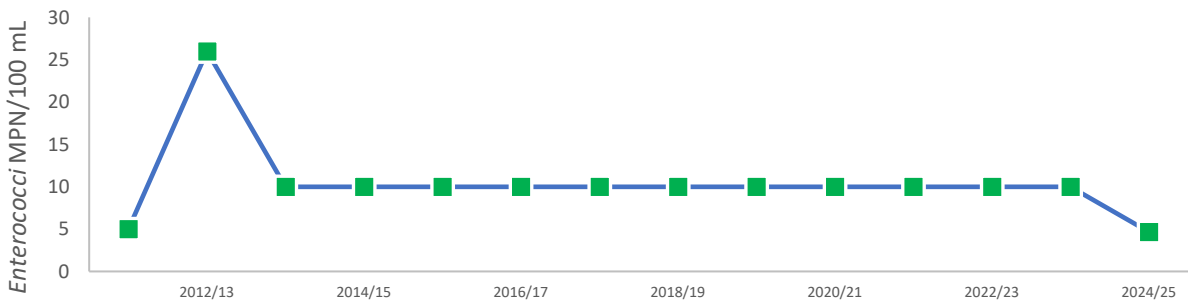
Over the previous four summers, the 95th percentile of *Enterococci* spp. concentrations at the boundary of the notional Contact Recreation Management OZI for the Swanbourne ocean outlet was below the limit of reporting at < 10 MPN/100 mL. Therefore, both primary (< 200 MPN/100 mL) and secondary (< 2,000 MPN/100 mL) contact recreation EQGs for faecal indicators were met (Table 20). The 95th percentile *Enterococci* spp. concentrations have not exceeded the EQGs historically (Figure 28).

**Table 20 The 95th percentile of *Enterococci* spp. concentrations at the boundary of the notional Contact Recreation Management OZI for the Swanbourne ocean outlet**

| Sampling period | 95th percentile[1,2] | Compliance[3,4] | |
|---|---|---|---|
| | | Primary contact | Secondary contact |
| Dec 2022 – Mar 23<br>Dec 2023 – Mar 24<br>Dec 2024 – Mar 25 | <10 MPN/100 mL | | |

Notes:

1. MPN = most probable number of *Enterococci* spp.
2. *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.
3. Green symbols indicate the Environmental Quality Criteria (EQC) were met.
4. Environmental Quality Criteria (EQC) based on EPA (2017) water quality guidelines for recreation waters.




Notes:

1. Environmental Quality Criteria (EQC): Green symbols indicate the Environmental Quality Guideline (EQG) was met.
2. *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.

**Figure 28 Historical compliance of the 95th percentile *Enterococci* spp.**

## 4.3 Toxic phytoplankton species

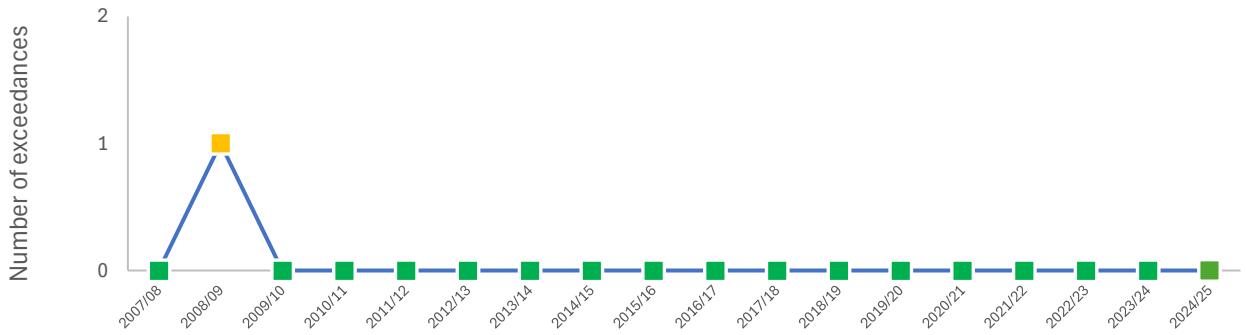
There were no instances where toxic phytoplankton species were present at densities greater than the Western Australian Shellfish Quality Assurance Program (WASQAP; DoH 2025) guideline values (Table 2) and the EQG (Table 19) for toxic phytoplankton species was met (Table 22). Toxic phytoplankton exceeding WASQAP concentrations have been present on 1 occasion historically (Figure 29).

