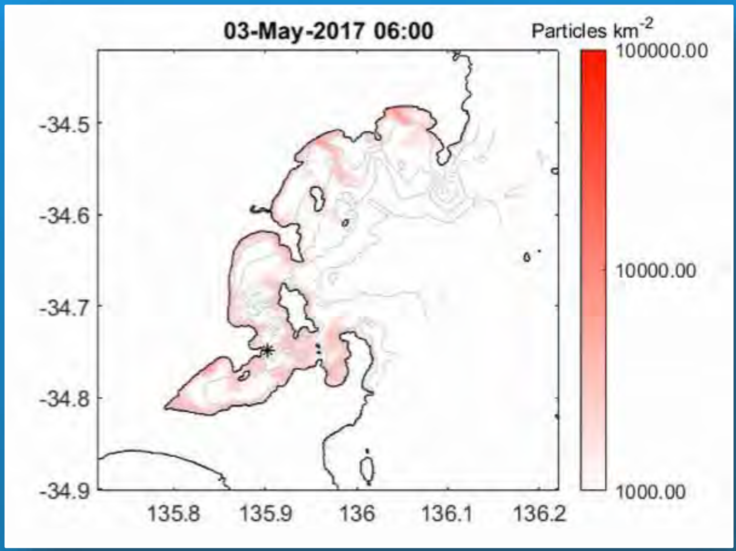
Appendix K SARDI Particle Tracking Update Report

Marine Ecosystems

Addendum: oceanographic modelling of larval connectivity to inform desalination in Boston Bay



M. Doubell and C. James

SARDI Publication No. F2022/000347-1
SARDI Research Report Series No. 1165

SARDI Aquatic and Livestock Sciences
PO Box 120 Henley Beach SA 5022

May 2024

Report to SA Water

Government of South Australia
Department of Primary Industries and Regions

SA Water

SARDI
South Australian Research and Development Institute

Addendum: oceanographic modelling of larval connectivity to inform desalination in Boston Bay

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The South Australian Research and Development Institute respects Aboriginal people as the state's first people and nations. We recognise Aboriginal people as traditional owners and occupants of South Australian land and waters. We pay our respects to Aboriginal cultures and to Elders past, present and emerging.

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ACKNOWLEDGEMENTS

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This report was reviewed by Professor Simon Goldsworthy (SARDI Marine Ecosystems Program Leader) and approved and cleared for release by Dr Mike Steer, Research Director, SARDI Aquatic and Livestock Sciences.

EXECUTIVE SUMMARY

This addendum provides an update to the larval tracking studies of Doubell and James (2023). New larval tracking results are presented to establish the possible effect of Stokes drift on entrainment by desalination intakes in the region. In addition, an update to the original larval tracking has been undertaken for a new intake site located near Billy Lights Point.

Following the approach and assumptions presented in Doubell and James (2023), the results show that the inclusion of Stokes drift in combination with the constraining of particles to the ocean's surface layer could significantly alter the predicted particle trajectories but had negligible effect on connectivity with intakes, with less <0.1% of the total number of particles released each spawning season estimated to be entrained into an intake area with a radius of 25m.

For the new intake location near Billy Lights Point less than 0.1% of the total number of particles released each spawning season were estimated to be at risk of entrainment into an intake area with radius of 25m. At smaller spatial scales, connectivity mapping with source locations showed that up to 0.6 % of particles released from locations within 2 km of the new intake location between Billy Lights Point and Kirton Point may be at risk of entrainment. The risk of entertainment decreased with distance from the intake, with the percentage of particles likely to be at risk of entrainment from source regions across Proper Bay and Boston Bay estimated to be less than 0.4 %.

The additional results presented here are consistent with the levels of connectivity and entrainment provided by Doubell and James (2023).

Keywords: hydrodynamic model, larval transport, desalination, dispersal, connectivity.

1. INTRODUCTION

1.1. Background

Doubell and James (2023) modelled the connectivity of blue mussel larvae to better understand the potential larval losses due to entrainment for several proposed desalination plant intake locations. The biophysical modelling simulations provided the first study of blue mussel larval transport pathways in the region. The estimated level of larval connectivity with the proposed intakes was low, with less than 0.1% of the total number of particles released throughout the spawning season estimated to be entrained in an intake area with radius of 25m.

Following the publication of Doubell and James (2023) concerns were raised by some critics that the influence of surface wave-induced transport due to Stokes drift (e.g., Feng et al. 2011) may significantly alter the entrainment estimates and were not considered. Although this would be unlikely unless the larvae remained on the surface (acting essentially as a surfactant like an oil slick), this addendum provides new larval tracking results to demonstrate effect of Stokes drift on entrainment of particles by previously proposed intakes in the region for both passive and surfactant examples. In addition, an update to the original larval tracking has been undertaken for a new intake site located near Billy Lights Point (BLP) (Table 1-1, Figure 1-1).

Table 1-1. Location of desalination plant intakes investigated in this study.

Site Name	Intake	
	Longitude (°E)	Latitude (°S)
Billy Lights Point – inshore	135.8855	34.7558
Billy Lights Point – extension	135.8968	34.7484
Point Boston – inshore	135.9460	34.6158
Billy Lights Point – inshore new	135.8983	34.7468

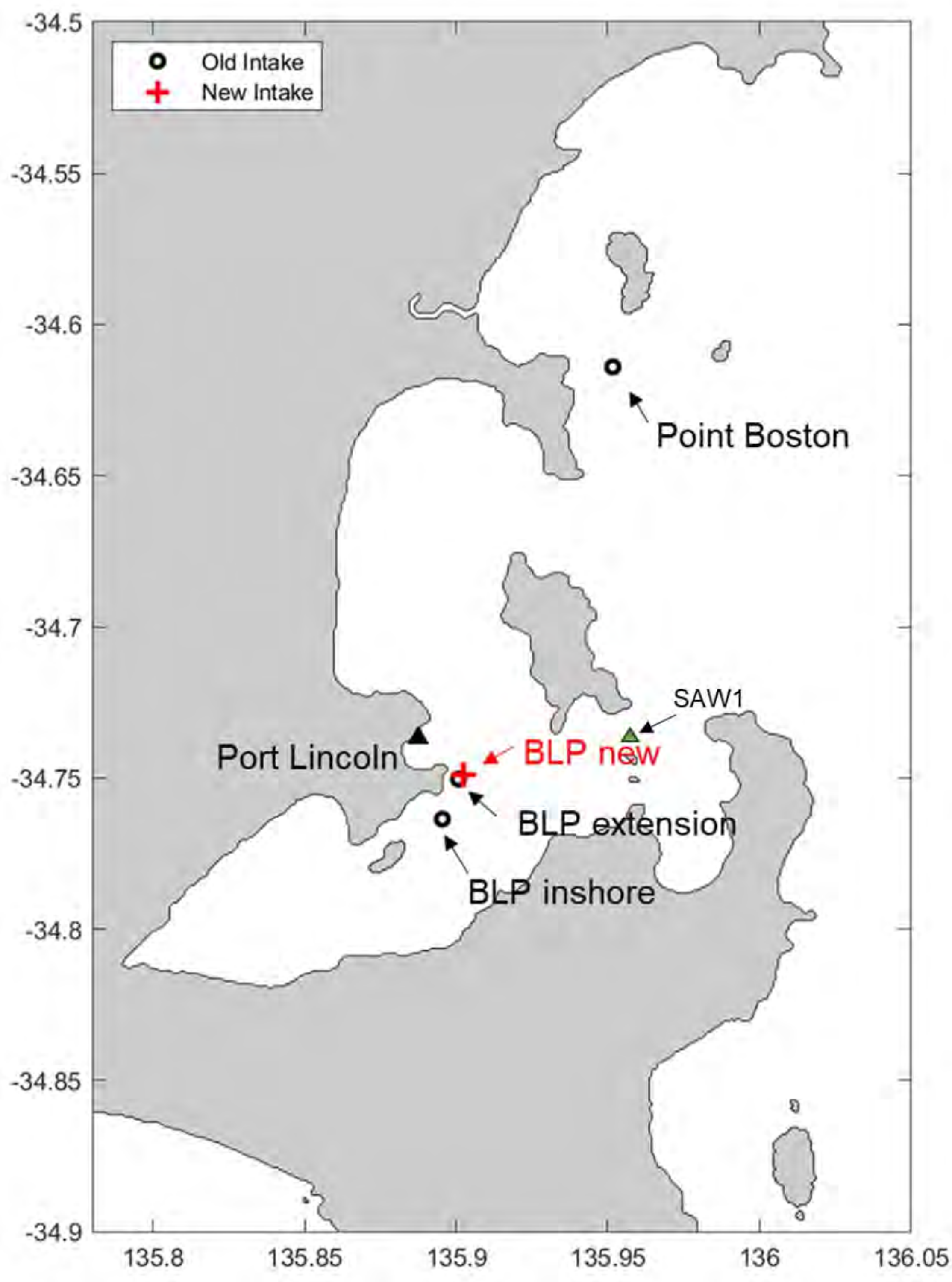

Figure 1-1. Map of the Port Lincoln region showing the location of the previously modelled proposed intake locations (black markers) and the new intake location (red marker) near Billy Lights Point (BLP). The oceanographic mooring was located at SAW1.

1.2. Objectives

The project objectives were to:

1. Use the coupled hydrodynamic and larval transport model developed by Doubell and James (2023) to establish the effect of Stokes drift on estimates of larval entrainment.
2. Use the coupled hydrodynamic and larval transport model developed by Doubell and James (2023) to update the estimates of larval entrainment for a new intake location.

2. METHODS

2.1. Ocean modelling system

In this study, a high-resolution three-dimensional hydrodynamic model was used for the Port Lincoln region to drive a particle tracking model to understand the far-field connectivity of planktonic mussel larvae with proposed intake locations. Details regarding the configuration and validation of the hydrodynamic and particle tracking models were presented in Doubell and James (2023). In summary, a 2-way nested high-resolution hydrodynamic model for Boston Bay (HRBBM) was embedded within the 1.5 km resolution Two Gulfs model (TGM) for Spencer Gulf and Gulf Saint Vincent using the open-source Regional Ocean Modelling System (ROMS, https://www.myroms.org/). The HRBBM has a horizontal spatial resolution of 300m and 15 sigma levels in the vertical. Lateral boundary conditions and interior solutions for the HRBBM are exchanged with the TGM and the model was run with a time-step of 40 s.

Both the TGM and HRBBM were forced with pressure, wind, humidity, heat-fluxes, and precipitation from global atmospheric models provided by the NCEP Climate Forecast System Reanalysis v.2 (Saha et al. 2014). Tidal forcing was provided by the global TPXO8 model (Erofeeva & Egbert 2014). Lateral oceanic boundary conditions and initial fields for TGM (i.e., temperature, salinity, currents, and sea level) were provided by the 10 km resolution Ocean Forecast Australia Model (OFAM). CSIRO's Blue Link Reanalysis 2020 (BRAN2020; Oke et al., 2013) was used for modelling the period from July 2015 to June 2021. A six-month model spin-up was run, using BRAN-derived initial conditions, from 1 July 2015 to 1 January 2016 to provide artefact-free initial conditions for the hindcast simulations. The Smagorinsky scheme (Smagorinsky, 1963) was used to calculate the horizontal eddy viscosity, and a constant horizontal tracer diffusion of 2 m^2/s was used for temperature and salt. The k-profile parameterisation of Large et al. (1994) was used for vertical diffusion and mixing. A quadratic bottom stress formulation was assumed with a bottom roughness length of 2 cm. Improvement to the model sea surface temperature (SST) was achieved by adjusting the heat-fluxes using remote sensed SST provided by the Level 4 Multi-scale Ultra-high Resolution (MUR) SST Analyses (Chin et al. 2017).

2.2. Particle tracking modelling

Larval transport was simulated using the larval transport particle tracking model (LTRANS; North et al. 2006; 2008). In summary, LTRANS uses hourly outputs from the ROMS hydrodynamic model to track the trajectories of particles in three dimensions. As described by North et al. (2008), LTRANS considers particle advection, vertical and horizontal turbulent particle motions and applies reflective boundary conditions. Current predictions from the HRBBM were interpolated in both space and time using an internal LTRANS time step of 120 seconds. Particle transport is simulated using a 4th order Runge-Kutta scheme for advection and a random displacement model to account for sub-grid scale turbulence on particle motions (Laurent et al., 2020). The horizontal diffusivity was assumed to be constant and was set at 1 $m^2 s^{-1}$. A logarithmic reduction in current velocities is implemented to simulate the influence of bottom friction on currents.

2.3. Effect of Stokes drift

To examine the effects of surface wave-induced transport, an effect known as Stokes drift, on particle trajectories and connectivity with desalination intakes model simulations with and without Stokes drift for three consecutive spawning seasons (2016, 2017, 2018) were compared. Since the waves in Boston Bay are almost entirely wind generated, with wave periods generally below 3 seconds and wave heights below 1 m (Figure 2-1), Stokes drift was applied using the wind-drift method described in Callies et al., (2017) based on a direct wind-drag, equivalent to 0.6% of the 10m wind applied across the surface layer of the model.

Simulations without Stokes drift followed those presented in Doubell and James (2023) for purely passive particles (i.e., neutrally buoyant, without vertical behaviour). Simulations with Stokes drift included two scenarios. In the first scenario the particles were assumed to be purely passive and could be mixed vertically throughout the water column. In the second scenario, since the effects of Stokes drift on larval transport are limited to organisms located near the surface (e.g., Monismith and Fong, 2004), particles were kept on the surface for the entire simulation.

Following the method of Doubell and James (2023), for each scenario and spawning season (May to September) particles were tracked until they exited the model domain or passed within a radius of 1 km of the previously proposed desalination intake locations (Figure 1; BLP inshore, BLP extension and Point Boston). The monthly spawning events lasted 5-days and involved the daily release of 10 particles from the HRBBM grid cells within 1 km of the coast (Figure 2-2). To estimate the percentage of particles with connectivity to the different intake pipe locations with a potential entrainment radius of 25 m, the total proportion of particles released during each spawning season with connectivity to within 1 km of the intake was downscaled by adjusting for the reduced cross-sectional area of the entrainment zone (i.e., $\pi 25^2/\pi 1000^2$).

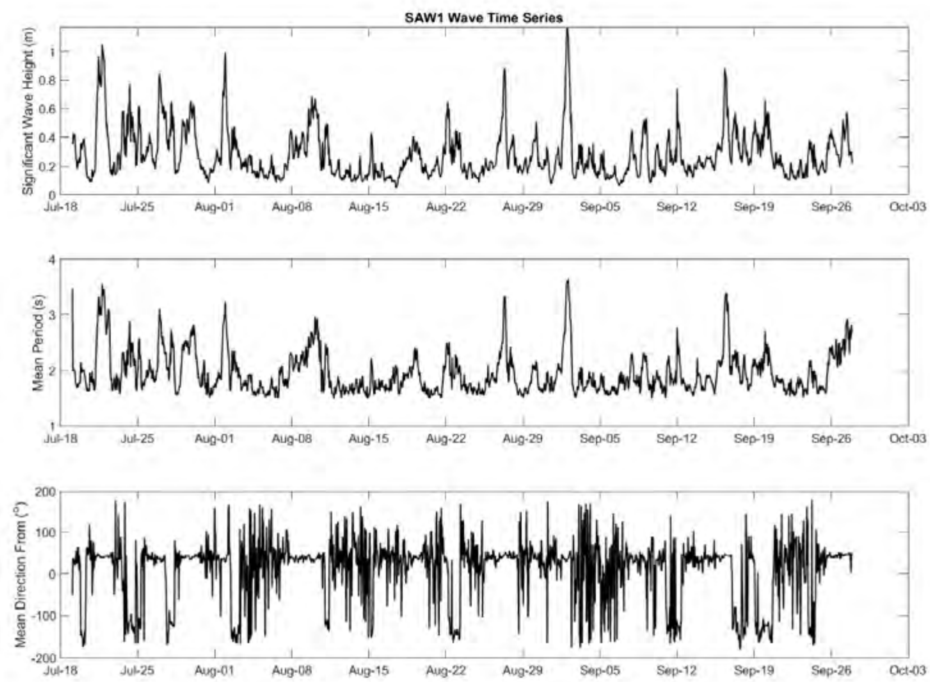

Figure 2-1. Wave observations taken at Site SAW1 using wave monitoring ADCP.

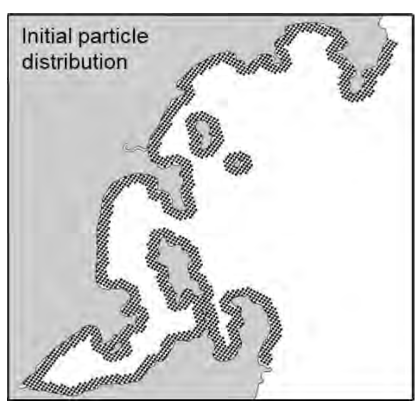

Figure 2-2. Initial distribution of particles corresponding to location model grid cells within 1 km of the coast.

2.4. Connectivity with the new proposed intake location

The new proposed intake location provided by SA Water near Billy Lights Point is located approximately 230 m north of the previously modelled Billy Lights Point extension location (Figure 1-1). The modelling approach followed that described in Doubell and James (2023), with connectivity assessed over three consecutive spawning seasons (2016, 2017, 2018). Vertical advection and turbulent mixing were improved using the values computed within the HRBBM. Based on recent sensitivity studies (Mitchell et al., 2023) the number of particles released per day in each grid cell was increased from 10 to 100 to improve the statistical confidence in the results and to allow tracking to within 300m of the intake. In total, 883,500 particles were released during each monthly spawning event, with a total of 4,417,500 released per spawning season, or 13,252,500 particles released over the three seasons.

3. RESULTS

3.1. Effect of Stokes drift

The inclusion of Stokes drift resulted in differences in the predicted particle distributions, but only when the particles were constrained to the ocean surface (Figure 3-1). Differences in particle distributions between simulations with and without Stokes drift for passive particles were negligible because only a small proportion of particles are in the surface layer at any given point in time. Figure 3-2 shows that for all scenarios <0.1% of the total number of particles released per spawning season were estimated to be entrained in an intake area with radius of 25 m. This demonstrated that the inclusion of Stokes drift made negligible difference to the predicted levels of entrainment. For the case of surface trapped particles, the inclusion of the Stokes wind-drift led to decreased connectivity in 6 of the 9 cases, and significantly less connectivity in 4 cases (Figure 3-2), presumably due to increased flushing by the wind-drift.

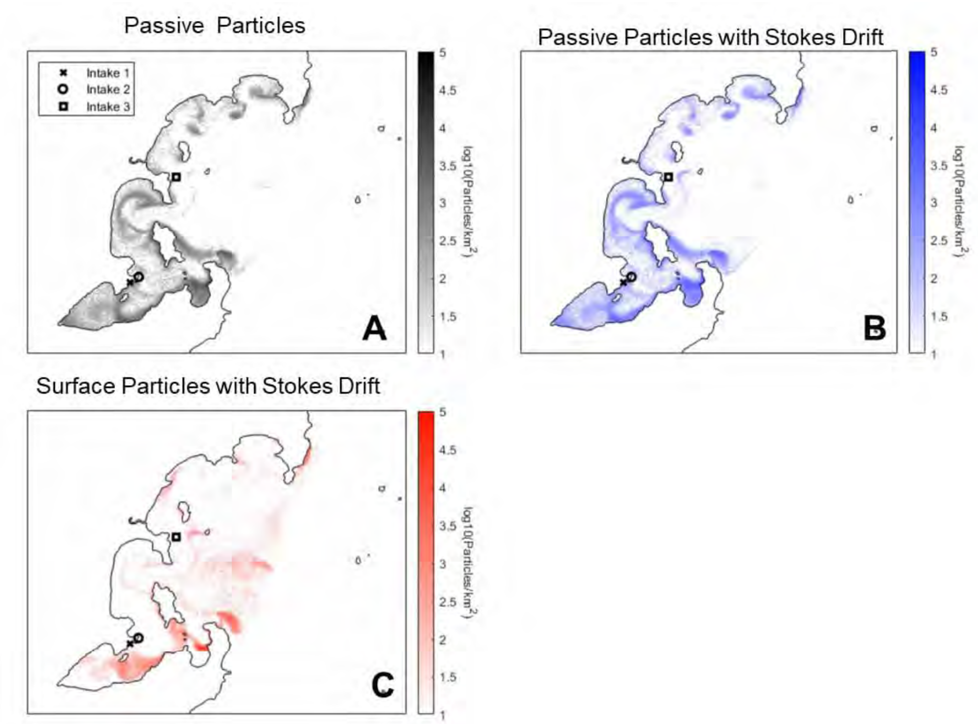

Figure 3-1. Example snapshot the particle distributions (particle densities) on 7 May 2018, modelled under different model scenarios (A) passive particles without Stokes drift, (B) passive particles with Stokes drift, and (C) with particles constrained to the ocean surface with Stokes drift. Intake locations for Billy Lights Point (BLP) inshore (intake 1), BLP extension (intake 2) and Point Boston (intake 3) are provided in the legend.

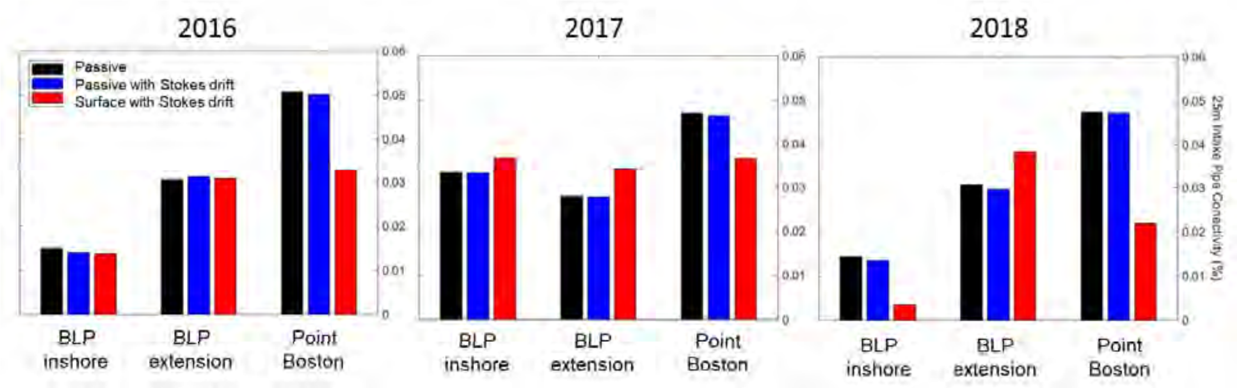

Figure 3-2. Comparison of the estimated percentage of particles (representative of larvae) released per spawning season (2016-2018) which came within 25m radius of intakes for the three scenarios studies (i) passive particles with no Stokes drift, (ii) passive particles with Stokes drift and (iii) particles held in the surface layer with Stokes drift. The intake locations corresponded to the Billy Lights Point (BLP) inshore, BLP extension, and Point Boston locations shown in Figure 1-1.

3.2. Connectivity with the new intake location

Figure 3-3 shows a snapshot of the predicted particle distributions on 30 September at the end of each spawning season for the years 2016-2018. Inter-annual differences in the local circulation patterns driven by winds result in different spatial distribution of particles from year to year. Regardless of these differences, for all seasons <0.1% of the total number of particles released per spawning season was estimated to be entrained into an intake area with a radius of 25m.

The percentage of particles from each source location estimated to arrive within a radius of 25 m of the new intake location for each spawning season, as well as the composite map averaged over the three spawning seasons, is shown in Figure 3-4. Spatial connectivity with the intake is estimated to be greatest within approximately 2 km of the intake and is concentrated on the region between Billy Lights Point and Kirton Point. At these scales, approximately 0.6% of the total number of particles released each spawning season were estimated to arrive within 25 m radius of the new intake location. Small differences in the regional connectivity between the new intake and Proper Bay and Boston Bay can be seen across years and are related to annual differences in the wind driven circulation patterns. For example, connectivity with Proper Bay is reduced while connectivity with Boston Bay is increased in 2018 compared to 2017. At spatial scales greater than a few kilometres from the intake the levels of connectivity with source locations reduce with distance, with less than 0.4 % of the particles released from their source locations across Boston and Proper Bay estimated to arrive within 25 m radius of the new intake location.

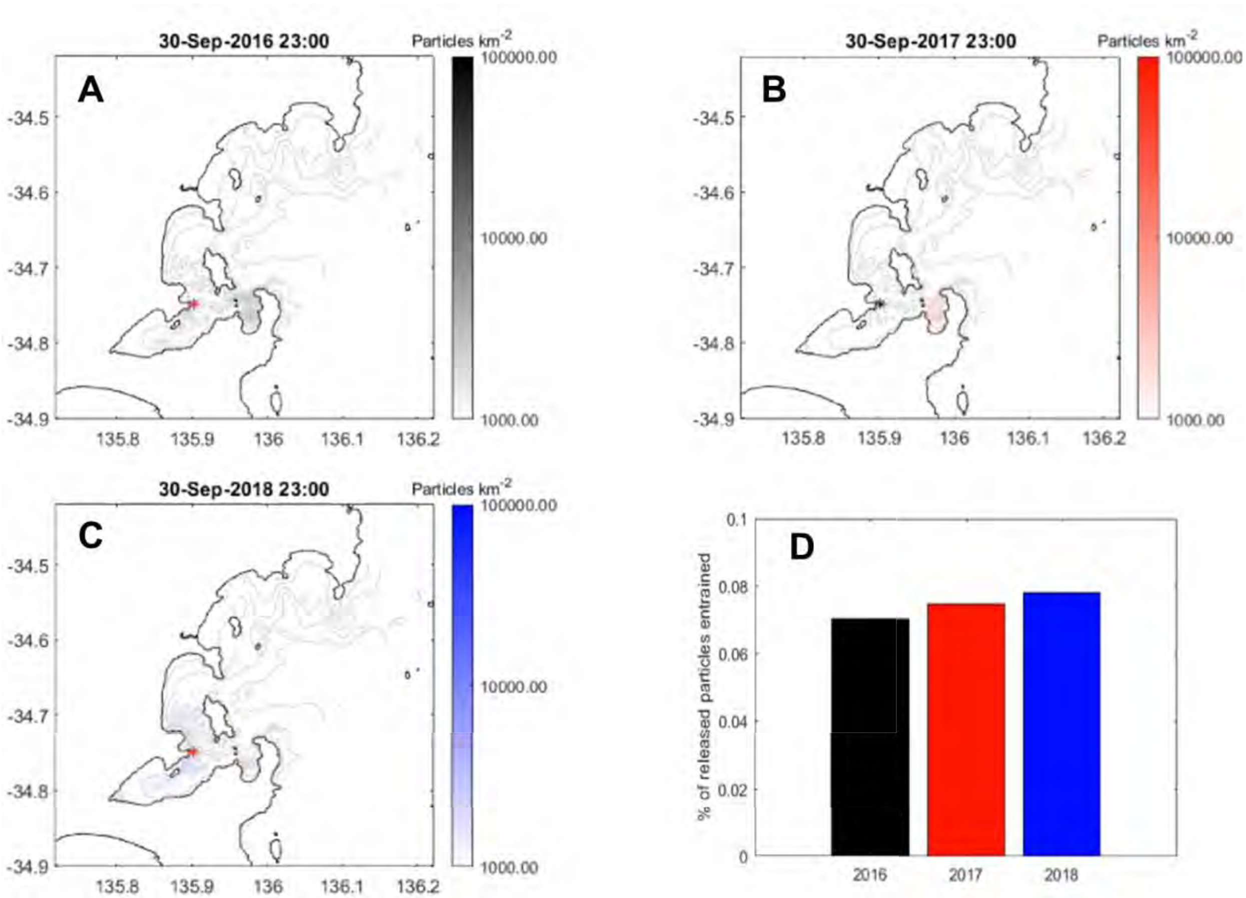

Figure 3-3. Example snapshot of particle distributions (particle densities) on 30 September at the end of each spawning season for (A) 2016, (B) 2017 and (C) 2018. (D) Estimated percentage of all particles (representative of larvae) released per spawning season (2016-2018) that were within a radius of 25m from the new intake location.

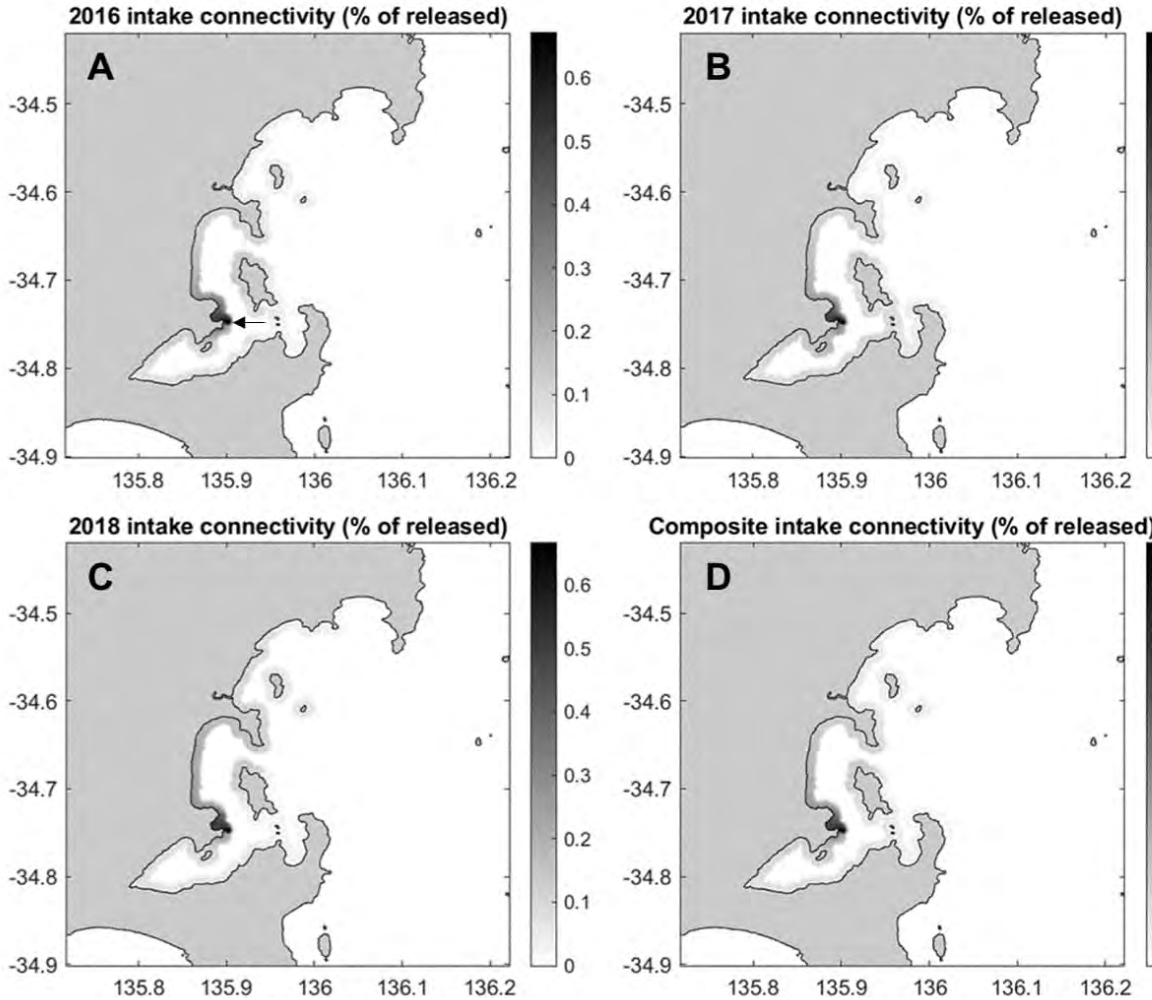

Figure 3-4. Modelled connectivity of larvae with the new Billy Lights Point intake location showing the percentage of larvae from each release point estimated to come within a 25m radius of the intake. A, B and C show the mean distribution averaged over each monthly spawning events for the 2016, 2017 and 2018 spawning seasons, respectively. (D) The mean connectivity distribution averaged over the three spawning seasons is shown in A, B and C. The black arrow in the top left plot (A) indicates the intake location.

4. CONCLUSIONS

Updated biophysical modelling of planktonic blue mussel larvae based on the approach and assumptions presented by Doubell and James (2023), indicated that less than 0.1% of the total number of particles released each spawning season are likely to be at risk of entrainment by the newly proposed desalination plant intake location near BLP. At smaller spatial scales, connectivity mapping with source locations showed that up to 0.6 % of particles released from locations within 2 km of the new intake location between Billy Lights Point and Kirton Point may be at risk of entrainment. The risk of entertainment decreased with distance from the intake, with the percentage of particles likely to be at risk of entrainment from source regions across Proper Bay and Boston Bay estimated to be less than 0.4 %.

Sensitivity studies investigating the effects of Stokes drift on entrainment levels showed the inclusion Stokes drift in combination with the constraining of particles to the ocean's surface layer could significantly alter the predicted particle trajectories. However, the inclusion of Stokes drift into the model had a negligible effect on connectivity with intakes, with less <0.1% of the total number of particles released each spawning season estimated to be entrained in an intake area with a radius of 25m.

The additional results presented here are consistent with the levels of connectivity and entrainment provided by Doubell and James (2023).

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Appendix L Near/midfield Hydrodynamic Modelling Report

Eyre Peninsula Desalination Plant: Hydrodynamic Modelling Report

Customer	Acciona
Project	003039.001
Deliverable	001
Version	02
	30 May 2024

Document Control

Document Identification

Title	Eyre Peninsula Desalination Plant: Hydrodynamic Modelling Report
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Customer	Acciona
Classification	BMT (OFFICIAL)

Authors	Mitchell Baum, Alex Waterhouse, Eduardo Pombo Lavin
Checked By	Ian Teakle
Approved By	Eduardo Pombo Lavin
Project Manager	Eduardo Pombo Lavin

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Version	Version Date	Distribution	Record
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01	30 April 2024	Acciona	Revised draft for review
02	30 May 2024	Acciona	Final

Executive Summary

The Eyre Peninsula Uley South Basin is a prescribed resource under the Water Allocation Plan (WAP) for the Southern Basin and Musgrave Prescribed Wells area and provides approximately 77 per cent of the drinking water supply to the Eyre Region.

Historical data shows that freshwater recharge in the Uley South Basin has been very low in years 2013 through 2020 and it has been determined that the basin is at risk of irreversible deterioration through increased salinity at current consumption levels. If the Uley South Basin becomes irreversibly damaged, there would be no remaining groundwater source that could sustain a reliable drinking water supply for the majority of the Eyre Peninsula. This has been assessed as being an unacceptable risk to SA Water.

A seawater desalination plant located in the lower region of the Eyre Peninsula was identified by SA Water as the most favourable augmentation option. SA Water engaged SARDI in early 2021 to undertake preliminary hydrodynamic modelling on the feasibility of the Boston and Proper Bay area hosting a small desalination plant. This work examined several sites including Point Boston and Billy Lights Point and concluded that provided the diffuser design met the dilution requirements, the dispersion was sufficient at the Billy Lights Point site (Doubell and James 2023).

An early concept design was presented by SA Water to the Regulatory Agencies and key stakeholders in October 2023. The concept design consultation highlighted that the proposed trenching of the pipelines through the coastal and intertidal habitat was of concern due to the impacts on the coastal cliffs and nearshore seagrass beds as well as having high community amenity and cultural heritage value.

SA Water subsequently engaged engineering consultancy Acciona SA and their specialist hydrodynamic modelling team at BMT to further develop the EP Desalination project into detailed design.

The design development incorporated the feedback during the initial regulatory and stakeholder consultation and from the independent Marine Science Review Panel (MSRP). The resultant design proposes a hybrid tunnel under the coastal and intertidal habitat with the intake and outfall pipes lying on the seabed in the deeper water. This prevents impacting the nearshore environment and reduces the amount of dredging offshore.

Further to the development of the tunnel alignment, the design team undertook a location and design optimisation analysis of the intake and outfall locations. This optimisation examined several potential locations around the Billy Lights Point through a multi-criteria analysis with the subsequent shortlisted sites being modelled in the mid-field. The mid-field dispersion results were examined in conjunction with construction and operational constraints and a preferred location was then selected for more refined hydrodynamic modelling.

To satisfy the regulatory requirements the brine dilution assessments require detailed near-field to mid-field hydrodynamic modelling in order to rigorously assess the proposed design performance and impact within Boston and Proper Bay. The EPDP project has undertaken a range of surveys to characterise the baseline coastal environment at Billy Lights Point, including bathymetry, sediment sampling, habitat mapping and a comprehensive metocean monitoring campaign conducted since July 2021.

The brine dispersion assessments have been undertaken using a coupled near-field and mid-field model configuration that effectively resolves mixing at spatial scales from metres to kilometres. Detailed

Computational Fluid Dynamics (CFD) modelling has been undertaken for the proposed desalination plant outfall diffuser design and location. A high-resolution mid-field 3D hydrodynamic model was developed for a domain covering Boston and Proper Bay. The model's performance at predicting water level, salinity, temperature and currents has been validated against metocean mooring datasets collected for the EPDP.

Nearfield modelling predicts that the proposed diffuser achieves a worst-case nearfield dilution performance of 1:59, which is in excess of the 1:40 performance target. The nearfield to midfield hydrodynamic modelling of brine dispersion shows that salinities beyond a 30 m mixing zone remain at all times below 0.978 ppt and confirms the suitability of the selected location for achieving acceptable levels of brine dilution under a range of seasonal and tidal conditions, including dodge tides. The risk of brine-intake recirculation was also assessed and indicates that the proposed design complies with a performance target of <1% brine recirculation under all conditions.

The potential for visible plumes due to elevated TSS in the brine discharge was found to be a low risk, with the mid-field model indicating no detectable surface plumes and compliance with a threshold of TSS less than 10% above ambient at the seabed.

Permanent impacts to coastal processes from the proposed EPDP design, including changes to water levels, currents and sediment transport are assessed as minor. The proposed design avoids direct impacts to the sensitive nearshore environment at Billy Lights Point through tunnelling the intake and outlet pipelines until approximately 470 m from the shoreline. At this point the intake and outlet pipelines transition to a seabed alignment. In the context of the relatively benign current and wave climate at Billy Lights Point, the seabed pipeline is not expected to significantly impact coastal processes including sediment transport.

Contents

Tables

Figures

Glossary

Dodge tide (see also Neap tide)	A unique feature of South Australian gulfs is the almost perfect compensation between semidiurnal principal lunar and solar tides, triggering particularly weak tidal flows during neap tides—a feature known as the dodge tide—that can last 2–3 days.
Neap tide	Refers to a period of moderate tidal range occurring on a fortnightly cycle (7-days after spring tides)
Spring tide	Refers to a period or large tidal range occurring on a fortnightly cycle.

Acronyms

ADCP	Acoustic Doppler Current Profiler
AHD	Australian Height Datum
BOM	Bureau of Meteorology, Australia
CD	Chart Datum
CFD	Computational Fluid Dynamics
CFSR	Climate Forecast System Reanalysis
DEA	Digital Earth Australia (https://www.dea.ga.gov.au/)
ECI	Early Contractor Involvement
EPDP	Eyre Peninsula Desalination Plant
HAT	Highest Astronomical Tide
IPCC	Intergovernmental Panel on Climate Change
ISLW	Indian Spring Low Water
LAT	Lowest Astronomical Tide
MHWN	Mean High Water Neap
MHWS	Mean High Water Spring
MSL	Mean Sea Level
MSRP	Marine Science Review Panel

NCEP	National Centre for Environmental Prediction (USA)
NHMRC	National Health and Medical Research Council
NOAA	National Oceanic and Atmospheric Administration (USA)
PPT	Parts Per Thousand (mass fraction measure of salinity)
SA Water	South Australian Water Corporation
SARDI	South Australian Research and Development Institute
SLR	Sea Level Rise
SWRO	Sea Water Reverse Osmosis
TSS	Total Suspended Solids
WWTP	Waste Water Treatment Plant

1 Introduction

1.1 Eyre Peninsula Desalination Project

The Eyre Peninsula Uley South Basin is a prescribed resource under the Water Allocation Plan (WAP) for the Southern Basin and Musgrave Prescribed Wells area and provides approximately 77 per cent of the drinking water supply to the Eyre Region.

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SA Water subsequently engaged engineering consultancy Acciona SA and their specialist hydrodynamic modelling team at BMT to further develop the EP Desalination project into detailed design.

1.2 Scope of Works

The design development incorporated the feedback during the initial regulatory and stakeholder consultation and from the independent Marine Science Review Panel (MSRP). The resultant design proposes a hybrid tunnel under the coastal and intertidal habitat with the intake and outfall pipes lying on the seabed in the deeper water. This prevents impacting the nearshore environment and reduces the amount of dredging offshore.

Further to the development of the tunnel alignment, the design team undertook a location and design optimisation analysis of the intake and outfall locations. This optimisation examined several potential locations around the Billy Lights Point through a multi-criteria analysis with the subsequent shortlisted sites being modelled in the mid-field. The mid-field dispersion results were examined in conjunction with construction and operational constraints and a preferred location was then selected for more refined hydrodynamic modelling.

To satisfy the regulatory requirements the brine dilution assessments require detailed near-field to mid-field hydrodynamic modelling in order to rigorously assess the proposed design performance and impact within Boston and Proper Bay. This refined hydrodynamic modelling builds upon a substantial body of baseline data collection and preliminary impact assessments.

A high-resolution mid-field 3D hydrodynamic model was developed for a domain covering Boston and Proper Bay. The model's performance at predicting water level, salinity, temperature and currents has been validated against metocean mooring datasets collected for the EPDP. Detailed Computational Fluid Dynamics (CFD) modelling has been undertaken for the proposed desalination plant outfall diffuser design and location.

The brine dispersion assessments have been undertaken using a coupled near-field and mid-field model configuration that effectively resolves mixing at spatial scales from metres to kilometres. The assessments undertaken include consideration of the risk of short-circuiting of the brine discharge with the proposed EPDP intake. The risk of connectivity between the existing Port Lincoln wastewater treatment plant outfall and the proposed EPDP intake was also considered.

A coastal process assessment, including hydrodynamic and wave model hindcasts for both ambient and storm conditions was undertaken and used to develop metocean design criteria for the EPDP.

Title: **Eyre Peninsula Desalination Plant and Intake/Outfall Locality**	Figure: 1-1	Rev: A

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2 Project Description

The site of the EPDP is situated at Billy Lights Point with seawater intake and brine outfall infrastructure located offshore as shown in Figure 2.1. The seawater reverse osmosis (SWRO) desalination plant is proposed to be developed over two stages; a Stage 1 capacity of 5.3 GL per year and an ultimate Stage 2 capacity of 8 GL per year. The ultimate Stage 2 capacity of 8 GL per year is the focus of this assessment as for the Development Application purposes, the modelling presents the most conservative case of more saline discharge in the marine environment.