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

| | |
|---|---|
| **EQG[1,2,3] 1** | Concentrations of potentially toxic algae in any sample at the notional Seafood Management OZI 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:<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) |

Notes:

1. EQG = Environmental Quality Guideline.
2. If this EQG is exceeded, 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) (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* groups 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.




Notes:

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

**Figure 29 Number of cell counts of toxic phytoplankton at the notional Seafood Management OZI exceeding the WAQSAP guideline (EQG)**

**Table 22 Estimated cell densities of phytoplankton species known to produce toxins**

| Date | Site | Species | Estimated density (cells/L) | WASQAP[2,4] Guideline (cells/L) | Compliance[1,3] |
|---|---|---|---|---|---|
| 04/12/2024 | SBR1 | *Pseudo-nitzschia* "*delicatissima*" group | 1,360 | 500,000 | |
| | SB1 | *Pseudo-nitzschia* "*delicatissima*" group | 8,160 | 500,000 | |
| | | *Pseudo-nitzschia* "*seriata*" group | 320 | 500,000 | |
| | SB17 | *Pseudo-nitzschia* "*delicatissima*" group | 3,920 | 500,000 | |
| | | *Pseudo-nitzschia* "*seriata*" group | 560 | 500,000 | |
| 13/12/2024 | SB2 | *Pseudo-nitzschia* "*delicatissima*" group | 1,040 | 500,000 | |
| | | *Pseudo-nitzschia* "*seriata*" group | 400 | 500,000 | |
| | SBR4 | *Pseudo-nitzschia* "*delicatissima*" group | 960 | 500,000 | |
| | SB18 | *Pseudo-nitzschia* "*delicatissima*" group | 880 | 500,000 | |
| | | *Pseudo-nitzschia* "*seriata*" group | 320 | 500,000 | |
| 08/01/2025 | SBR3 | *Pseudo-nitzschia* "*delicatissima*" group | 560 | 500,000 | |
| | SB28 | *Pseudo-nitzschia* "*delicatissima*" group | 80 | 500,000 | |
| | SB11 | *Pseudo-nitzschia* "*delicatissima*" group | 80 | 500,000 | |
| 29/01/2025 | SBR3 | *Pseudo-nitzschia* "*seriata*" group | 44,640 | 500,000 | |
| | | GK Complex (*Gymnodinium-Karenia* Complex) | 240 | 250,000 | |
| | SB28 | *Pseudo-nitzschia* "*delicatissima*" group | 5,920 | 500,000 | |
| | | *Pseudo-nitzschia* "*seriata*" group | 12,640 | 500,000 | |
| | | GK Complex (*Gymnodinium-Karenia* Complex) | 160 | 250,000 | |
| | SB11 | *Pseudo-nitzschia* "*delicatissima*" group | 7,920 | 500,000 | |

| Date | Site | Species | Estimated density (cells/L) | WASQAP[2,4] Guideline (cells/L) | Compliance[1,3] |
|---|---|---|---|---|---|
| | | *Pseudo-nitzschia* "*seriata*" group | 11,920 | 500,000 | |
| 05/02/2025 | SBR3 | *Pseudo-nitzschia* "*seriata*" group | 77,360 | 500,000 | |
| | SB12 | *Pseudo-nitzschia* "*seriata*" group | 37,200 | 500,000 | |
| | | GK Complex (*Gymnodinium-Karenia* Complex) | 240 | 250,000 | |
| | SB29 | *Pseudo-nitzschia* "*seriata*" group | 71,440 | 500,000 | |
| | | GK Complex (*Gymnodinium-Karenia* Complex) | 80 | 250,000 | |
| 19/02/2025 | SBR3 | *Pseudo-nitzschia* "*delicatissima*" group | 320 | 500,000 | |
| | | *Pseudo-nitzschia* "*seriata*" group | 1,360 | 500,000 | |
| | SB9 | *Pseudo-nitzschia* "*seriata*" group | 5,440 | 500,000 | |
| | | *Pseudo-nitzschia* "*delicatissima*" group | 4,160 | 500,000 | |
| | | GK Complex (*Gymnodinium-Karenia* Complex) | 160 | 250,000 | |
| | SB26 | *Pseudo-nitzschia* "*delicatissima*" group | 560 | 500,000 | |
| | | *Pseudo-nitzschia* "*seriata*" group | 2,080 | 500,000 | |
| | | *Dinophysis* spp. | 80 | 1000 | |
| 4/03/2025 | SBR3 | *Pseudo-nitzschia* "*delicatissima*" group | 320 | 500,000 | |
| | | *Pseudo-nitzschia* "*seriata*" group | 800 | 500,000 | |
| | SB8 | *Pseudo-nitzschia* "*seriata*" group | 1,680 | 500,000 | |
| | | *Pseudo-nitzschia* "*delicatissima*" group | 160 | 500,000 | |
| | SB22 | *Pseudo-nitzschia* "*delicatissima*" group | 2,560 | 500,000 | |