2.1 EPDP Infrastructure

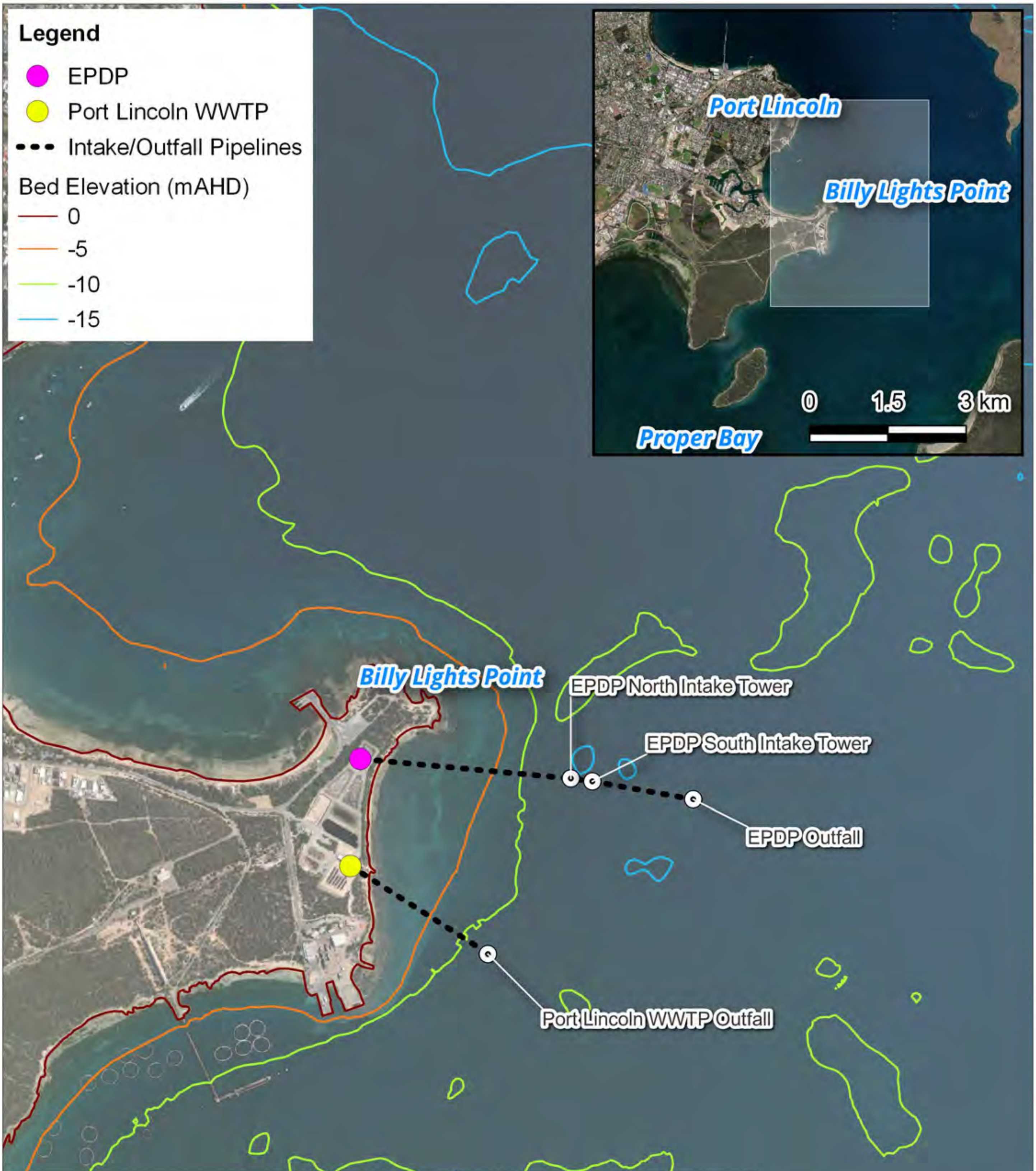
Relevant to the hydrodynamic assessment, the EPDP desalination plant consists of intake and outfall infrastructure, proposed to be located offshore of Billy Lights Point (Figure 2.1). Under the proposed design the intake and outfall pipelines follow the same alignment, starting as a subterranean tunnel at the marine pump station before transitioning to exposed pipelines at approximately -12 mAHD approximately 470 m offshore. Continuing along the same heading, two intake risers are located approximately 600 m offshore. Projecting further along the pipeline, a bed-mounted diffuser is located furthest offshore approximately 900 m off Billy Lights Point. Further details on the intake and outfall infrastructure used as input for the hydrodynamic modelling assessment are presented in Sections 2.1.2 and 2.1.3, respectively.

2.1.1 EPDP Intake and outfall pipeline design

The EPDP preferred option proposes two separate and independent marine pipelines of equal size running in parallel from the intake tower structures offshore, to the intake pump station on the coastline. It also proposes a single terrestrial pipeline running alongside the single intake delivery pipeline, transporting brine in the opposite direction to raw seawater, terminating in the recessed brine sump adjacent to the pump station. The brine sump serves as an intermediary point within the outfall pipeline system. Finally, a single marine pipeline runs from the brine sump on the coast, to the diffuser offshore.

The first stretch of 490m of pipelines from the shore runs through a TBM (tunnel boring machine) constructed tunnel (Figure 2.2). Then the 3 pipelines run under an backfill soil layer with geotextile and under the current seabed on a dredged pocket for approximately 42m. From that point the set of pipelines are slowly emerging to the seabed this time resting on a base of rock until reaching the north intake tower (Figure 2.3). The remaining intake and outfall pipeline continue for another 57m until arriving at the south intake tower. Finally, the outfall pipeline goes on for 320m finishing on the diffuser (Figure 2.4).

During construction a temporary dredged pocket of up to 6 m depth below the existing seabed would be excavated at the offshore termination of the tunnel. Following construction and protection of the pipelines with rubble and geotextile, the temporary dredged pocket would be completely backfilled with stored dredged material. Shallow dredging would also be undertaken along the full length of the subsea pipeline route before placement of the rock foundation. The level of the base rock layer is expected to sit between 0.0 and 1.0m above the existing bathymetry. (Figure 2.3 and Figure 2.4).



Name	Longitude (°)	Latitude (°)	Easting (m)	Northing (m)
EPDP North Intake Tower	135.89798	-34.74672	582195.20	6154676.53
EPDP South Intake Tower	135.89867	-34.74680	582258.54	6154667.81
EPDP Outfall	135.90211	-34.74727	582572.76	5154159.80
Port Lincoln WWTP	135.89536	-34.75140	581950.67	6154159.80

Title:

Location of Existing and Proposed EPDP Infrastructure near Billy Lights Point

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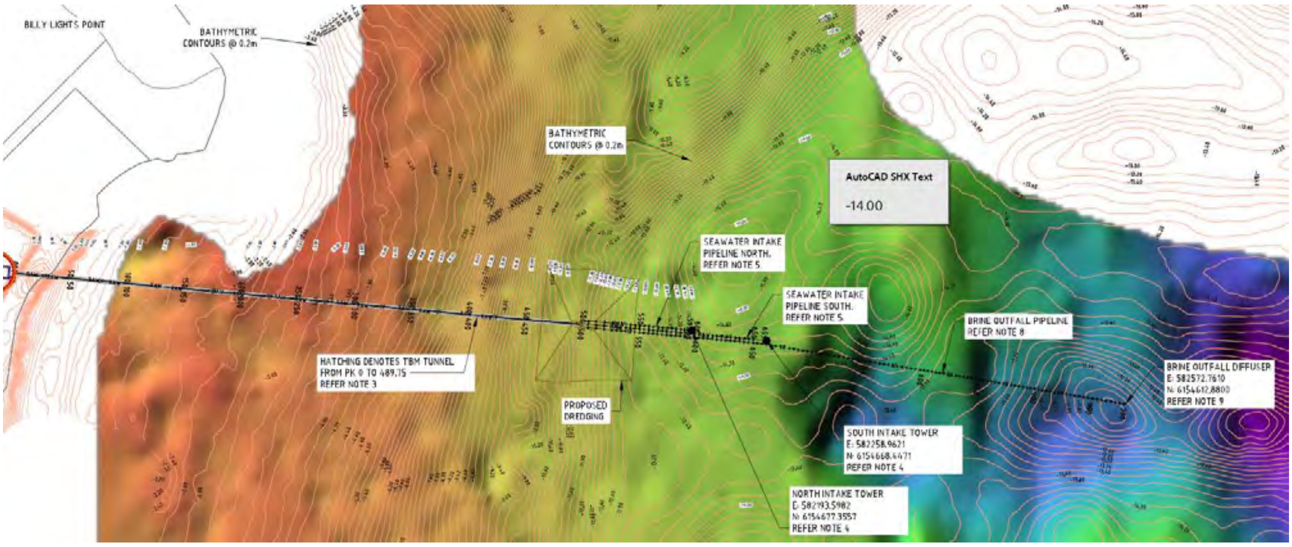


Figure 2.2 EPDP proposed pipelines alignment, showing transition from tunnel to seabed.

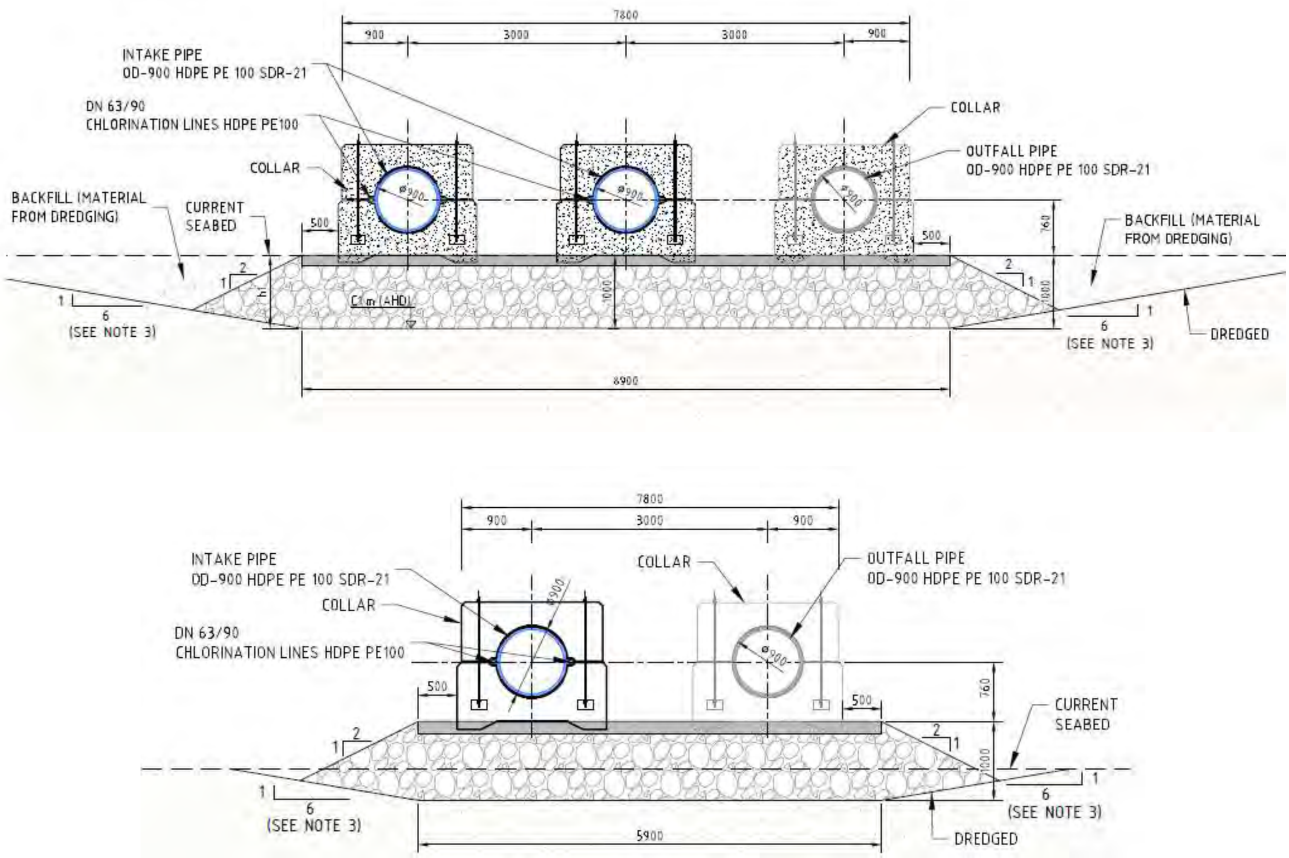


Figure 2.3 EPDP proposed design geometry for intake and outfall pipelines.

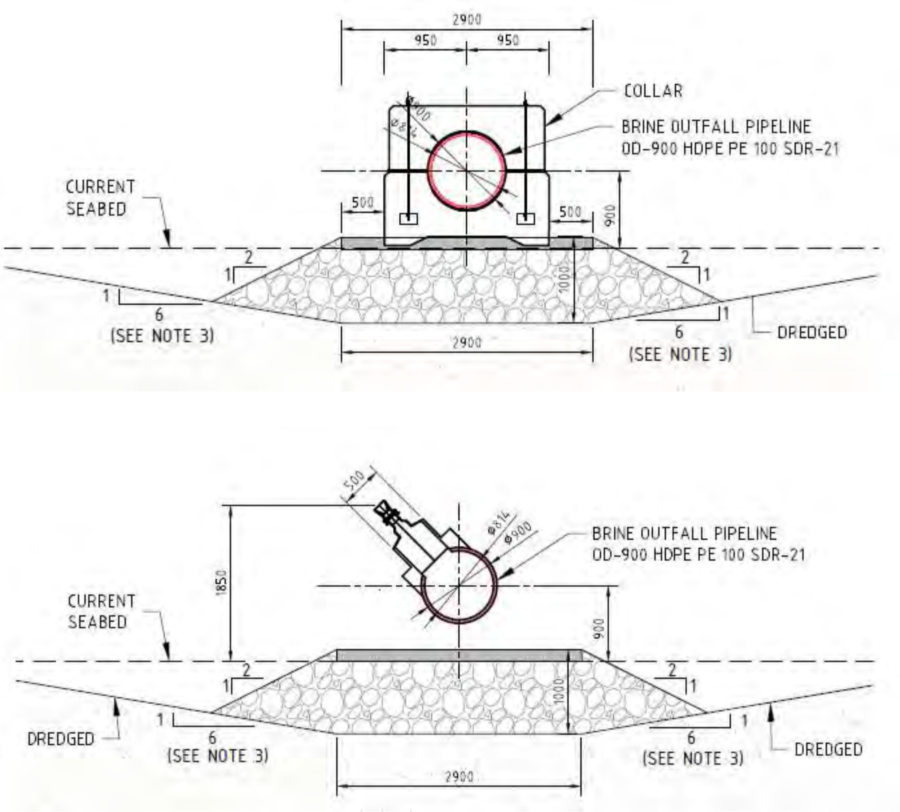


Figure 2.4 EPDP proposed design geometry for intake and outfall pipelines.

2.1.2 EPDP Intake Design

Two offshore intake structures are proposed, with indicative coordinates shown in Figure 2.1 and configuration schematics presented in Figure 2.5. The intake structures are situated at approximately -14.5 mAHD existing seabed elevation. The north intake structure has intake screens between -9.95 mAHD to -8.65 mAHD and the south intake structure has screens between -10.25 mAHD to -8.65 mAHD, with the undersides of the intakes situated approximately 3.6 m above the seabed. Both intake structures are planned to be operational during Stage 2 EPDP operations (8 GL/yr) with a combined intake flow rate of 0.92 m^3/s.

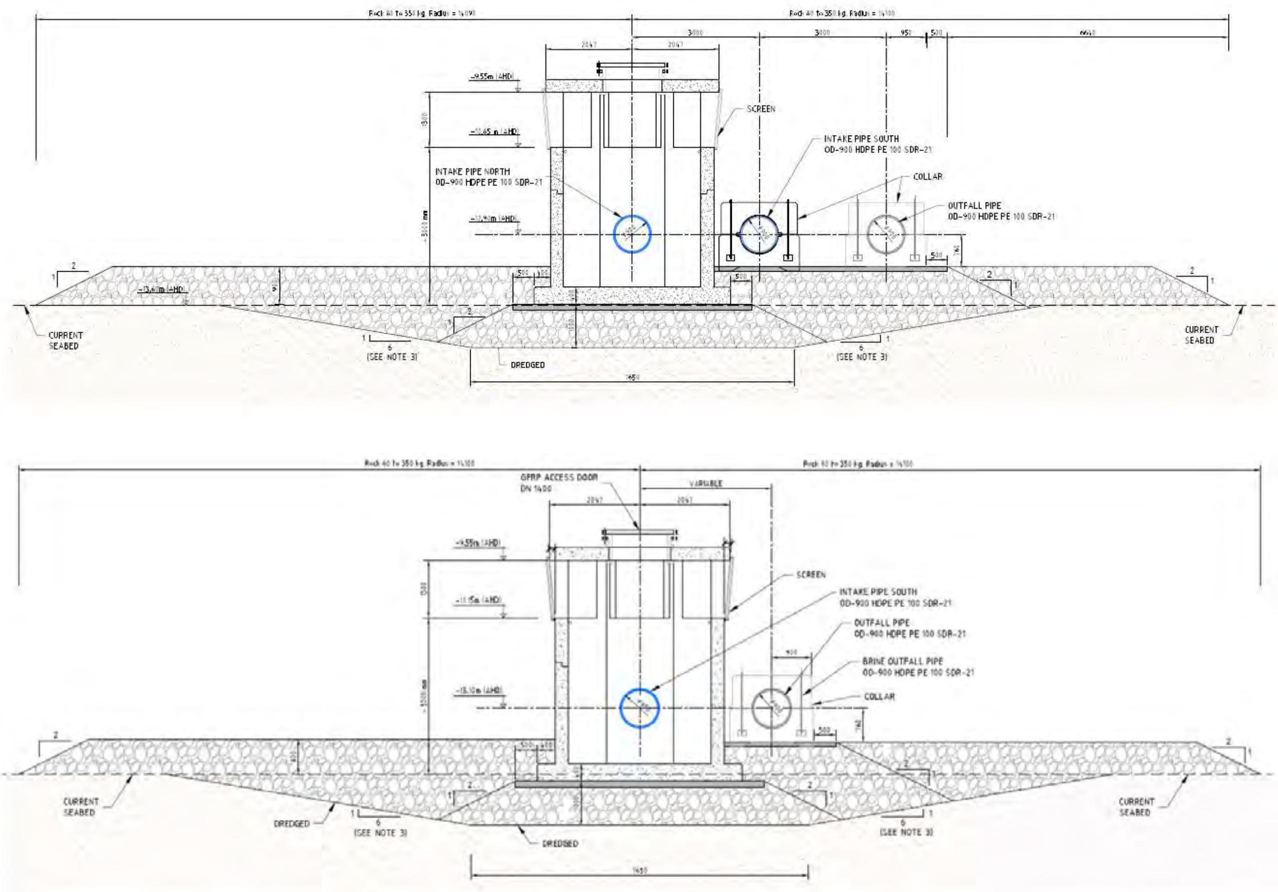


Figure 2.5 EPDP proposed design intake geometry for intake north (top) and intake south (bottom).

2.1.3 EPDP Outlet Diffuser Design

The design proposes a brine outfall pipe with a total length of 990 m, with a diffuser manifold located at the terminus of the outfall pipeline (Figure 2.1). The diffuser will have an ultimate Stage 2 brine flow rate of 1,728 m^3/h (0.48 m^3/s). Under normal plant operations the composition of the diffuser effluent stream will include additional waste streams with standard seawater salinity (UF/DF waste flow, UF neutralisation flow and RO neutralisation flow) with a total standard operation flow rate of 2,153 m^3/h (0.598 m^3/s). Higher diffuser flow rates are expected to occur during system commissioning but are considered to be not a critical case for the brine dilution assessment. The critical case for assessing diffuser performance is the minimum flow rate comprising only the 1,7248 m^3/h brine flow component.

The brine effluent is proposed to be discharged via a seabed mounted diffuser structure (Figure 2.6). Details of the proposed diffuser configuration include:

- The diffuser is proposed to located offshore at an average elevation of -11.7 mAHD. The location of the diffuser is situated atop a marine hillock which sits approximately 4 m higher than the surrounding substrate.
- The diffuser manifold has a length of 95.65 m with a heading of 101.8°T.
- The proposed diffuser has 16 ports, each spaced 6 m apart. In the planform direction the ports are oriented in an alternating configuration facing normal to the diffuser, with the most seaward port facing southwards. The total length of the diffuser between the first and the last port is 90 m.
- Each port has a vertical inclination of 50° above the horizontal (Figure 2.7), with openings situated approximately 2.0 m above the seabed.
- To achieve the required exit velocities and avoid the risk of bio-ingress and seawater entrainment through the ports, each port is fitted with Tideflex type duckbill valve 100mm-HC101WB.
- Based on the 1,728 m^3/h outfall flow rate and even distribution of the discharge flow rate along each diffuser port (zero headloss assumed), the average port flow rate corresponds to 30 L/s. For the 100mm-HC101WB duckbill valve, average port flow velocity is approximately 5.39 m/s.

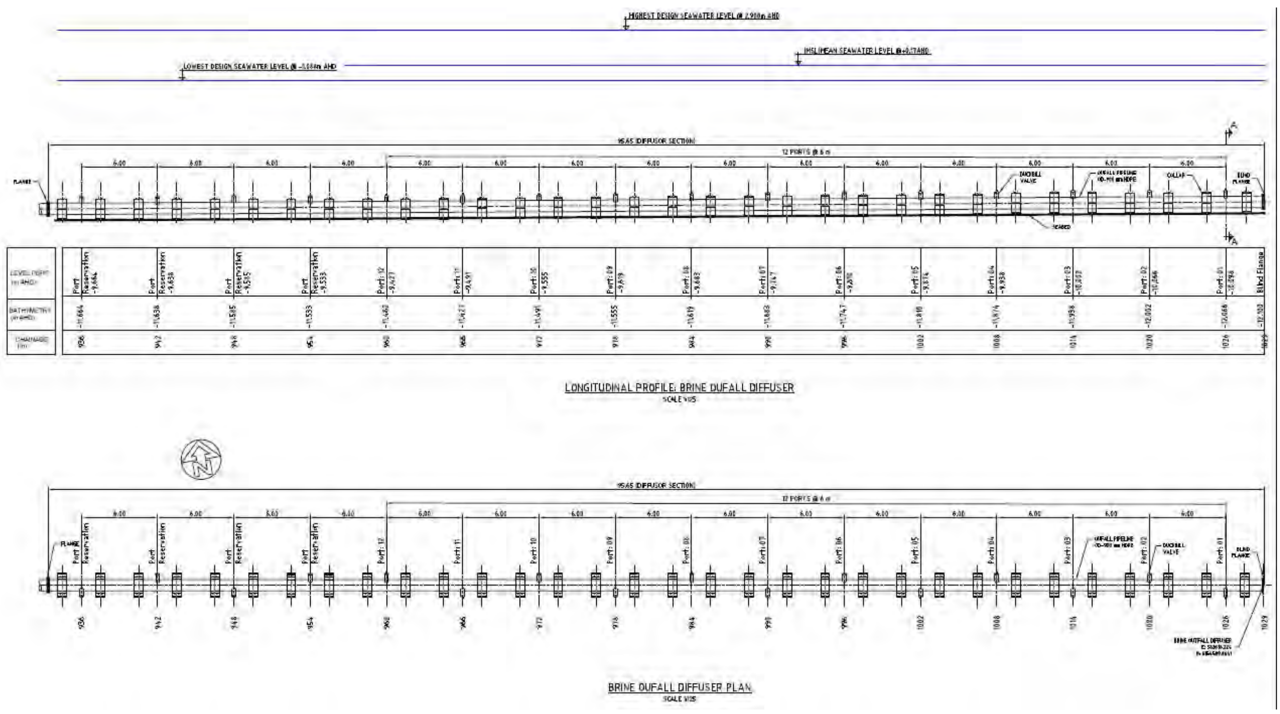


Figure 2.6 EPDP proposed diffuser design (Acciona, 2024). Top: longitudinal view; bottom: plan view

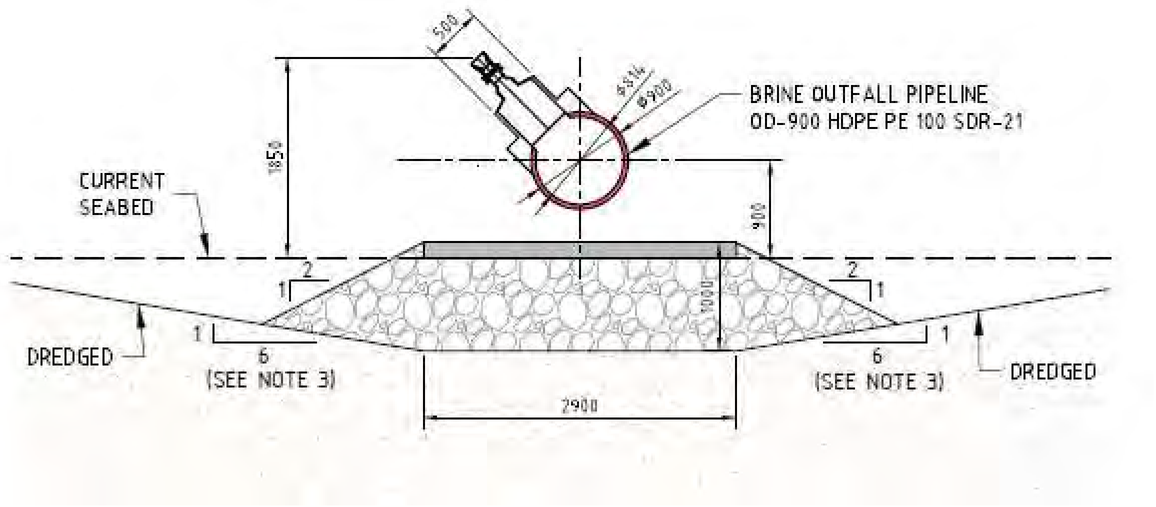


Figure 2.7 Elevation view of the EPDP proposed diffuser design.