| Date | Site | Species | Estimated density (cells/L) | WASQAP[2,4] Guideline (cells/L) | Compliance[1,3] |
|---|---|---|---|---|---|
| | | *Pseudo-nitzschia* "*seriata*" group | 2,560 | 500,000 | |
| 21/03/2025 | SBR4 | *Pseudo-nitzschia* "*delicatissima*" group | 74400 | 500,000 | |
| | | *Pseudo-nitzschia* "*seriata*" group | 17840 | 500,000 | |
| | SB16 | *Pseudo-nitzschia* "*delicatissima*" group | 40160 | 500,000 | |
| | | *Pseudo-nitzschia* "*seriata*" group | 20800 | 500,000 | |
| | SB32 | *Pseudo-nitzschia* "*delicatissima*" group | 28240 | 500,000 | |
| | | *Pseudo-nitzschia* "*seriata*" group | 10400 | 500,000 | |

Notes:

1. Samples were analysed for one monitoring site and one reference site per sampling occasion. Reference results are not applicable (N/A) to compliance.
2. Marine Biotoxin Monitoring and Management Plan 2025 version 5: Western Australian Shellfish Quality Assurance Program (WASQAP) (DoH 2025).
4. Green symbols indicate the Environmental Quality Criteria (EQC) were met; amber symbols represent an exceedance of the EQG.
5. *Karenia/Karlodinium/Gymnodinium* group trigger for DoH (2025)

## 4.4 Phytoplankton cell concentrations

The concentrations of phytoplankton cells are compared to the EQC for toxic algae in marine recreational water. Table 23 presents the specific EQC values for toxic algae in marine recreational water as outlined in EPA (2017).

**Table 23 Environmental Quality Guideline for phytoplankton cell count**

| | |
|---|---|
| **EQG[1] 1** | The phytoplankton cell count from a single site should not exceed 10,000 cells/mL; or detect the Department of Health (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) |

Note:
1. EQG = Environmental Quality Guideline.

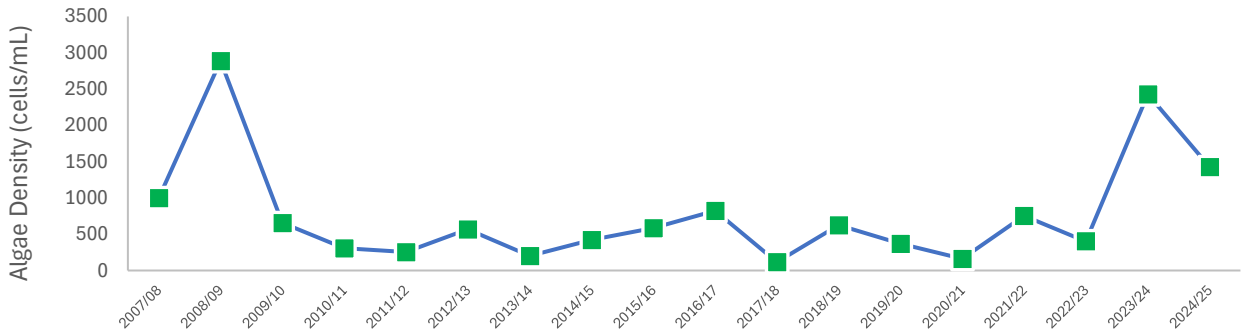
The density of phytoplankton was below 10,000 cells/mL at each of the individual monitoring sites during the 2024/25 monitoring period (Table 24). The EQG for phytoplankton concentrations was met. Historically, algal cell density has not exceeded the EQG criteria (Figure 30).

No DoH algal watchlist species were detected at levels exceeding their trigger values during the 2024-25 extended summer monitoring period, meeting the EQG (Table 25; Figure 33). Additionally, Water Corporation did not receive any reports from DoH concerning skin or eye irritation, or potential algal poisoning in swimmers at Swanbourne during the monitoring period, thus meeting the EQG (Figure 34).

**Table 24 Estimated phytoplankton total cell densities collected at fixed monitoring sites for contact recreation down-current of the Swanbourne outlet**

| Date | Site | Total density (cells/mL) | Compliance[1] |
|---|---|---|---|
| 04/12/2024 | SB17 | 199 | |
| 13/12/2024 | SB2 | 221 | |
| 08/01/2025 | SB18 | 7 | |
| 29/01/2025 | SB11 | 116 | |
| 05/02/2025 | SB29 | 1,428 | |
| 19/02/2025 | SB9 | 52 | |
| 4/03/2025 | SB8 | 32 | |
| 21/03/2025 | SB32 | 877 | |

Notes:
1. Green symbols indicate the Environmental Quality Criteria (EQC) were met.




Notes:

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

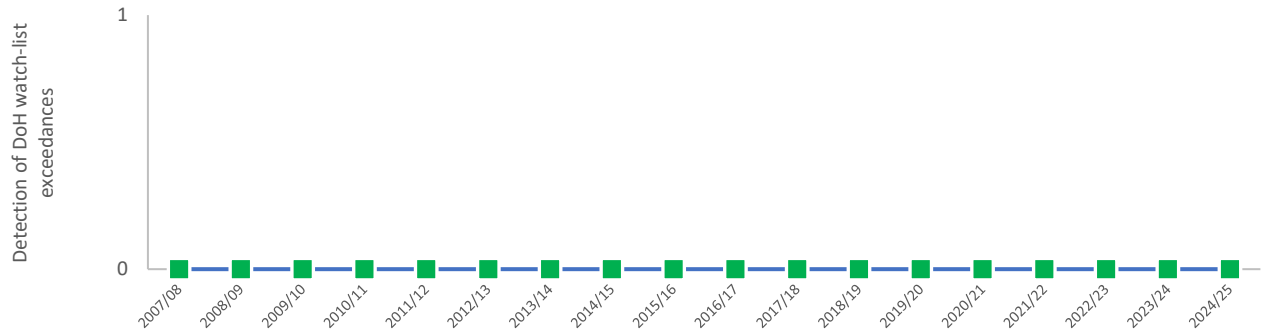
**Figure 30 Median algal cell density**

**Table 25 Estimated cell densities of DoH watch-list phytoplankton species at Swanbourne outfall sites**

| Date | Site[2] | Species[3] | Estimated density (converted to cells/mL)[4,5] | DoH Guideline[3] (cells/mL) | Compliance[1] |
|---|---|---|---|---|---|
| 4/12/2024 | N/A | No watch-list species detected. | - | - | |
| 13/12/2024 | N/A | No watch-list species detected. | - | - | |
| 8/01/2025 | N/A | No watch-list species detected. | - | - | |
| 29/01/2025 | N/A | No watch-list species detected. | - | - | |
| 5/02/2025 | SBR3 | *Trichodesmium* spp. | 0.16 | 5,000 | |
| | SB-12 | *Trichodesmium* spp. | 0.08 | 5,000 | |
| | SB-29 | *Trichodesmium* spp. | 0.16 | 5,000 | |
| 19/02/2025 | SB-9 | *Trichodesmium erythraeum* | 0.24 | 5,000 | |
| | SB-26 | *Trichodesmium erythraeum* | 0.08 | 5,000 | |
| 4/03/2025 | SB-8 | *Trichodesmium erythraeum* | 0.08 | 5,000 | |
| | SB-22 | *Trichodesmium erythraeum* | 0.16 | 5,000 | |
| 21/03/2025 | SBR4 | *Trichodesmium erythraeum* | 0.64 | 5,000 | |
| | SB-16 | *Trichodesmium erythraeum* | 0.40 | 5,000 | |
| | SB-32 | *Trichodesmium erythraeum* | 0.72 | 5,000 | |