2.1.4 EPDP Effluent Discharge Properties

As per Figure 2.8, the SWRO effluent (brine and backwash flows) will accumulate in a brine pit on land. The effluent is pumped out of the brine pit at the plant, passes through an open brine holding tank adjacent to the coast, and flows offshore at the same rate. The reject brine stream is proposed to operate at a fixed flow rate of 1,728 m^3/h. This flow corresponds to the minimum expected outfall flow rate and maximum effluent salinity as determined from the process design. Under normal operating conditions the total effluent flow rate comprising additional waste streams is expected to be 2,153 m^3/h. The additional waste streams are close to standard seawater salinity and reduce the effluent salinity.

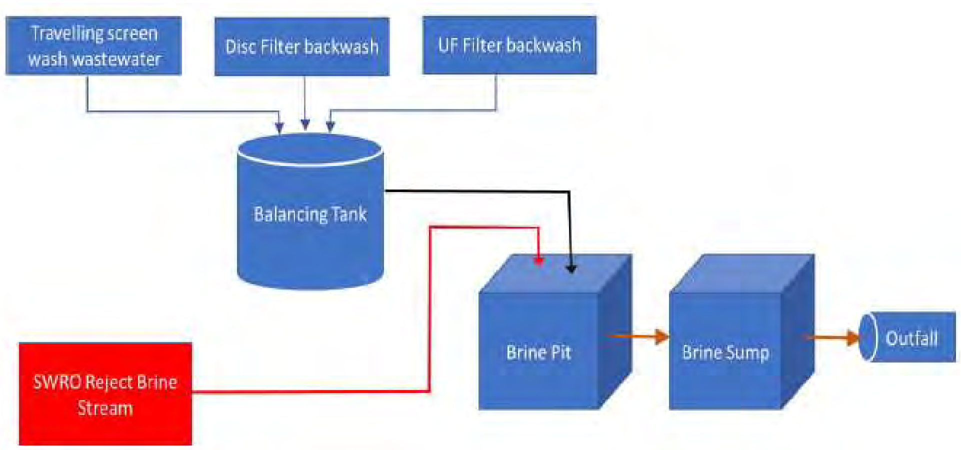


Figure 2.8 SWRO brine and the backwash flows (via a balancing tank) into the brine pit (following further to the brine sump at the coast and out to sea).

The EPDP proposed design discharge properties are summarised as per Table 2.1. For the purposes of hydrodynamic modelling the design effluent stream salinity has been converted to an equivalent salinity anomaly above the intake salinity. A brine-only effluent scenario represents the minimum diffuser flow rate and maximum salinity and constitutes a worst case for diffuser performance. Under normal operating conditions with the inclusion of additional waste streams the effluent discharge occurs at a higher flow rate and lower salinity anomaly, which will improve the nearfield dilution performance.

An effluent stream temperature anomaly of +1°C above the intake water temperature has been assumed. The Total suspended solids (TSS) of the effluent stream is estimated based on a 1:1.9 ratio between the inlet and outlet concentrations. Analysis of ambient TSS from monitoring of the adjacent marine waters indicates that normally TSS levels in the vicinity of Billy Lights Point are typically less than 1.4 mg/L and a corresponding effluent TSS of 2.66 (1.9-times ambient) is assumed.

For the purposes of the hydrodynamic modelling assessment, these values are assumed to be constant. The brine-only stream represents a worst case for assessing nearfield diffuser performance and the normal effluent stream is the relevant condition for assessing midfield brine dilution over daily or longer timeframes.

Table 2.1 EPDP outfall discharge properties

Property	Brine-only Stream	Normal Effluent Stream
Flow rate	1,728 m^3/h	2,153 m^3/h
Salinity anomaly	+39.1 ppt [1]	+33.5 ppt [2]
Temperature anomaly	+1.0°C	+1.0°C
Total suspended solids (TSS) [3]	–	2.66 mg/L

Note 1: Brine stream salinity anomaly calculated on basis of the difference between the upper-bound reject brine stream salinity (75.1 ppt) and the lower bound of ambient salinity variability (36.0 ppt).
Note 2: Effluent stream salinity anomaly calculated on basis of the difference between the normal operation effluent stream salinity (69.5 ppt) and the lower bound of ambient salinity variability (36.0 ppt)
Note 3: TSS of effluent stream is calculated based on a 1:1.9 ratio between inlet and outlet concentrations. An inlet TSS of 1.4 mg/L gives an outlet concentration of 2.66 mg/L.

2.2 Existing Infrastructure

2.2.1 Port Lincoln WWTP Diffuser

Due to its close-proximity to the proposed EPDP infrastructure, the Port Lincoln wastewater treatment plant (WWTP) diffuser is also relevant to this assessment in terms of short-circuiting risk assessment for the EPDP intakes. The Port Lincoln WWTP effluent is discharge via a submerged seafloor diffuser located approximately 310 m offshore, approximately 580 m south-south-west of the proposed EPDP intakes (Figure 2.1). The existing WWTP diffuser is configured as follows:

- The diffuser is located at a depth of approximately -11.8 mAHD.
- The diffuser manifold is constituted by two segments:
  - The first (innermost) segment has a 350 mm internal diameter (assumed 400 mm outside diameter). This segment has five ports facing normal to the manifold in an alternating pattern, with the most landward port facing south-westward. All ports are spaced 5 m apart.
  - The second (outermost) segment has 250 mm internal diameter (assumed 280 mm outside diameter). This segment has three ports, also in an alternating pattern, spaced 5 m apart. At the terminus of the diffuser, this segment has a fourth port directed parallel to the manifold heading. This fourth port is spaced 4.5 m from the penultimate port.
- All ports consist of horizontally oriented orifices with 85 mm diameters in the diffuser manifold.
- In lieu of dimensions relating to the height of the diffuser manifold above the seafloor, the manifold is assumed to be situated 400 mm above the seabed.

The assumed WWTP diffuser configuration is shown in Figure 2.9.

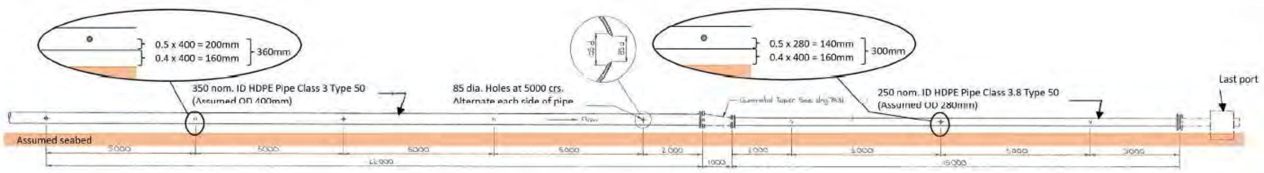


Figure 2.9 Assumed WWTP diffuser configuration. Acciona, personal communication, 2023.

2.2.2 WWTP Effluent Discharge Properties

The Port Lincoln WWTP effluent is monitored in the WWTP outlet chamber. The discharge rate is monitored in real-time, while the constituent properties are sampled at two-to-three week frequency. SA Water provided constituent data ranging from March 2018 to February 2023, and flow rate data at 15-minute frequency from March 2018 to March 2023.

This study is focussed on the discharge rate and the bacteriological counts of the effluent under both normal and assumed upset operating conditions. The relevant effluent properties are summarised in Table 2.2, with timeseries' shown in Figure 2.10.

To capture the buoyant processes of the plume in the assessment, temperature and salinity are required as input for the mid-field model. In lieu of temperature measurements, the temperature here is defined from a 5-day rolling average of Bureau of Meteorology Port Lincoln Airport (Station ID: 018192) temperature measurements. Similarly, in lieu of direct salinity measurements, measured conductivity is applied with a fixed temperature approximation (22°C) to derive the effluent salinity in accordance with the TEOS-10 equations (McDougall and Barker, 2011).

Table 2.2 Summary of Port Lincoln WWTP discharge properties

Property	Median	Maximum
Flow Rate (m^3/s)	0.023	0.097
Temperature (°C)[1]	15.07	25.60
Salinity (g/kg)[2]	1.50	2.26
Bacteriological Counts (MPN/100mL)	5,500	120,000

Note 1: Derived from 5-day rolling average air temperature.
Note 2: Derived using measured WWTP conductivity, assuming a fixed temperature of 22°C.

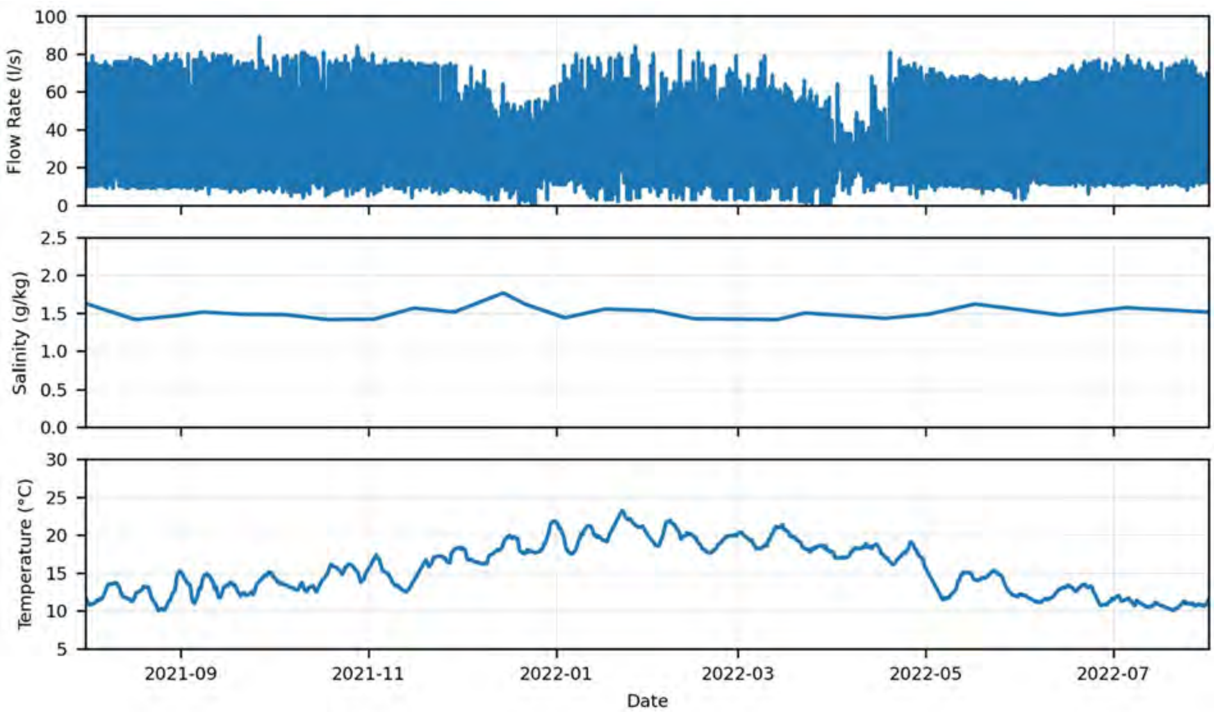


Figure 2.10 Port Lincoln WWTP discharge properties

3 Baseline Coastal Environment

3.1 Bathymetry

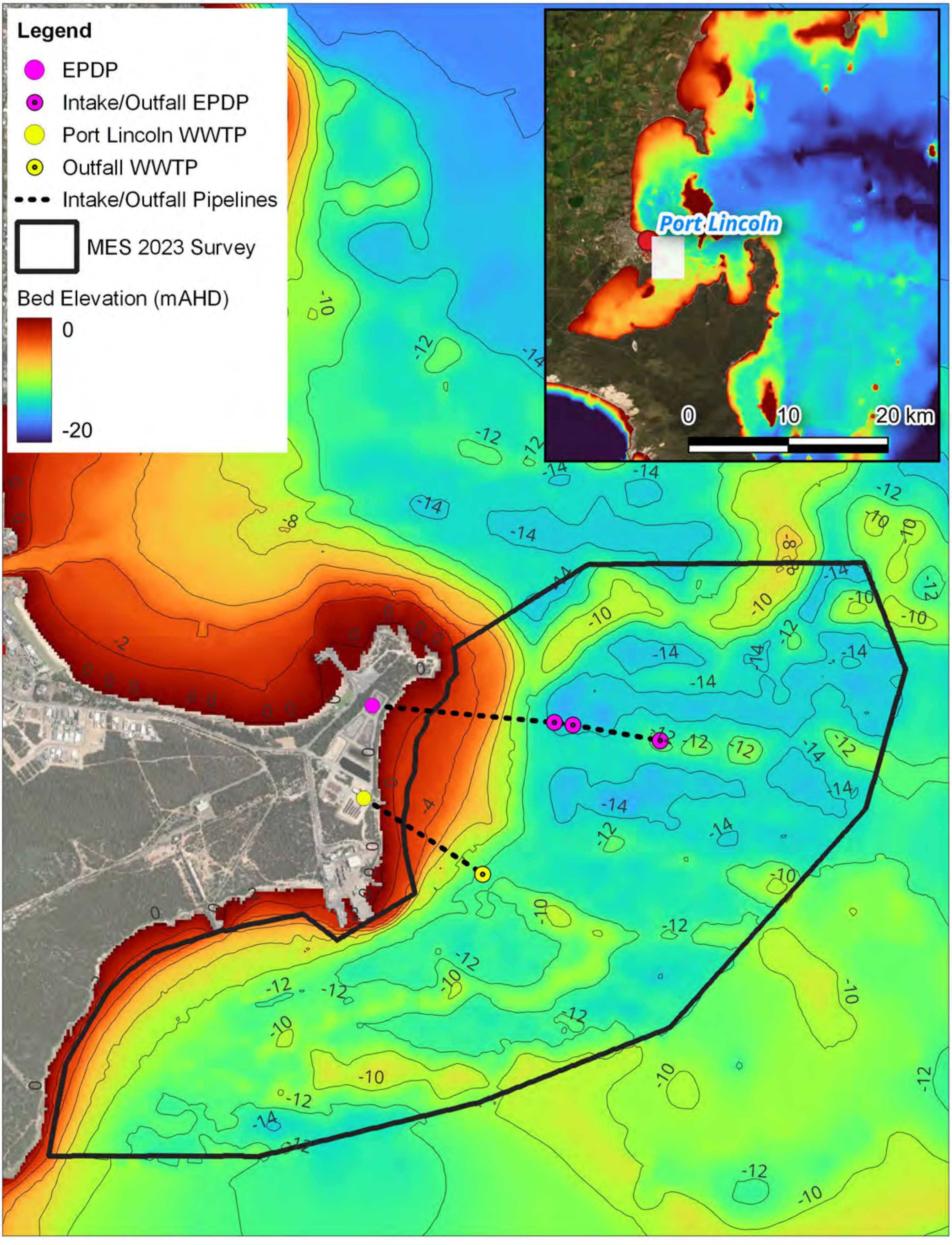
Applicable bathymetry sources to be used as input for the near-field, hydrodynamic and wave model development include (in order of increasing hierarchy):

- AusENC charts:
  - AUS435135
  - AUS435136;
- 50m Multibeam Dataset of Australia 2018 (Parums and Sprinoccia, 2019)
- SADesal23_GDA2020-53_AHD_2m_MA (MES, 2023). Bathymetric survey of Billy Lights Point undertaken by Marine & Earth Sciences.

The composite bathymetry used as input for the hydrodynamic and wave modelling assessment is illustrated in Figure 3.1.

3.2 Habitat Mapping

As part of the SA Water baseline data collection habitat mapping was undertaken for Boston and Proper Bays (J Diversity for SA Water, 2023). 153 sites were surveyed using video drop footage and the results were collated in GIS format. Further data collection was undertaken at a higher resolution around Billy Lights Point to provide baseline information (Figure 3.2). The areas around the Billy Lights Point are described with a strong presence of macroalgae and Posidonia with almost no presence of sand. This validates the stability of the seabed in that part of the Boston Bay.



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Port Lincoln Bathymetry

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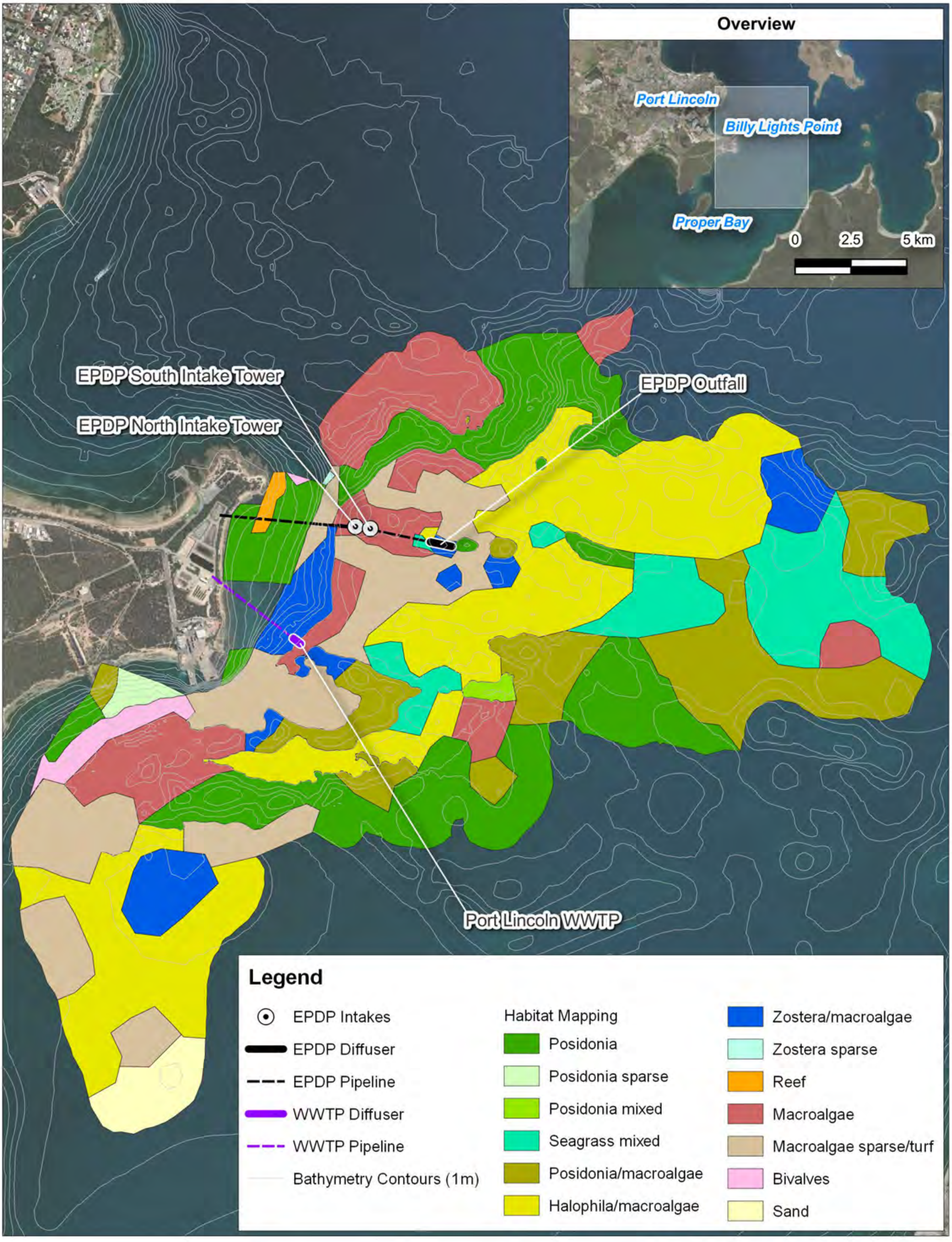

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Billy Lights Point Benthic Habitat Mapping

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3.3 Sediment Characterisation

A sediment sampling and analysis plan (SAP) was undertaken for the EPDP in October 2023 (BMT, 2024a). That SAP was part of the technical investigations and assessments which are required to inform the detailed design of the plant. Since there were not contemporary good quality data to characterise the contaminant status of sediments in the area, Acciona, on behalf of SAW, engaged BMT to undertake this sediment quality characterisation study.

For the development of the SAP twelve (12) sediment core samples were collected from the proposed Project area (Figure 3.4).

The results from the SAP show that sediment samples were dominated by sand and gravel fractions. The sediment grain particle size distribution (PSD) results for each sub-sample are presented in Figure 3.3. Sand fractions generally dominated, ranging from 47% to 100%. Fines (clay and silt) made up a smaller percentage of the PSD ranging from 0 – 27%. Coarse fractions (>2 mm) were present in all but one sample, comprising 0 – 43% of sample mass.

The 0.0-0.5 m stratum typically had a higher proportion of sand than deeper layers at most sites. Percentile 50 (median or D_{50}) results for the sediment samples were ranging between values of 0.3 mm and 1.1 mm for the ones taken in the projected pipeline area (samples number 2 to 6).