Notes:

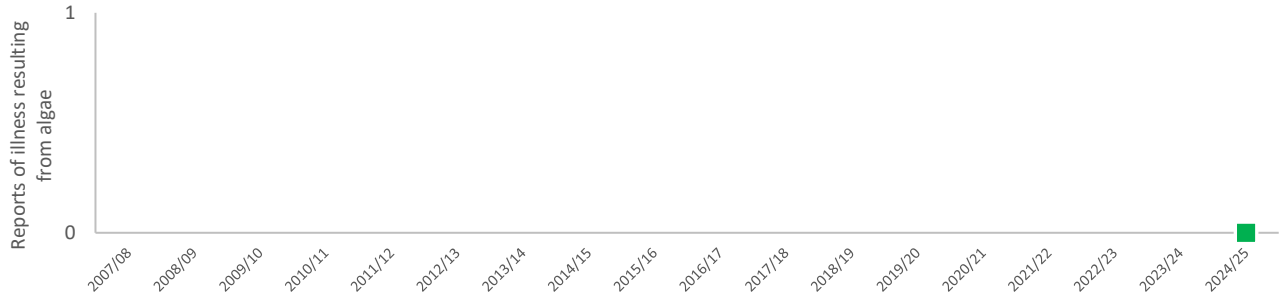
1. Green symbols indicate the Environmental Quality Criteria (EQC) were met.
2. Samples were analysed for one monitoring site and one reference site per sampling occasion.
3. Department of Health watch-list species (DoH 2022).
4. Cell density has been converted from cells/L used in laboratory reports to cells/mL for assessment against the guidelines.
5. Limit of reporting = 80 cells/L (0.008 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.

**Figure 31 Detections of DoH (2022) watch-list species in exceedance of guideline values**




Note:

1. Environmental Quality Criteria (EQC): Green symbols indicate the Environmental Quality Guideline (EQG) was met.
2. Monitoring for this EQC commenced in the 2024/25 summer monitoring period.
3. Reports are received via the Department of Health

**Figure 32 Reports from DoH of skin or eye irritation, or potential algal poisoning in swimmers (when less than 10,000 cells/mL is present in the water column).**

# 5 Shoreline Monitoring

## 5.1 Thermotolerant coliforms

Water Corporation conducts additional TTC monitoring along the shoreline. These results are informally assessed against the EQC (Table 26).

TTC were sampled at eight shoreline monitoring sites eight times over the 2024/25 summer period (yielding a total of 64 samples). NHMRC (2008) guidelines and EPA (2005) recommend that a minimum of 100 samples is required for accurate assessment of the EQG. Data from multiple years can be pooled where there are <100 samples, provided local pollution conditions have not changed (NHRMC 2008). Assuming conditions have not changed, data collected over three summers (summer 2023/24 and 2024/25) were pooled to yield 128 samples.

**Table 26 Informal Environmental Quality Guideline for Thermotolerant Coliforms at shoreline monitoring sites**

| | |
|---|---|
| **EQG[1] 1** | Median TTC[2,3] concentrations at the shoreline monitoring sites for the Swanbourne outlet are not to exceed 14 CFU[2]/100 mL, with no more than 10% of the samples exceeding 21 CFU[2]/100 mL. |

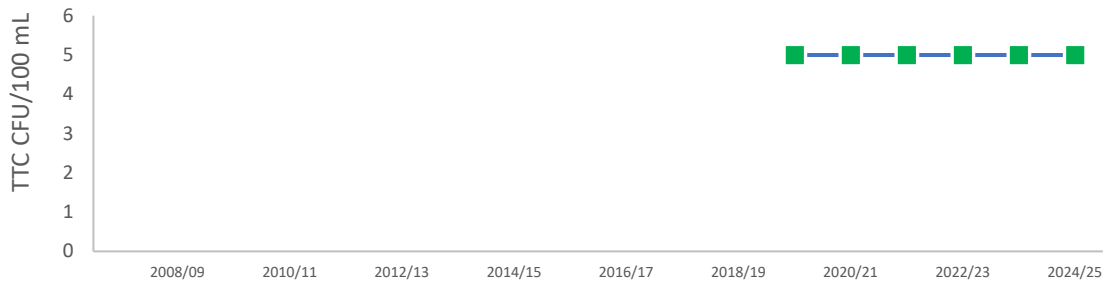
Notes:
1. EQG = Environmental Quality Guideline.
2. OZI = Observed Zone of Influence; TTC = thermotolerant coliforms; CFU = Colony Forming Units
3. TTC concentrations are measured using the membrane filtration method.