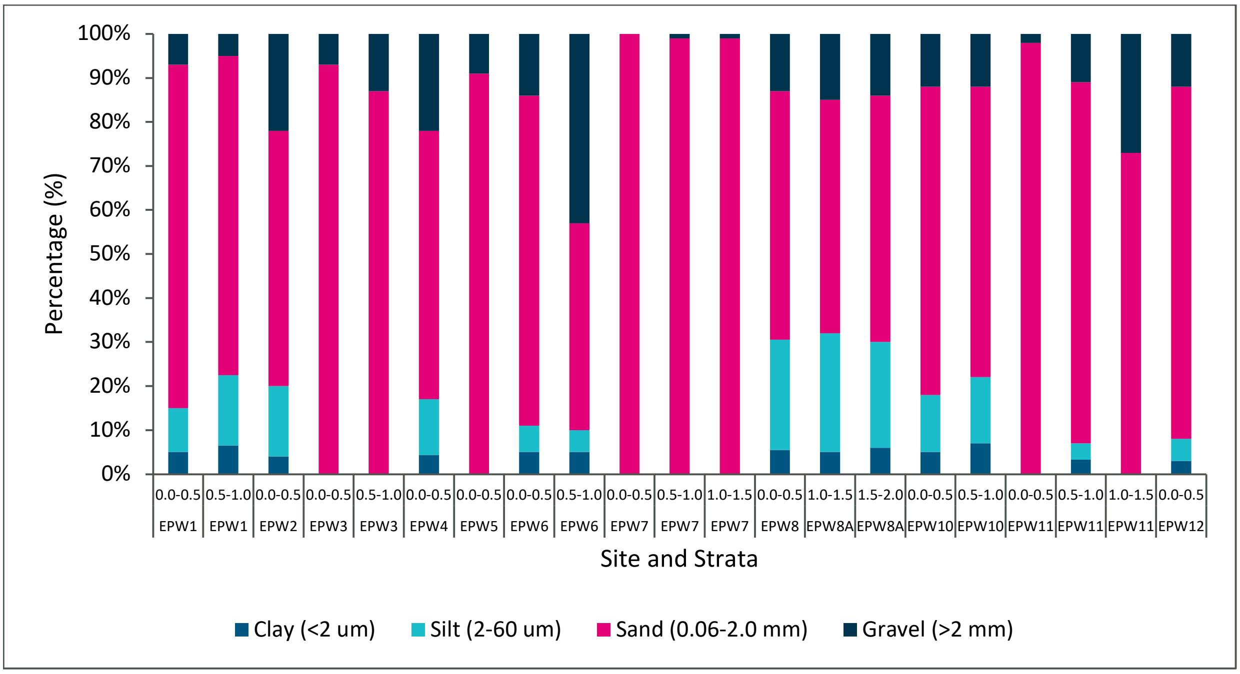
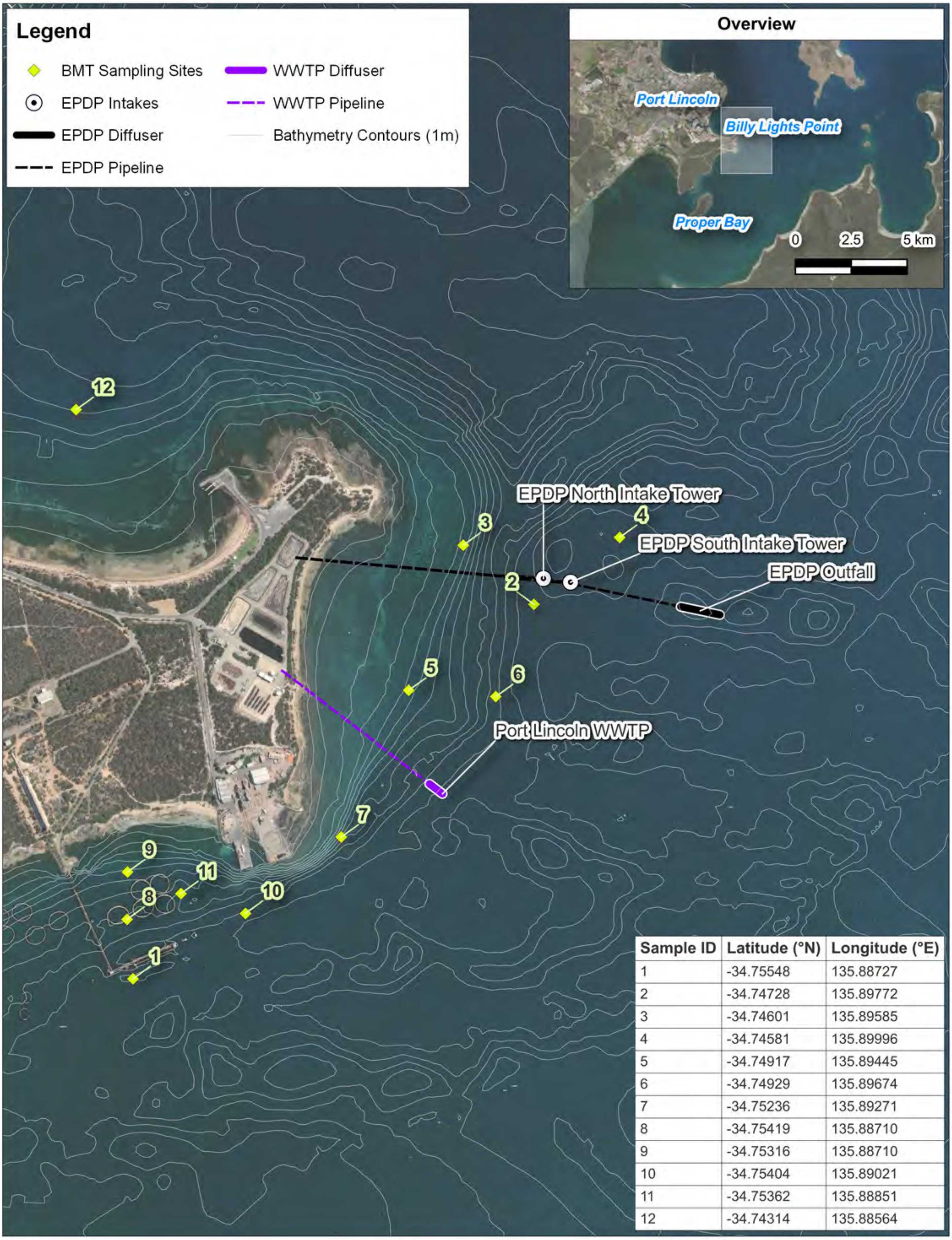


Figure 3.3 Particle size distribution of sediments sampled at each site and sub-sample



Sample ID	Latitude (°N)	Longitude (°E)
1	-34.75548	135.88727
2	-34.74728	135.89772
3	-34.74601	135.89585
4	-34.74581	135.89996
5	-34.74917	135.89445
6	-34.74929	135.89674
7	-34.75236	135.89271
8	-34.75419	135.88710
9	-34.75316	135.88710
10	-34.75404	135.89021
11	-34.75362	135.88851
12	-34.74314	135.88564

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Locations of Sediment Sampling Sites

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3.4 Meteorology

Records of air temperature, rainfall and wind speed were provided by the Bureau of Meteorology (BoM) for the Port Lincoln Airport automatic weather station (AWS), station number 018192.

Timeseries of air temperature and rainfall are shown in Figure 3.5. Air temperatures show strong seasonal variation with the mean daily minimum and maximum temperatures ranging between 7°C to 16.1 °C during winter (July/August) and 16 to 26°C during summer (January / February). Individual temperatures can reach much higher with temperatures above 40°C observed most years. Rainfall is highest during winter, with mean monthly rainfall totals of around 16mm to 61mm in summer and winter respectively.

Seasonal wind roses are shown in Figure 3.6 below based on unprocessed measured wind speed (10-minute average at an elevation of 9m). Wind speed and direction is similarly seasonal with a greater proportion of south to south-easterlies occurring during summer and north-westerlies during winter.

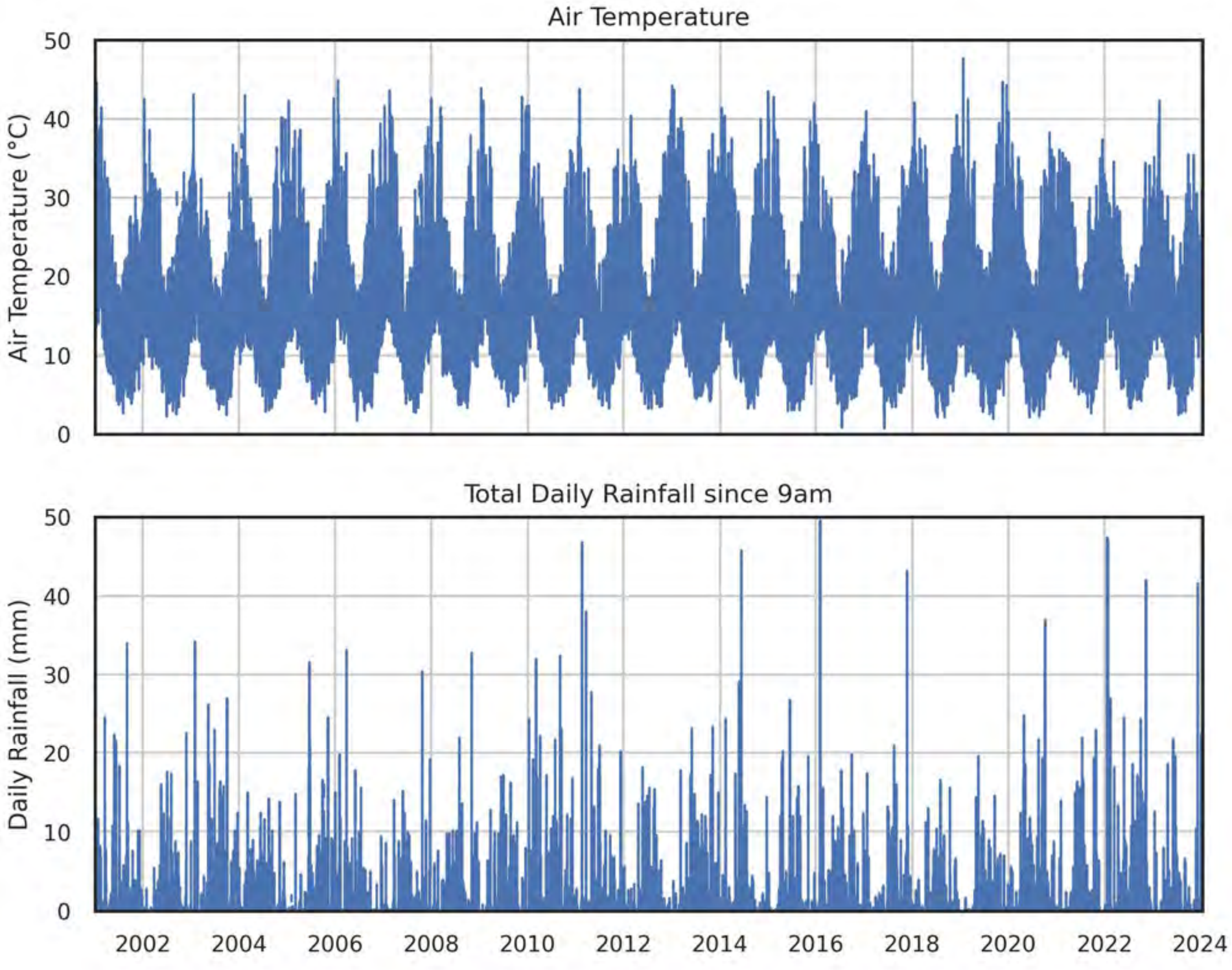


Figure 3.5 Air temperature and rainfall at Port Lincoln (BoM Station: 018192)

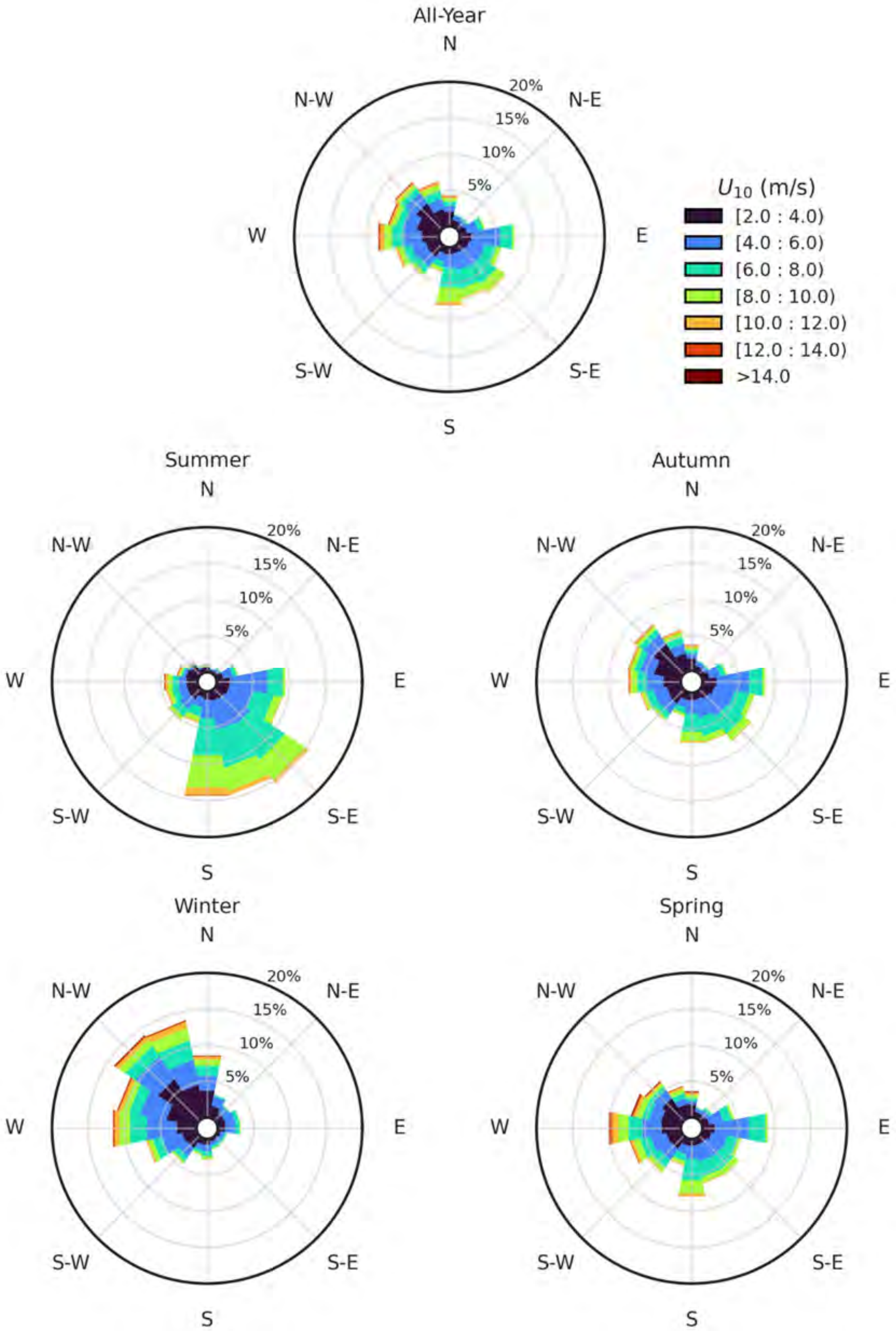


Figure 3.6 Seasonal Wind Roses at Port Lincoln (BoM Station: 018192, data from 2001 to 2024)

3.5 Tides

Tides in Spencer Gulf are semidiurnal with non-uniform phase and amplitude increasing to the upper estuary (Ansell et al.1997).

Table 3.1 Tidal Planes at Port Lincoln (Acciona, 2024)

Tidal Plane	Level to LAT (m)	Level to CD (m)	Level to AHD (m)
Highest Astronomical Tide (HAT)	1.9	1.97	1.22
Mean High Water Springs (MHWS)	1.5	1.57	0.82
Mean High Water Neaps (MHWN)	1.0	1.07	0.32
Mean Sea Level (MSL)	0.86	0.93	0.18
Australian Height Datum (AHD)	0.7	0.77	0.02
Lowest Astronomical Tide (LAT)	0.2	0.27	-0.48
Indian Spring Low Water (ISLW)	0.0	0.07	-0.68
Chart Datum (CD)	-0.14	0.00	-0.82

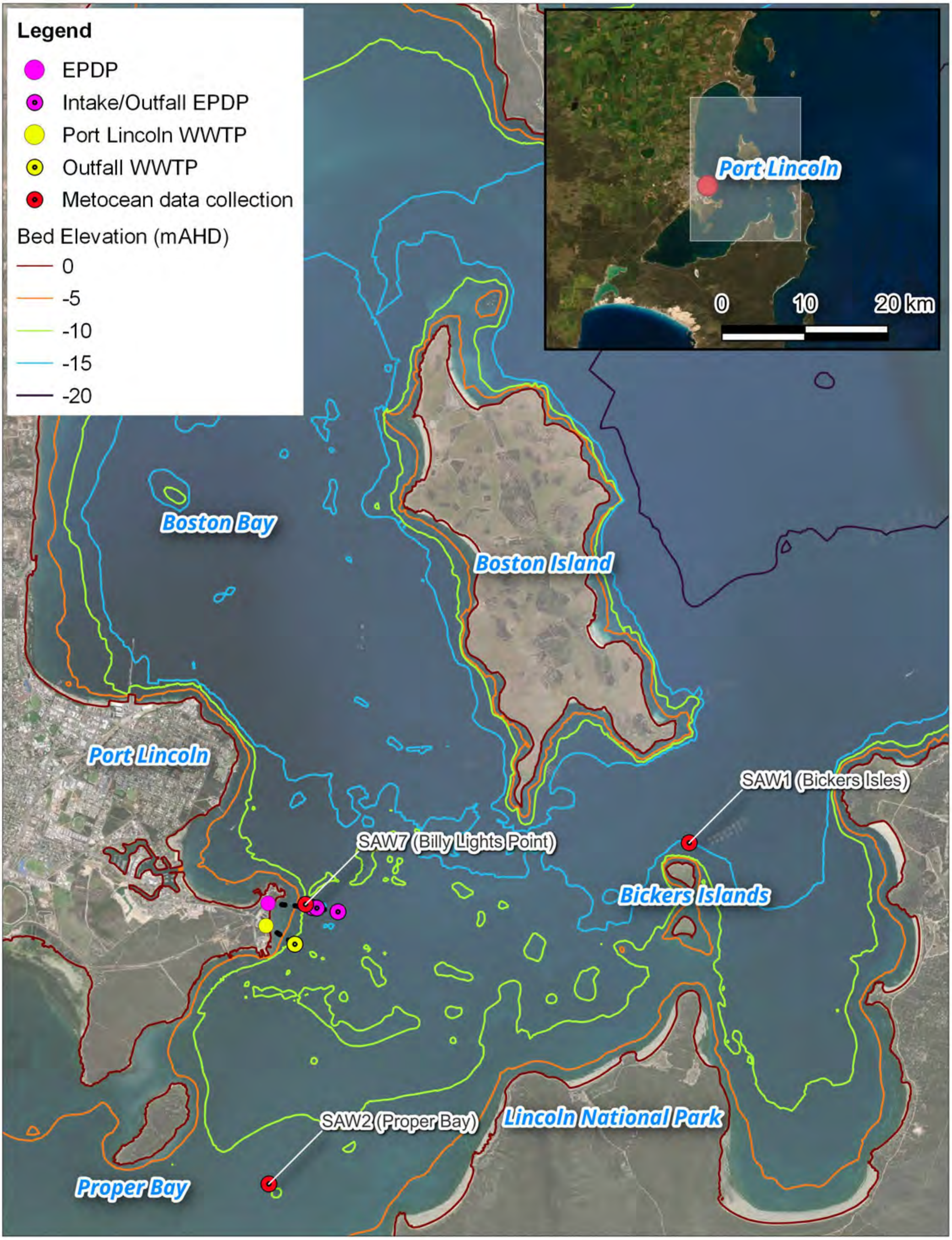
3.6 Metocean monitoring

Metocean data has been collected for the EPDP project since July 2021 and has included deployment of moorings installed with seabed-mounted Acoustic Doppler Current Profilers (ADCP), Conductivity Temperature Depth (CTD) and Water Quality (WQ) instruments. The metocean monitoring deployments for the period up to August 2022 are described in Doubell & James (2022) while the complete details of the deployments up to May 2023 are summarised in Table 3.2. The metocean deployment locations are shown in Figure 3.7.

Processed metocean mooring data is presented below for salinity and temperature (3.6.2), currents (3.6.4) and waves (3.6.5). Data is primarily shown for the July 2021 to August 2022 period measurements at SAW1 and SAW2 as this corresponds to the 12-month validation period for the hydrodynamic model (Section 4.5.7).

Table 3.2 Description of the metocean mooring locations, periods and instrumentation.

Mooring Name	Deployment Period/s	Sensors	Location Latitude (°S), Longitude (°E)	Water Depth (m)
SAW1	19 July 2021 to 18 August 2022	Nortek Signature ADCP Seabird SBE 16plus CTD with WQ sensors	34.7381, 135.9557	17
SAW2	19 July 2021 to 18 August 2022 16 March 2023 to 23 August 2023	Nortek Signature ADCP YSI EXO2 CTD with WQ sensors and/or RBR Duo TS loggers	34.7818, 135.8917	11
SAW3	19 July 2021 to 18 August 2022	YSI EXO2 CTD with WQ sensors and/or RBR Duo TS loggers	34.7176, 135.9042	17
SAW7	16 March 2023 to 23 August 2023	Nortek Signature ADCP Nortek Signature waves YSI EXO2 CTD with WQ sensors and/or RBR Duo TS loggers	34.7463, 135.8969	13



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Metocean Data Collection Locations

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3.6.2 Salinity and Temperature

In-situ salinity and temperature were recorded at two locations at Bickers Island and Proper Bay (SAW1 and SAW2, refer to Figure 3.8), with these levels being relevant to a height of around ~2m above the seabed (approximate deployment height).

Both variables show significant seasonal variation with the highest values for each occurring during summer. Salinities typically vary between about 35.8 to 37.5 ppt, with slightly higher peak salinity observed at SAW2 further inside Proper Bay (where there is less connection to the Spencer Gulf). Water temperatures vary between around 12 to 24 °C, with SAW2 also showing marginally higher peak temperatures during summer.

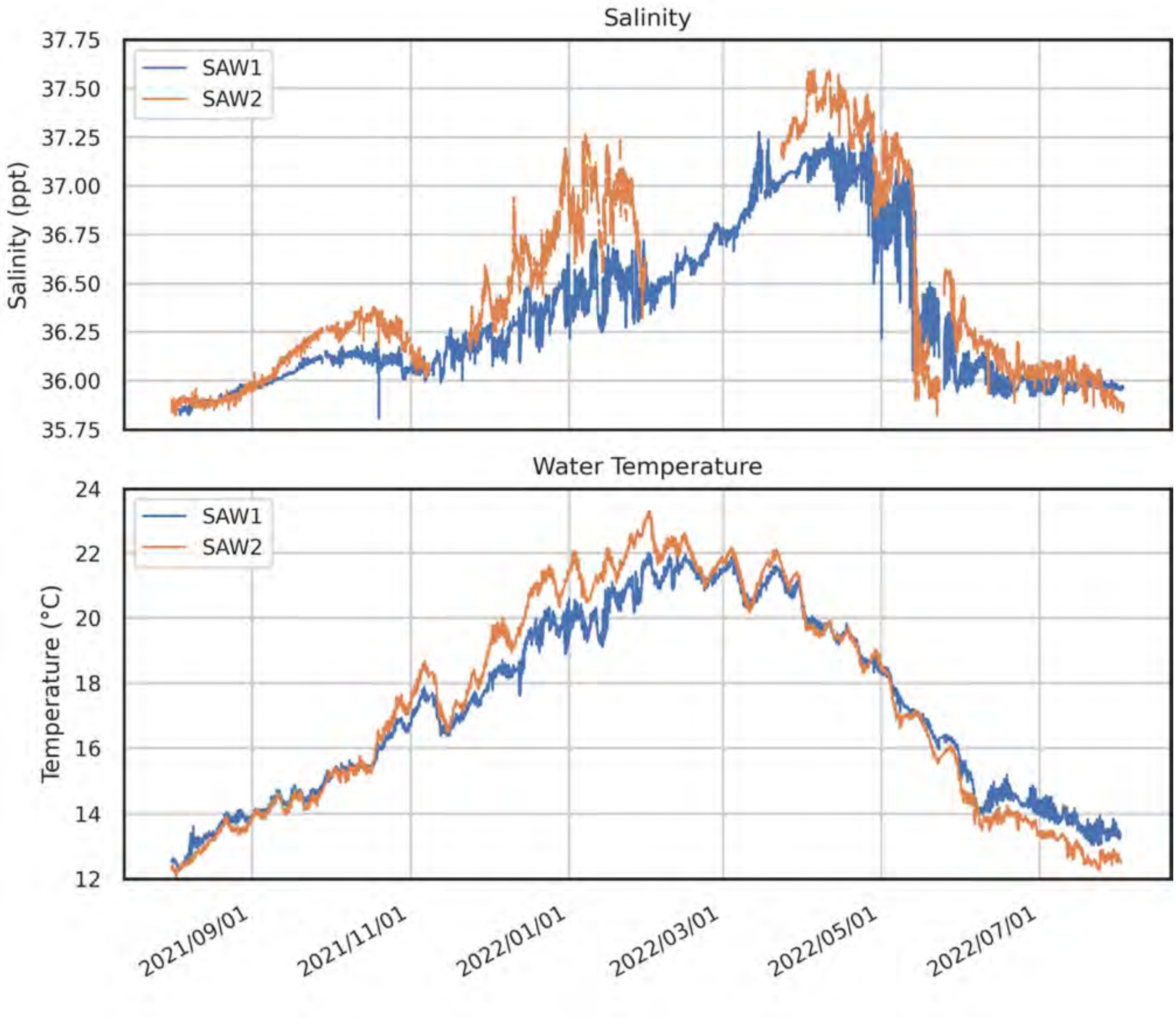


Figure 3.8 Measured salinity (TOP) and water temperature (BOTTOM) at SAW1 and SAW2

3.6.3 Turbidity and TSS

Turbidity and TSS measurements were undertaken through a combination of water column sampling and testing , Seabird instrument profiling of the water column and continuous measurement of near-seabed turbidity at the SAW1, SAW2 and SAW7 monitoring locations (Patterson, 2022). The statistical distribution from each of the sampling methods is summarised in Figure 3.9, where turbidity measurements have been converted to TSS assuming a 1:1 (turbidity:TSS) scaling. The summary of ambient TSS levels shows typical (median) values less than 1.0 mg/L.

For the purpose of SWRO effluent modelling (refer Section 5) an ambient TSS level of 1.4 mg/L has been assumed at the seawater intake, which corresponds to the maximum TSS sample level and sits above the typical range of the turbidity instruments. The turbidity measured at SAW2 is significantly higher than at the other locations but this instrument may have been recording unrealistically high levels due to sensor bio-fouling.

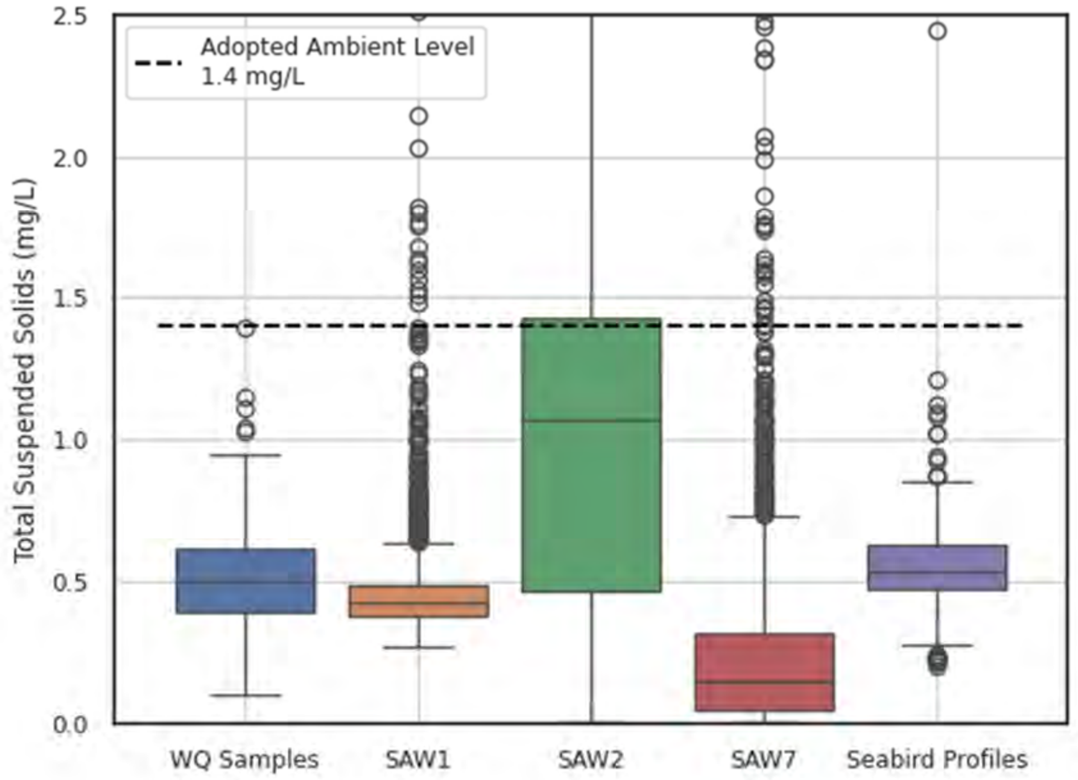


Figure 3.9 Ambient TSS from sampling and inferred from turbidity measurements

3.6.4 Currents

Vertical current profile data was recorded at SAW1 and SAW2 (see Table 3.2) with a summary of this data presented below as depth-averaged timeseries (Figure 3.10), histograms (Figure 3.11) and seasonal rose plots (Figure 3.12 and Figure 3.13 for SAW1 and SAW2 respectively).

Depth-averaged current speeds at SAW1 and SAW2 typically vary between 0 m/s and up to 0.25m/s and 0.15m/s respectively at SAW1 and SAW2. The current regime shows a typical semi-diurnal pattern with little variation in direction, flowing between west-southwest to east-northeast at SAW1 and south-southwest to north-northeast at SAW2.

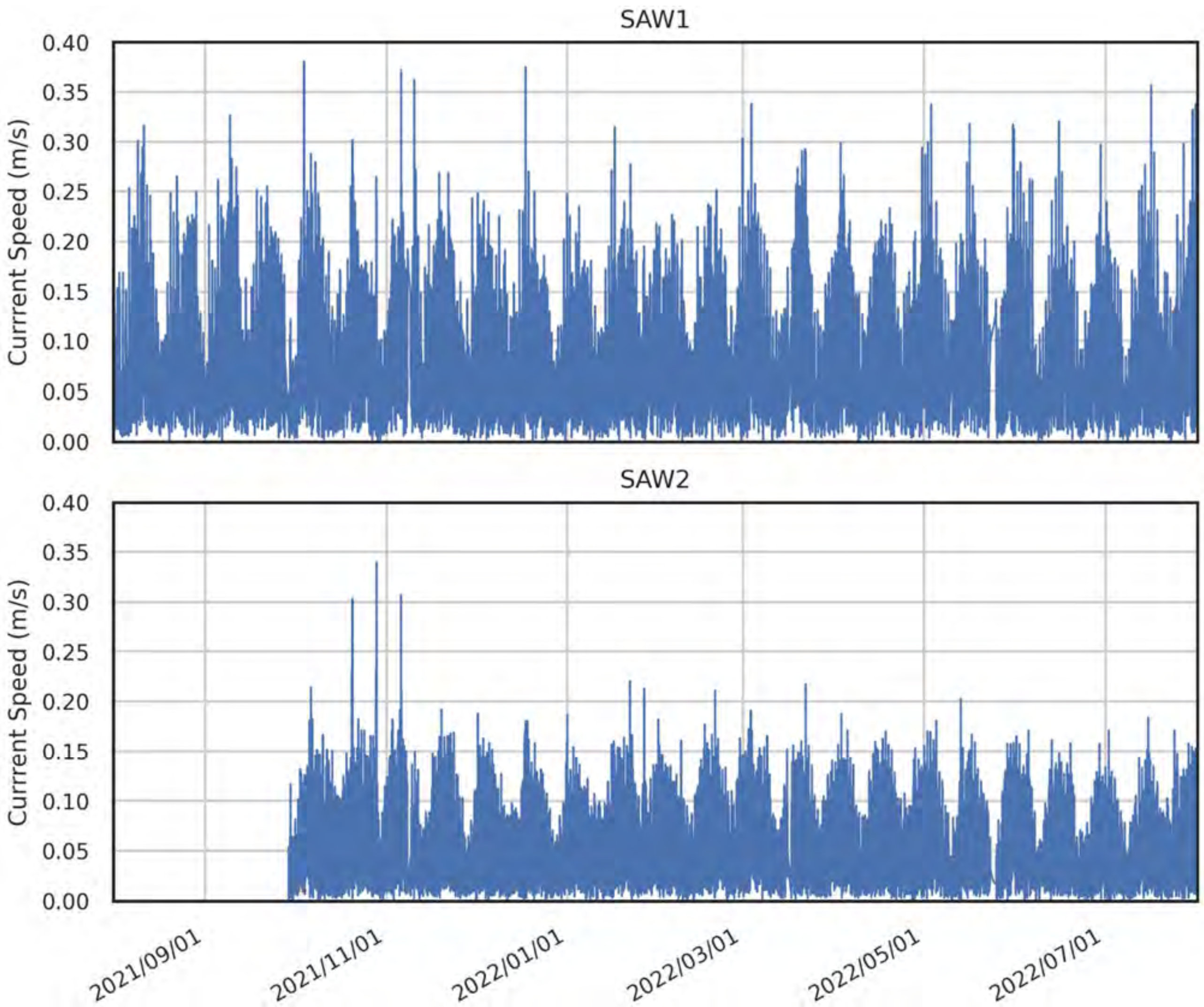


Figure 3.10 Current speed timeseries at SAW1 and SAW2

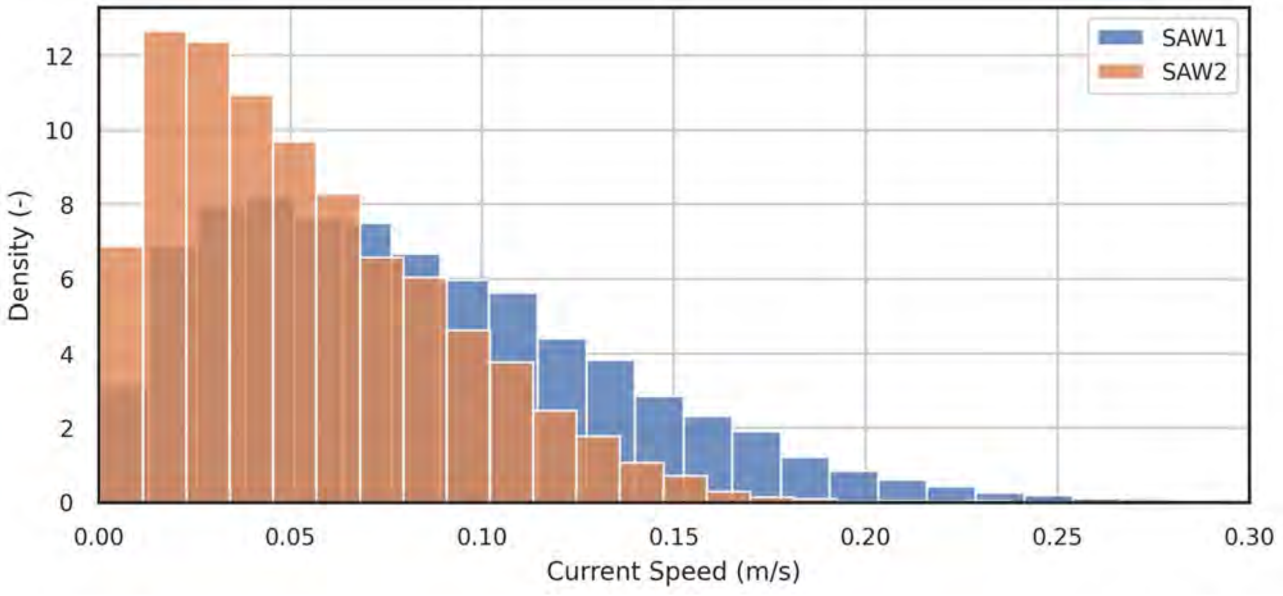


Figure 3.11 Histograms of current speed at SAW1 and SAW2

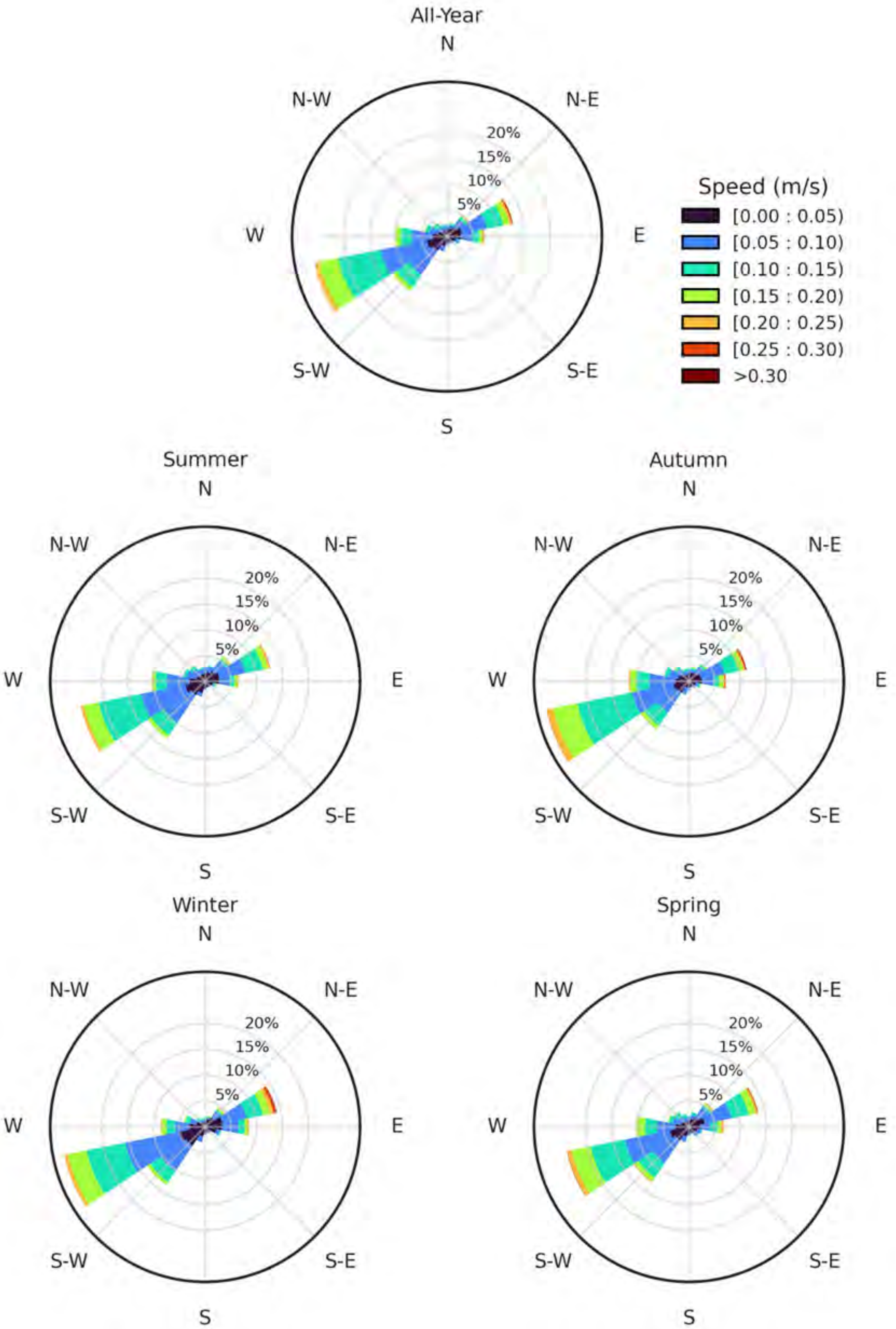


Figure 3.12 All-year and seasonal current roses at SAW1

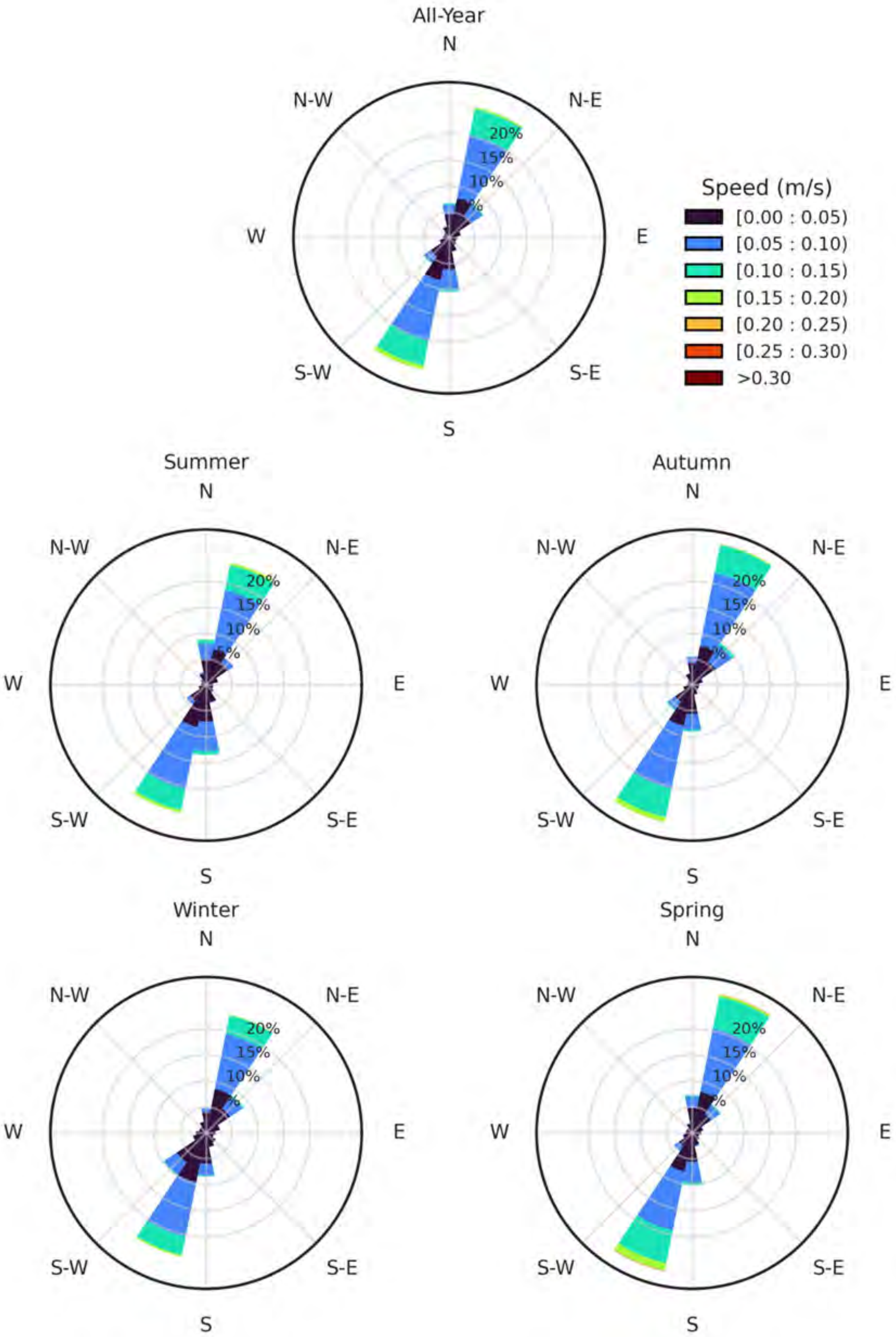


Figure 3.13 All-year and seasonal current roses at SAW2

3.6.5 Waves

In-situ wave measurements at SAW7 are presented in Figure 3.14 and Figure 3.15 as timeseries and a wave rose respectively.

Wave energy at the development site is generally very mild and dominated by short-period wind swell, evidenced by typical significant wave heights of up to 0.4m and peak wave periods in the order of 2.5-3.5 seconds. Several short duration storms were captured during the measurement period, with wave heights of up to around 0.8m being observed with associated peak wave periods of around 4 seconds.

Longer peak wave periods in the order of 12-seconds are observed only during periods of very low wave heights, indicating very mild swell energy penetration into the bay.