The shoreline sites are not formally assessed against the EQC but the median and 90$^{th}$ percentile TTC concentrations derived from the 128 samples was <10 CFU/100 mL and less than the 14 and 21 CFU/100 mL criteria, respectively meeting the EQG (Table 16; Table 27). Median thermotolerant coliforms in shoreline samples were <10 CFU/100 mL since shoreline monitoring commenced (Figure 33). There were 3 instances TTC concentrations exceeded 21 CFU/100 mL, representing 2.3% of samples and therefore below the 10% exceedance criteria (Table 27). Since 2020/21, TTC concentrations exceeding 21 CFU/100 mL were below the 10% criteria at all times (Figure 34).

**Table 27 Median thermotolerant coliform concentrations at the shoreline monitoring sites for the Swanbourne outlet pooled over for 2023–2025 sampling periods**

| Sampling period | Median[3] | Compliance (EQG)[1,2,4] |
|---|---|---|
| Dec 2023 – Mar 24<br>Dec 2024 – Mar 25 | <10 CFU/100 mL | |

Notes:
1. CFU = Colony Forming Unit
2. Green symbols indicate the Environmental Quality Guideline (EQG) were met.
3. Thermotolerant coliform results below the limit of reporting (<10 CFU/100 mL) were halved (= 5 CFU/100 mL) to calculate the median.
4. Environmental Quality Criteria are based on EPA (2017).




Notes:

1. Environmental Quality Criteria (EQC): Green symbols indicate the Environmental Quality Guideline (EQG) was met.
2. Thermotolerant coliform results below the limit of reporting (<10 CFU/100 mL) were halved (= 5 CFU/100 mL) to calculate the median.
3. CFU = Colony Forming Unit
4. Sampling commenced in 2020-2021.

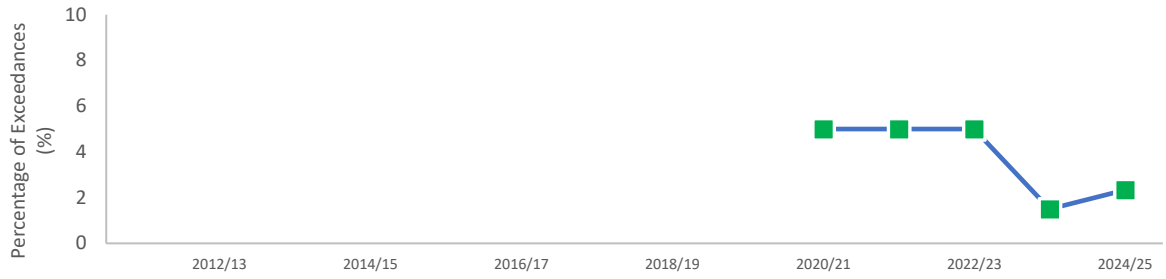
**Figure 33 Median thermotolerant coliforms at shoreline monitoring sites**

**Table 28 Thermotolerant coliforms at the shoreline monitoring sites for the Swanbourne outlet over 2024–2025 summer sampling periods that exceed 21 CFU/100 mL**

| Sampling season | Date | Site | TTC concentration (CFU/100 mL)[2] | Compliance[1] |
|---|---|---|---|---|
| Dec 2023 – Mar 2024 | - | - | - | |
| Dec 2024 – Mar 2025 | 4/12/2024 | SBSL2 | 30 | |
| | | SBSL3 | 310 | |
| | | SBSL4 | 100 | |
| % total samples (n= 128) >21 CFU/100 mL = 2.34% | | | | |

Notes:

1. Green symbols indicate the Environmental Quality Criteria (EQC) were met.
2. TTC = thermotolerant coliforms; CFU = colony forming units
3. No TTC concentrations >21 CFU/100 mL recorded during the 2023-24 summer monitoring period.




Notes:

1. Green symbols indicate the Environmental Quality Criteria (EQC) were met.
2. Sampling commenced in 2020-21

**Figure 34 Percentage of samples exceeding 21 CFU/100 mL at shoreline monitoring sites**

## 5.2 *Enterococci* spp.

Water Corporation conducts additional *Enterococci* spp. monitoring along the shoreline. These results are informally assessed against the EQC (Table 29).

Samples were collected eight times at eight shoreline monitoring sites over the 2024-2025 summer monitoring period (yielding a total of 64 samples) for analysis of faecal indicators. NHMRC guideline and EPA (2005) recommend that a minimum of 100 samples over the monitoring period are required for accurate assessment of the EQC. Data from multiple years can be pooled where there are < 100 samples provided local pollution conditions have not changed (NHRMC 2008). Assuming conditions have not changed, data collected over two summers (2023–2024 and 2024-2025) were pooled to yield 128 samples.

Shoreline sites are not formally assessed against the EQC but over the 2024–2025 summer monitoring period, the 95$^{th}$ percentile of *Enterococci* spp. concentrations at the shoreline monitoring sites for the Swanbourne ocean outlet was 52 MPN/100 mL (Table 30), and below both the primary and secondary (< 200 and < 2,000 MPN/100 mL, respectively) contact recreation EQGs (Table 29). The 95$^{th}$ percentile *Enterococci* spp. concentrations at the shoreline monitoring sites were at the limit of reporting at all other times, except 2023-2024, since monitoring began (Figure 35).

**Table 29 Informal Environmental Quality Guideline for *Enterococci* spp. at shoreline monitoring sites**

| | | |
|---|---|---|
| **Primary[2]** | **EQG[1]1** | The 95$^{th}$ percentile bacterial content (*Enterococci* spp.) of marine waters should not exceed 200 MPN/100 mL. |
| **Secondary[3]** | **EQG[1]1** | The 95$^{th}$ percentile bacterial content (*Enterococci* spp.) of marine waters should not exceed 2,000 MPN/100 mL. |

Notes:

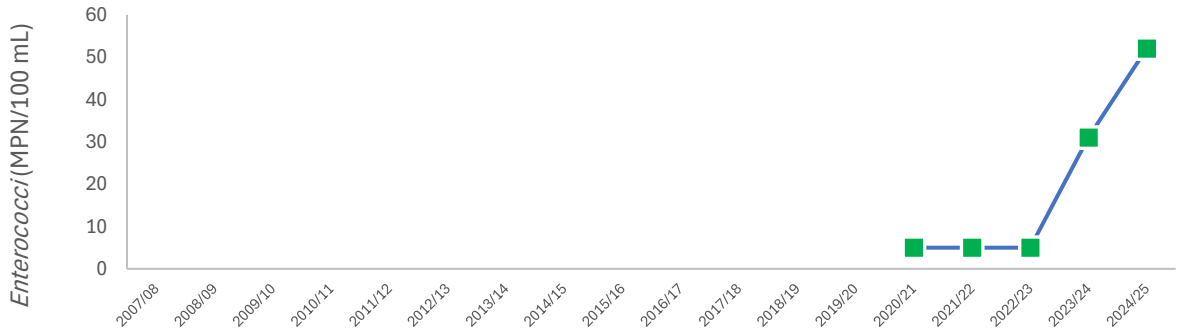
1. EQG = Environmental Quality Guideline.
2. Primary contact recreation = activities where humans are in direct contact with the water (e.g. swimming, snorkelling and diving).
3. Secondary contact recreation = activities where humans are in secondary contact with the water (e.g. boating and fishing).

**Table 30 The 95th percentile of *Enterococci* spp. concentrations at the shoreline monitoring sites for the Swanbourne ocean outlet pooled over the 2023–2025 sampling periods**

| Sampling period | 95th percentile[1,2] | Informal comparison to the criteria[1,3,4] | |
|---|---|---|---|
| | | Primary contact | Secondary contact |
| Dec 2023 – Mar 24<br>Dec 2024 – Mar 25 | 52 MPN/100 mL | | |

Notes:

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




Notes:

1. Environmental Quality Criteria (EQC): Green symbols indicate the Environmental Quality Guideline (EQG) was met; amber and red symbols represent an exceedance of the EQG or Environmental Quality Standard (EQS), respectively
2. Sampling commenced in 2020-2021.