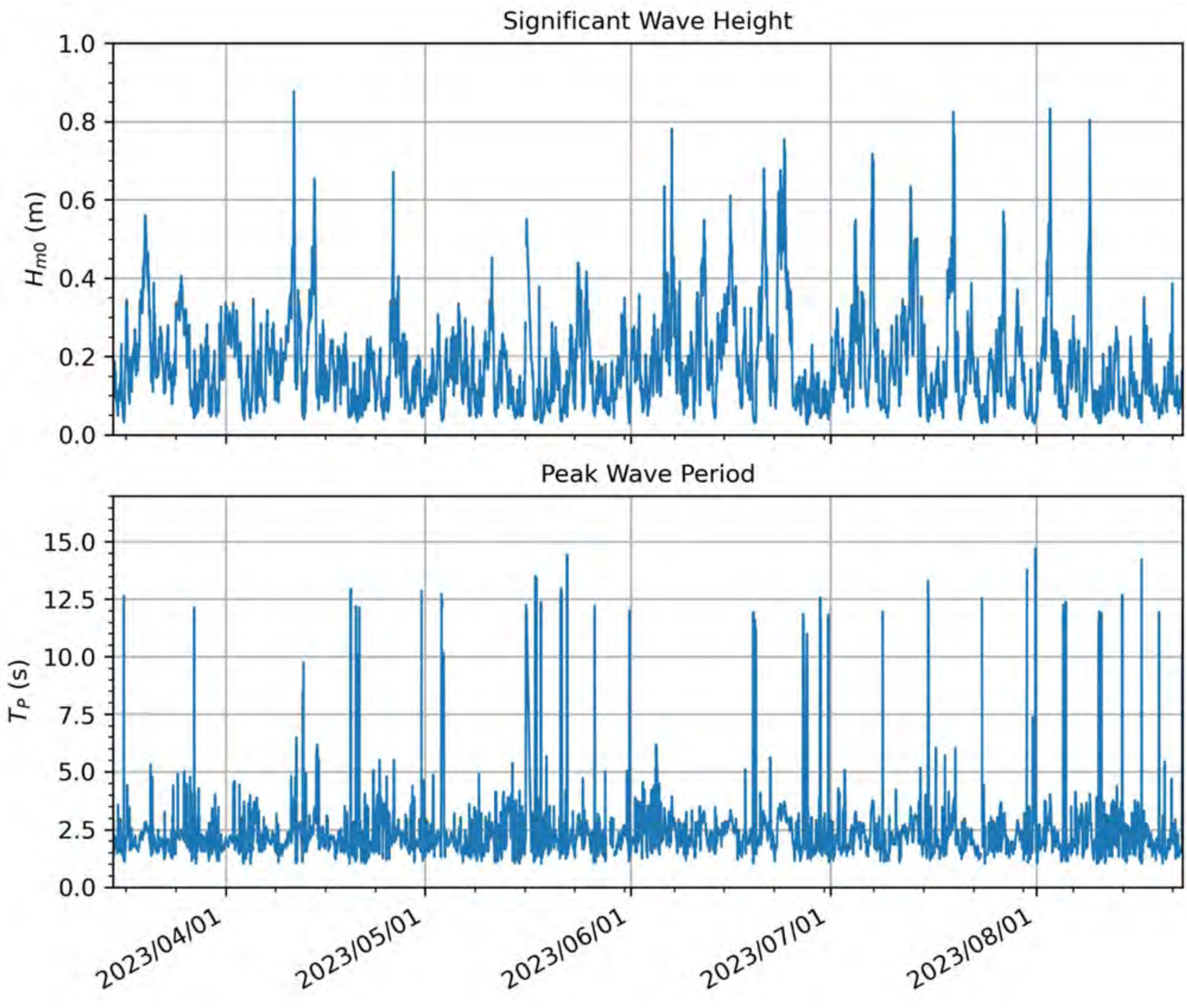


Figure 3.14 Wave height and period timeseries at SAW7

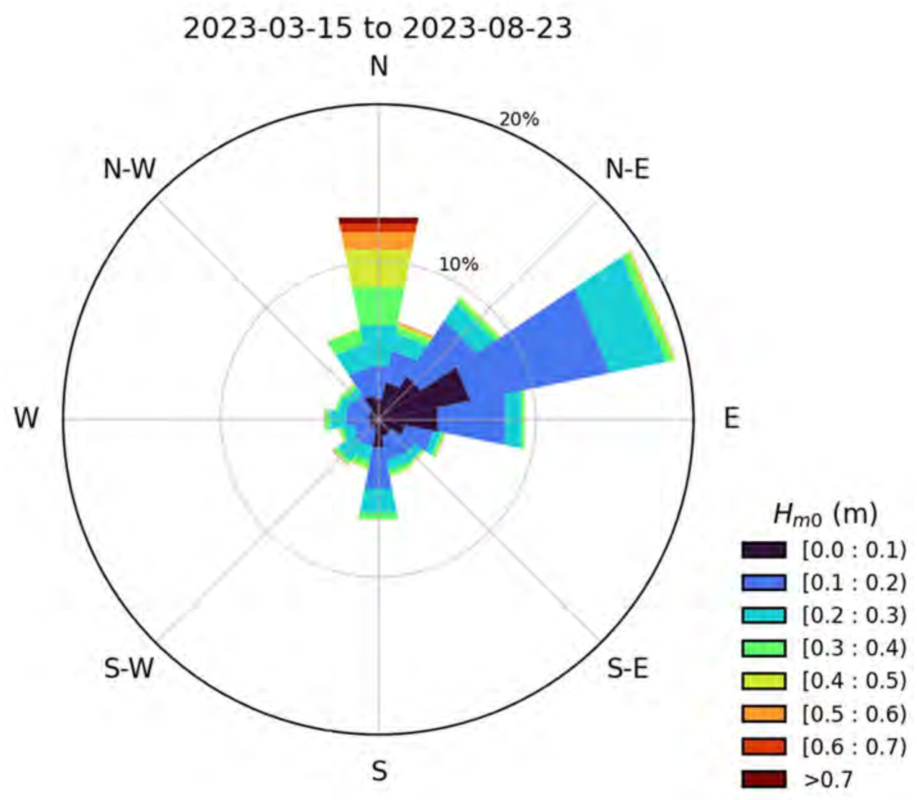


Figure 3.15 Wave rose at SAW7 (2023-03-15 to 2023-08-23)

4 Model Description and Validation

4.1 Overview of Models Developed for EPDP

The following numerical models have been developed as part of this study to support the ECI phase of the EPDP:

1. Near-field diffuser model (Section 4.4)
2. Mid-field hydrodynamic model (Section 4.5)
3. Coupled brine dispersion model (Section 4.6)
4. Wave model (Section 4.7)

These numerical models are described in further detail below.

4.2 Previous EPDP Modelling Studies

An oceanographic monitoring and far-field modelling assessment was undertaken on behalf of the EPDP by SARDI (Doubell & James, 2023). The objective of this study was to collect baseline data to support the development and validation of a three-dimensional hydrodynamic model for the Boston Bay region. The far-field model was developed with a spatial resolution of 300 m in the Boston Bay region and was nested within SARDI's regional Two Gulf's model. The nested model was used to produce a 5-year baseline hindcast simulation and was also used to assess the far-field dispersion potential for five outfall locations in the vicinity of Billy Lights Point, Point Boston and Cape Donnington. The brine dispersion assessment was based on a desalination plant with an assumed capacity of 12 GL per year (33 ML per day), which is approximately 37% higher than the current EPDP ultimate capacity.

The far-field modelling derived seasonally-averaged salinity anomalies due to the brine discharge and allowed for assessment of the receiving environment assimilative capacity as well as the relative dispersion characteristics of the five outfall locations. The SARDI report highlighted that a more detailed assessment, including near-field modelling would be required to ensure that the proposed outfall design achieved sufficient dilution in the near field. Doubell & James (2023) also modelled the far-field transport and connectivity of blue mussel planktonic larvae with the proposed desalination plant intake locations.

4.3 Brine Plume Mixing and Modelling Approach

The EPDP brine effluent discharged via the diffuser is characteristically denser than the receiving waters due to its higher salinity. As a result, and noting the vertical inclination of the discharge port, the high-velocity jet rises to a point until buoyancy forces become dominant and a descending trajectory ensues – causing the plume to impact the seabed where it spreads as a density current thereafter. The highest point in the plume trajectory is referred to as the terminal rise height and the horizontal translation where the plume impacts the bed is termed the impact point (Figure 4.1). The region where these processes take place is denoted the near-field (Abessi and Roberts, 2014a). In the near-field, the mixing processes are influenced by a combination of momentum and volumetric flux in the ascending phase, and by buoyancy and the associated gravitational instability-induced entrainment in the descending phase.

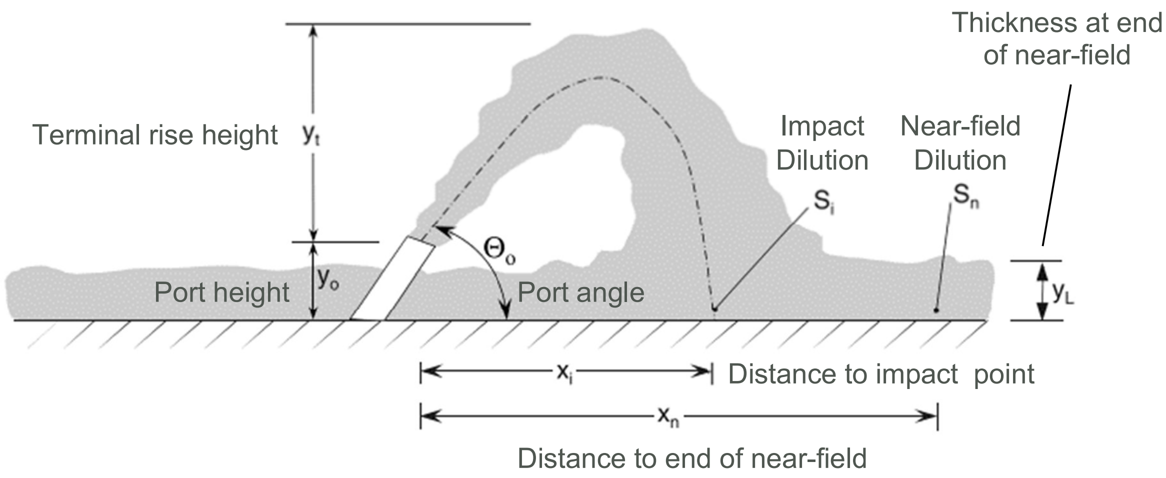


Figure 4.1 Definition diagram for key near-field characteristics of a singular dense jet (adapted from Abessi and Roberts (2014a))

After impact with the seabed, the effect of the initial jet momentum becomes less significant, where turbulent radial dispersion leads to further entrainment until the influence of density stratification leads to turbulent collapse, marking the end of the near-field mixing zone. Hereafter, the discharge is passively transported by ambient hydrodynamic forcing (Roberts et al., 1997; Choi et al., 2016). In this region, mixing and advection are governed by a combination of far-field processes including local currents, bottom friction and shear mixing. Further discussion on the near-field hydrodynamic mixing zone is provided in Annex A.

The dynamics associated with the momentum and buoyancy forces within the near-field occur at relatively small spatial scales (0.001 to 10 metres, Figure 4.2) and are inherently non-hydrostatic. This region of flow is termed the near-field mixing zone. In general, the scales of ambient motion are significantly larger (100 to 1000s of metres, Figure 4.2) than the near-field. For this reason, the region where the ambient conditions take control of the mixing processes are termed far-field (hereafter referred as the mid-field in this report), and commonly modelled with larger-scale hydrodynamic models which typically apply a hydrostatic approximation.

The length and timescales of these near-field mechanisms are not able to be resolved directly within mid-field hydrodynamic models, thus necessitating the need to resolve these processes with a dedicated near-field solver.

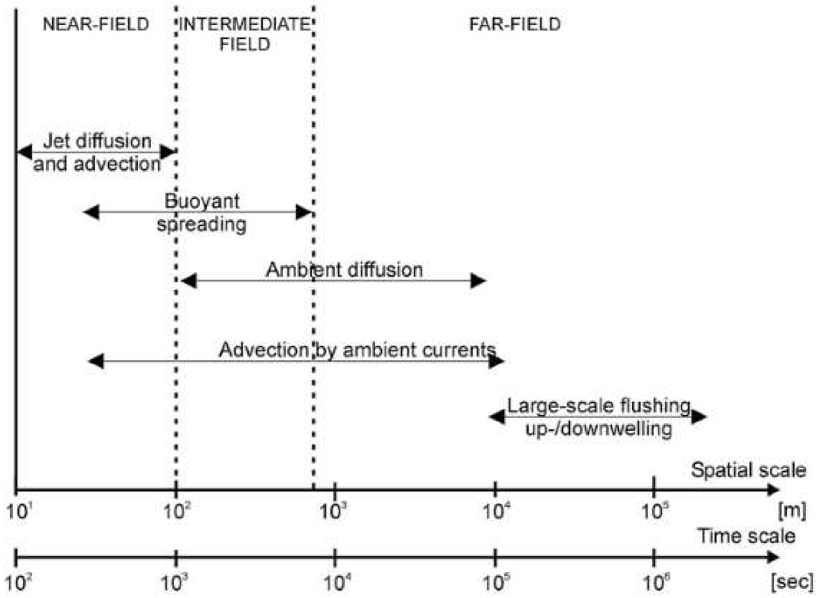


Figure 4.2 Typical temporal and length scales related to transport and mixing processes of coastal discharges (Bleninger and Morelissen, 2015)

4.4 Near-field Diffuser Model

The present study adopted a proven computational fluid dynamics (CFD) tool for simulating the near-field behaviour of the proposed EPDP discharge. This CFD tool was used to obtain realistic plume characteristics under different ambient conditions at the nominal discharge salinity, temperature and flow rate for the predetermined EPDP operating conditions. The use of CFD for the near-field modelling was rationalised over commercial integral entrainment models such as Visual Plumes, CORMIX and VISJET for several reasons including, but not limited to:

- Ability to resolve complex diffuser configurations, including the representation of the multiport diffuser design;
- Ability to resolve plume dynamics beyond the point of plume impact with the seabed (or sea surface) and into the intermediate-field. This bathymetric interaction is particularly pertinent for the EPDP outfall due to its proposed positioning on a (submerged) hillock, where the undulating bathymetry can be directly accommodated in the CFD model;
- Ability to resolve brine sublayer accumulation under low current conditions. While a steady-state methodology is proposed, CFD can resolve the density-induced accumulation of brine around the diffuser under low current speeds, whereas this mechanism cannot be accommodated with entrainment models. This is particularly relevant to the Port Lincoln site, where the occurrence of dodge tides may result in extended periods under near-quiescent conditions.
- Superior near-field model validation performance relative to integral entrainment models (Zhang et al., 2016).

The most important output from the CFD model was the concentration map of the plume in proximity of the diffuser (not just on the seabed), which was then subsequently used for integration with the mid-field model (Section 4.5). These methods, including the integration approach, are consistent with the published methods of Botelho et al. (2013) and Botelho et al. (2016). Details of the CFD model and results are presented below.

4.4.1 Model Software

OpenFOAM (Open Field Operation and Manipulation) was adopted as the CFD modelling tool for the near-field diffuser performance assessment. OpenFOAM (Weller et al., 1998) is developed by Open CFD Ltd (based in the United Kingdom). Advantages of using OpenFOAM include:

- Transparency of code. The user is able to interrogate any aspect of the source code to determine exactly which equations are being used;
- Extension of code. The user is able to write tailored conditions, modify equations, and create new solvers for specific problems; and
- Parallel computation. As the software is licenced under a GNU license, a mutli-CPU computer cluster may be used to solve large problems without incurring significant licence fees. This translates to significant increases in run speeds for complex models.

BMT has been using OpenFOAM for a significant portion of its CFD work for many years and this method has previously been applied by BMT to the analysis of several diffusers, for both positively and negatively buoyant discharges. For example, CFD simulations were employed for analysis of the proposed BHPB desalination plant diffuser at Point Lowly, South Australia, as part of the Olympic Dam EIS works. As part of those works, this CFD model was compared to experimental results of negatively buoyant plumes and yielded excellent results (BMT WBM, 2010).

Of relevance to the current scope, the same CFD methods used in this study were also recently deployed in an analysis of the Sepia Depression ocean outfall. Field measurements of plume dilution at that outfall were made using Rhodamine WT (RWT) and then compared to CFD model predictions. Excellent agreement was found between measurements and numerical predictions, therefore validating the CFD model in a real-world setting (BMT WBM, 2015). This, in addition to further RWT validation studies undertaken for legal proceedings around a site on the East coast of Australia (details unable to be disclosed) as well as model validations undertaken for the Gold Coast Desalination Plant (Baum and Gibbes, 2019), provide a wealth of evidence that the near-field diffuser simulation methods are well tested and robust in their predictive capability.

4.4.2 Model Setup

The equations solved in this application of OpenFOAM were configured for quasi-steady-state solutions of the flow using a Reynolds Averaged Navier-Stokes (RANS) approach. Here, the RANS equations were discretised using the finite volume method. Applicable equations for this approach are summarised in Baum and Gibbes (2019).

The turbulent contribution to the viscosity is calculated by a turbulence model which estimates the energy and length scales of the random fluctuations in the flow field. This variable influences the rate of dispersion/diffusion of the plume, in terms of both momentum and brine concentration. As the Reynolds numbers of the plumes are of the order of 100,000 (>450,000 for the proposed design), both the *k-ε* and *k-ω SST* (shear-stress transport) turbulence models were appropriate choices. The *k-ω SST* model was selected due to its greater stability and reduced sensitivity to initial conditions. Standard model constants were used.

Model constants used as input for the near-field CFD modelling are listed in Table 4.1. The port effluent concentration, C, assumes a value of 1 at the diffuser nozzles such that the inverse of C can be used to derive the effluent dilution. Note that the molecular diffusion constant, D, is very small compared to the turbulence induced mass diffusion (ν_t/Sc_t) throughout most of the model domain.

It is also worthwhile noting that the assumed densities take into account the background winter conditions obtained from density calculations at the intake locations and the assumed outfall salinity/temperature anomalies (Section 2.1.4). From Roberts et al. (1997), the near-field dilutions inversely scale as function of the discharge Froude number. From this relationship, analysis of the historical temperature and salinity data presented that winter density conditions constituted marginally reduced dilutions, and were subsequently used for the basis of the near-field modelling.

Table 4.1 Near-field model constants

Parameter	Symbol	Value
Molecular diffusivity	D	1.0×10^{-9} m^2/s
Turbulent Schmidt Number	Sc_t	0.70
Kinematic viscosity	ν	1.0×10^{-6} m^2/s
Gravitational acceleration	g	-9.81 m/s^2
Ambient density	ρ_a	1026.916 kg/m^3
Effluent density	ρ_0	1056.911 kg/m^3
Port effluent concentration	C	1.0

4.4.3 Mesh Development

The model domain was centred about the EPDP diffuser and spanned 300 m (N-S axis) by 352 m (E-W axis). To ensure accurate forcing of ambient currents, the domain was aligned with the principal component current direction derived from mid-field model results at the diffuser location. The surface interface was approximated with a “rigid lid” approximation, with an elevation of -1.088 mAHD (extreme low-seawater level). As a notable feature of the proposed discharge site, the undulating terrain of the bathymetry (captured by the high-resolution MES (2023) survey) was also accommodated included in model setup. The model domain and its context within the local outfall location bathymetry is shown in Figure 4.3.

Discretisation of the model domain used a base hexahedral cell length of 4.0 m, with refinements progressively defined on approach to the diffuser, with internal cell size lengths stepping down to as small as 0.015 m at the port orifices (Figure 4.4). Due to the negative buoyancy of the discharge, the seabed was also refined, with a maximum cell length of 2 m.

It is noted that the duckbill nozzle geometry from the diffuser design (Section 2.1.3) has been represented as a circular orifice in the near-field CFD model. This simplification of the nozzle orifice area is based on application of the continuity principal, where for a given flow rate and velocity (as specified by the manufacturer, Tideflex), the equivalent port diameter has been derived. Based on the works of Duer (2016) and Lee et al. (1997), this circular orifice approximation is considered to provide marginal conservatism over the elliptical geometry of a dilated duckbill valve. Here, an 84.2 mm port diameter was used.

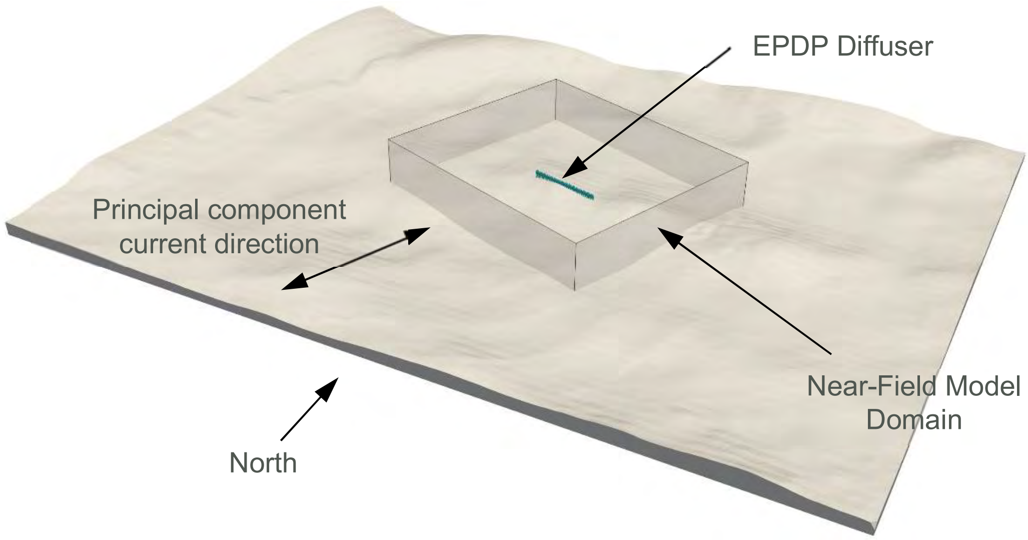


Figure 4.3 Near-field EPDP diffuser model domain and bathymetric setting. Note: vertically exaggerated by 5:1 scale

Accurately calculating the evolution of the predicted plumes is fundamental to the CFD modelling process. To appropriately resolve plume morphology and mixing, a fine mesh around the boundaries of the plumes, where spatial gradients in velocity, density and concentration are high, was required. However, the use of fine mesh through the entire model domain was not tractable and locating the plume to selectively provide this high resolution for each simulation in advance (where plume position responds to applied boundary conditions) was not possible. As such, an automatic mesh refinement strategy was developed for dynamically enforcing resolution where required within the CFD solutions. Specifically, for each simulation, a first pass solution was computed, then the mesh was automatically refined in the regions where spatial gradients exceeded a pre-defined threshold. This refinement process was repeated until predictions converged. This refining process has been developed at BMT over recent years, and has been applied, for example, to the Olympic Dam EIS diffuser modelling (BMT WBM 2011, Botelho et al. 2013) for the Port Pirie Transformation Project diffuser modelling (BMT WBM 2014), the Sepia Depression Ocean Outlet (BMT WBM 2015) and more recently, hydrotest discharge modelling in Papua New Guinea (BMT 2023). The mesh refinement steps for this case are shown in Figure 4.5, whereby the initial mesh began at ~830,000 cells and was progressively refined to ~5,200,000 cells in 6 steps.