**Figure 35 95th percentile *Enterococci* spp. concentrations at shoreline monitoring sites**

# 6 Aesthetics

Aesthetic quality was assessed on each field sampling event via a questionnaire completed by field personnel on eight occasions during the non-river flow period (Table 31; Table 32). On each occasion, the questionnaire was completed at one location on the recreation contact boundary down-current of the outlet. Water clarity around the outlet (mean LAC at 350 m from the diffuser, pooled from all days) was compared against water clarity at a greater distance from the outlet (mean LAC at 1,500 m from the diffuser from all days pooled) to assess whether aesthetic differences exist. Water Corporation also maintains a complaints register for the Swanbourne PLOOM program.

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

| Indicator | Environmental Quality Criteria | |
|---|---|---|
| | EQG | EQS |
| Nuisance organisms | Macrophytes, phytoplankton scums, filamentous algal mats, blue-green algae and sewage fungus should not be present in excessive amounts. | There should be no overall decrease in the aesthetic water quality values of the marine receiving environment |
| 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. | |

The field surveys found algae/plant material visible on the surface on seven (87.5% of) occasions (Table 32). No dead marine organisms were visible on any occasion (Table 32). There was noticeable colour variation on two (12.5% of) occasions (Table 32). There were no films or oil on the surface, noticeable odour or floating debris on any sampling occasion (Table 32). There was no overall decrease in the aesthetic water quality values of Swanbourne.

Mean LAC at 1,500 m from the ocean outlet (0.092 $m^{-1}$) was slightly higher than at 350 m from the outlet (0.085 $m^{-1}$) suggesting that light was more quickly attenuated at 1,500 m than 350 m (Table 33). Overall water clarity was decreased by ~9% and therefore the EQG that the natural visual clarity of the water should not be reduced by more than 20% was met.

**Table 32 Aesthetic observations and measurements near the Swanbourne ocean outlet from December 2024 to March 2025.**

| Date | Site | Algae/plant material? | Dead marine organisms? | Secci depth (m) | Colour variation? | Oil or other films? | Floating debris? | Odour? | Cotton buds? |
|---|---|---|---|---|---|---|---|---|---|
| 4/12/2024 | SB1 | Yes (seagrass) | No | 4.1 | No | No | No | No | No |
| 13/12/2024 | SB1 | Yes (seagrass) | No | 7.5 | No | No | No | No | No |
| 08/01/2025 | SB4 | Yes (seagrass) | No | 9.3 | No | No | No | No | No |
| 29/01/2025 | SB13 | Yes (seagrass) | No | 10.5 | No | No | No | No | No |
| 5/02/2025 | SB13 | Yes (wrack) | No | 5.2 | Yes | No | No | No | No |
| 19/02/2025 | SB9 | Yes (seagrass/wrack) | No | 12 | No | No | No | No | No |
| 4/03/2025 | SB7 | No | No | 8.5 | No | No | No | No | No |
| 21/03/2025 | N/A | Yes (seagrass) | No | 6.8 | No | No | No | No | No |

**Table 33 Light attenuation coefficient at sites 350 m and 1500 m from the Swanbourne ocean outlet from December 2024 to March 2025.**

| Date | Light attenuation coefficient ($m^{-1}$) | |
|---|---|---|
| | 350 m (site SBT-350 m) | 1500 m (site SBT – 1500 m) |
| 4/12/2024 | 0.109 | 0.117 |
| 13/12/2024 | 0.070 | 0.088 |
| 08/01/2025 | 0.072 | 0.080 |
| 29/01/2025 | 0.074 | 0.078 |
| 5/02/2025 | 0.121 | 0.140 |
| 19/02/2025 | 0.071 | 0.073 |
| 4/03/2025 | 0.077 | 0.069 |
| 21/03/2025 | 0.082 | 0.091 |
| **Mean** | **0.085** | **0.092** |

# 7 References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