Handling of such large domains were achieved by running the simulations in parallel on dedicated 16-core processor computing nodes on one of BMT’s high-performance-computing (HPC) facilities.

4.4.4 CFD Simulations

The near-field CFD simulations were designed to cover a wide range of ambient current conditions and the average typical diffuser flow properties. The background ambient currents were specified to cover a range between 0.01 – 0.25 m/s. Seven ambient velocity magnitudes were considered (Table 4.2), where currents were imposed along each direction on the principal axis, constituting a total of 14 model simulation configurations. It is noted that the north-north-east/south-south-west aligned principal axis is representative of the prevailing preferential longshore flow directions.

Finally, the outflow at each port was assumed to be constant (i.e., it was assumed there was no head loss along the outfall diffuser). The resulting outflows for the individual ports were 30 L/s. For each port the outflow was assigned as a velocity vector parallel to the port axis applied to cell faces defining the nozzle exit. The magnitude of the velocity vector was computed by the CFD solver using the specified flow rate and the total projected area of the cell faces. A tracer concentration equal to 1.0 was assigned at each of the diffuser ports.

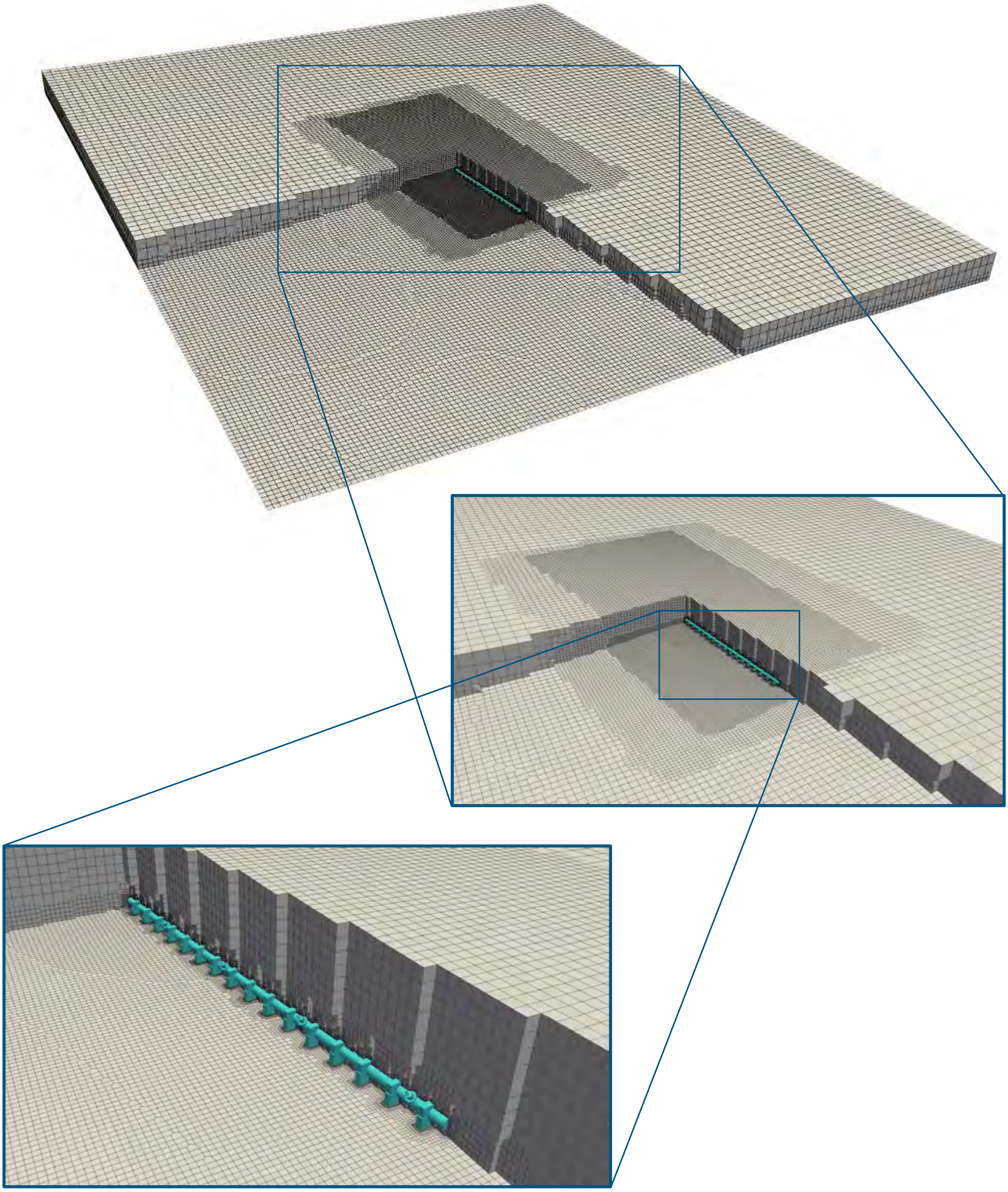
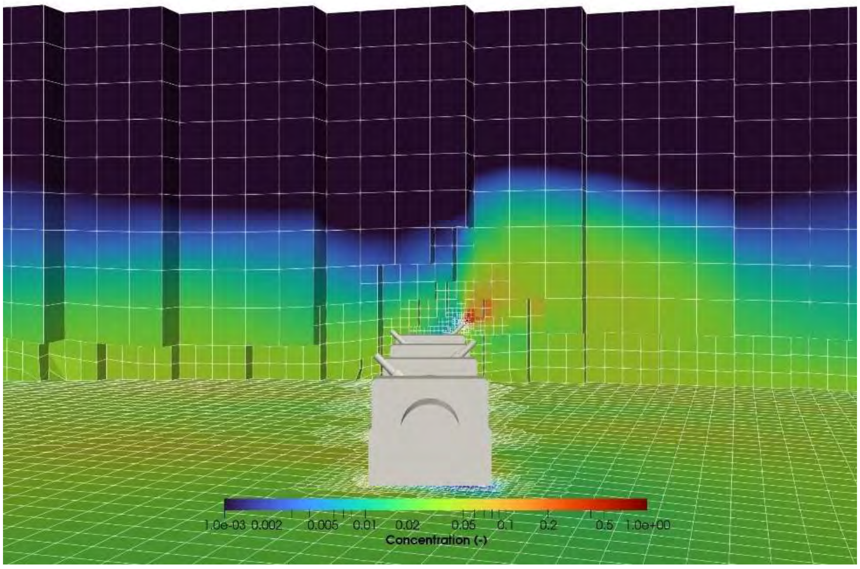


Figure 4.4 Near-field model mesh showing an increase in resolution towards the diffuser ports

Refinement Step 0: 389,964 cells



Refinement Step 6: 12,765,235 cells

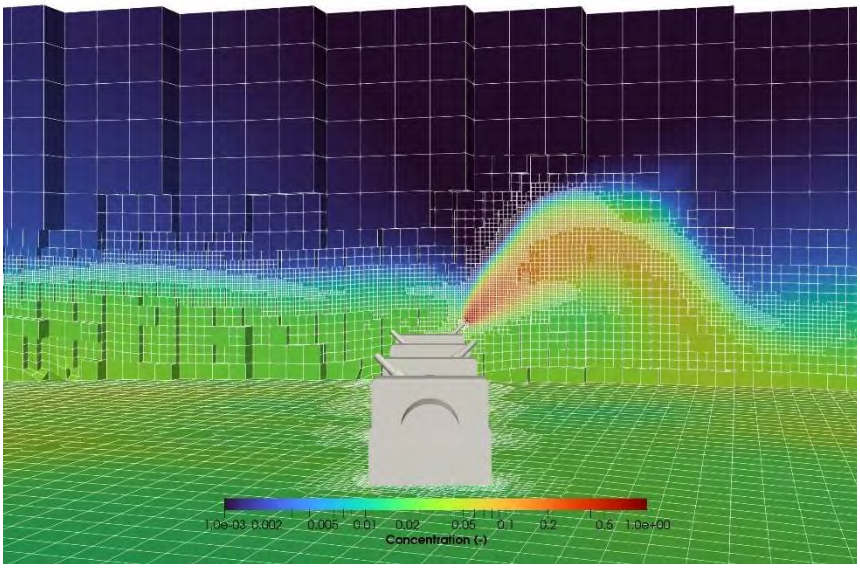


Figure 4.5 Near-field adaptive mesh refinement

Table 4.2 Boundary conditions considered in the near-field CFD simulations

Ambient Velocity (m/s)	Discharge Flow Rate (m^3/s)	Discharge Density (kg/m^3)	Ambient Density (kg/m^3)
0.010	0.48	1056.911	1029.916
0.025			
0.050			
0.100			
0.150			
0.200			
0.250			

Note 1: Discharge density is based on a +39.1 ppt salinity and +1°C temperature anomaly from the ambient properties.

4.4.5 Nearfield Mixing Distance

As discussed in detail in Annex A, turbulent diffuser mixing processes are distinctively characterised by near-field and far-field regions. The former near-field region is the zone in which transport and mixing are governed by diffuser-induced turbulent processes. Moving away from the diffuser these mixing dynamics eventually decay, whereby mixing thereafter is passively governed by ambient mixing processes, thus marking the transition from the near-field hydrodynamic mixing zone to the far-field. This near-field hydrodynamic mixing zone distance is typically used as basis to define the regulatory compliance point for specified threshold limits. The near-field region has been subject to scientific research, with description of the governing mixing processes and distance defining the hydrodynamic mixing zone captured in Annex A.

From non-dimensional scaling arguments presented in Abessi and Roberts (2015), the presented brine-only discharge conditions constitute a hydrodynamic mixing zone up to 32 m from the diffuser, and 40 m under normal plant operating conditions. Hereon, the presented analysis provides assessment relative to a 30 m radius from the diffuser. Further description around the 30 m mixing zone with comparison against regulatory guidelines applicable to similar desalination outfalls is provided in Annex A.

4.4.6 Model Results

Model results showing the predicted 1:40 iso-surface dilution for all simulated conditions are presented in Figure 4.6 (other iso-dilution surfaces of 1:60 and 1:80 are presented in Annex B). The iso-surface dilution presentation style was adopted to reveal the shape of the plume in three dimensions. To place these results in some context, a dilution of 40 is the equivalent of a salinity increase of approximately 0.978 ppt for a discharge salinity anomaly of +39.1 ppt (refer Section 2.1). To articulate the plume spatial extents relative to the mixing zone (Section 4.4.5), a 30 m radius around the diffuser is also illustrated.

With the alternating port diffuser configuration, the plumes follow relatively symmetrical distributions either side of the diffuser for low current speeds (< 0.10 m/s). The 12-m spacing between consecutively oriented plumes appears to concur with the “widely-spaced” port spacing regime set by Abessi and Roberts (2014a), where the plumes do not present any form of coalescence along their trajectory. For the 1:40 dilution iso-contour, bed impact is observed for current speeds up to 0.10 m/s. Following impact, the 1:40 iso-contours do not present plume interaction and continue to dilute due to turbulent entrainment (refer Annex A). Merging of adjacent plumes following impact is visible for the 1:60 iso-contour (Annex B) for current speeds ≤ 0.10 m/s as the plumes radially spread, forming a brine sub-layer along the seabed.

The effect of ambient current dynamics appears to be more significant than the effect of the irregular bathymetry. With increasing ambient current, the counter-propagating jets present shortening of the horizontal abscissa of the jet trajectory, ultimately falling back on themselves for current speeds ~0.10 m/s. For higher current speeds, the counter-propagating jet trajectories are reversed – impacting downstream. As expected, the co-propagating jet trajectories become elongated in the co-flowing direction. For current-governed conditions (≥ 0.10 m/s), the effect of the co-flowing current on elongation and increasing dilution can be observed as the plume iso-surface becomes progressively thinner for higher ambient velocities.

Under moderately dynamic current conditions (0.05 m/s), the effect of bathymetry is most pronounced for the 1:80 dilution iso-contours (Annex B). Just to the north of the diffuser, the hillock features a slight gully-like depression north-east of the diffuser, where at its deepest location along the 30 m radius the gully is up to 1.1 m lower than the inshore-end. Resulting from the densimetric bathymetry interactions, the 1:80 plume iso-contours show additional merging and increased pronation for both current directions. This effect is not discernible under the 1:40 and 1:60 iso-contours, suggesting that the bathymetric features at the diffuser location play a minor role in the near-field mixing zone.

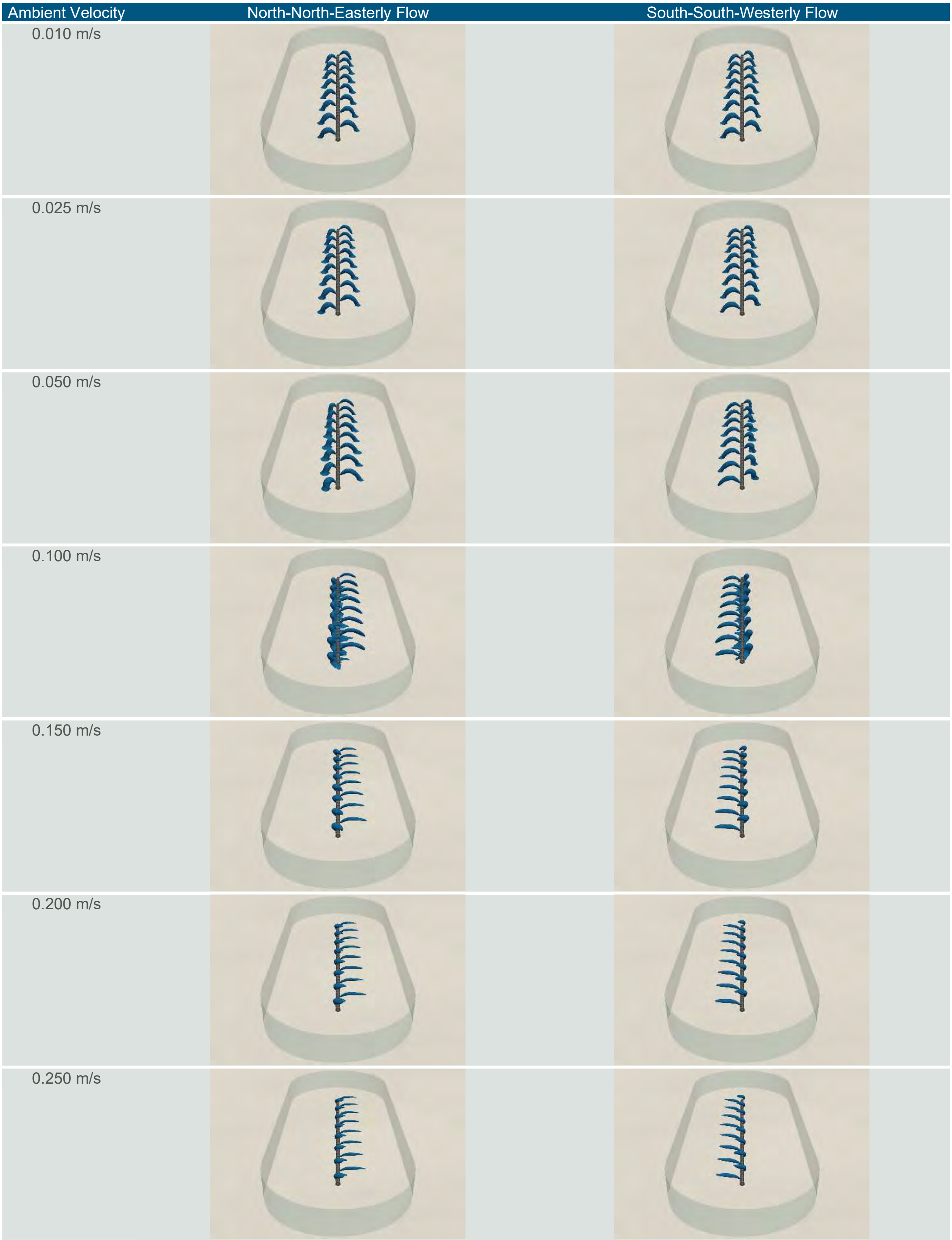


Figure 4.6 EPDP brine discharge plume resulting from near-field CFD simulations. Results show the 1:40 iso-surface dilution looking on-shore. Opaque boundary represents 30 m mixing zone

Minimum Seabed Dilutions

As discussed in Section 4.4.5 nearfield mixing of the dynamic plumes occurs within a distance of 30 m from the diffuser. Lower dilutions are modelled closer than 30 m from the diffuser, however these represent an intermediate condition where dynamic mixing is still ongoing. Predicted minimum dilutions at 30 m (or more) summarise the performance of the diffuser following the completion of nearfield turbulent mixing processes.

The predicted minimum seabed dilutions are presented for the array of modelled current conditions in Table 4.3. For this analysis, the near-field CFD results have been resampled on a 0.5 m three-dimensional grid.

Table 4.3 Minimum near-field dilution for various current conditions

Ambient Velocity (m/s)	Minimum Dilution ≥ 30 m from the Diffuser (–)	
	North-North-East Current	South-South-West Current
0.01	70.5	70.9
0.025	64.9	65.8
0.05	58.9	63.5
0.1	63.8	67.5
0.15	83.2	86.8
0.2	100.0	102.9
0.25	103.8	107.9

Minimum dilutions beyond the hydrodynamic mixing zone perform better than a 1:40 dilution threshold for all modelled current directions and their respective current velocities. Moderately dynamic conditions of about 0.05 m/s current velocity constitute the worst case for dilutions at the 30 m radius, with a dilution of 58.9 at the seabed under a north-northeasterly current condition. The south-southwesterly current also yields worst case dilutions for 0.05 m/s, however due to the bathymetric features previously noted in Section 4.4.6, dilutions for the north-northeasterly condition are marginally less.

Plume Terminal Rise

To consider the effect of plume terminal rise and the impact to visual amenity, assessment has been undertaken to determine the maximum elevation of the discharge in the diffuser near-field, using a nominal 0.5% concentration threshold (i.e., 200 dilution units), with results presented in Table 4.4. Here, the maximum brine plume elevation corresponds to -4.77 mAHD (0.15 m/s current speed), where for the extreme low-seawater level, this equates to 3.7 m freeboard. In accordance with Abessi and Roberts (2015a), this condition corresponds to a fully-submerged deep-discharge regime and is considered to have no visible surface impact from the brine plume itself.

The maximum brine plume elevation corresponds to the moderately dynamic ambient current condition as the counter-propagating discharges are deflected against the opposing current, resulting in terminal rise heights ~0.5 m higher than the near-quiescent conditions. Under near-quiescent conditions (0.01 m/s), near-field model results indicate approximately 4.1 m freeboard between the jet terminal rise and the extreme low-seawater level.

Table 4.4 Summary of near-field maximum jet terminal rise elevations

Ambient Velocity (m/s)	Maximum Jet Terminal Rise Elevation (mAHD)	
	North-North-East Current	South-South-West Current
0.010	-5.22	-5.29
0.025	-5.29	-5.63
0.050	-5.50	-5.66
0.100	-5.39	-5.36
0.150	**-4.77**	-4.78
0.200	-5.25	-5.29
0.250	-5.64	-5.71

Note: Extreme low-seawater level: -1.088 mAHD

4.4.7 Discussion of Near-Field Diffuser Performance

A near-field CFD modelling assessment has been conducted for the proposed EPDP diffuser design, where the performance was evaluated for an array of ambient current conditions. Model validation assessment (Annex A) indicates a margin of 25% conservatism in the CFD model's seabed dilution estimates, relative to equivalent laboratory-based experiment outcomes. This validation result provides confidence that the modelled dilution should be a realistic representation of the real-world performance.

The near-field model assessment indicates that the EPDP diffuser design achieves a worst case 1:59 brine dilution which is exceeding the 1:40 performance target.

4.5 Midfield Hydrodynamic Model

4.5.1 Hydrodynamic Modelling Software

The hydrodynamic modelling component of the study was undertaken using the TUFLOW FV software, which is developed and distributed by BMT (https://www.tuflow.com/products/tuflow-fv/). TUFLOW FV is a numerical hydrodynamic model for the two-dimensional (2D) and three-dimensional (3D) Non-Linear Shallow Water Equations (NLSWE). The model is suitable for solving a wide range of hydrodynamic systems ranging in scale from open channels and floodplains, through estuaries to coasts and oceans. The three-dimensional, baroclinic model configuration was deployed in this study.

The Finite-Volume (FV) numerical scheme employed by TUFLOW FV can solve the NLSWE on both structured rectilinear grids and unstructured, i.e., flexible, meshes comprised of triangular and quadrilateral elements. The flexible mesh allows for seamless boundary fitting along complex coastlines or open channels as well as accurately and efficiently representing complex bathymetries with a minimum number of computational elements. The flexible mesh capability is efficient at resolving a range of scales in a single model without requiring multiple domain nesting. This allows increased resolution in areas of specific interest for projects while avoiding excessive computational expense due to unnecessarily detailed representation where this is not required. In coastal regions a flexible mesh allows for much more detailed and accurate representation of complex shorelines and bathymetries and the influence that these have on flow fields, such as the case of Boston Bay and pertinent to the EPDP discharge assessment.

4.5.2 Model Domain

The hydrodynamic mid-field hydrodynamic model domain is shown in Figure 4.7. To facilitate continuity from previous modelling efforts, the offshore boundary aligns with boundary conditions supplied from the SARDI model (Doubell), extending from Massena Bay in the north, to Maclaren Point in the south. The domain extends approximately 37 km from the proposed EPDP discharge site, with depths up to approximately 25 m.

The flexible, unstructured mesh consists of 24,382 horizontal mesh cells with characteristic dimensions varying from approximately 950 m along the offshore boundary, decreasing to 20 m in vicinity of the proposed EPDP infrastructure locations and the existing Port Lincoln WWTP outfall off of Billy Lights Point. The mid-field model mesh is shown in Figure 4.7 and Figure 4.8. In order to accurately facilitate integration of the near-/mid-field model coupling, the model mesh adopts a 20 × 20 m rectilinear grid in vicinity of the proposed EPDP diffuser.

4.5.3 Numerical Scheme and Parameterisation

The mid-field hydrodynamic model was undertaken in three-dimensional baroclinic mode and adopted a hybrid sigma/z-coordinate vertical layer scheme. This vertical discretisation of the model was defined with the following configuration:

- -1.5 mAHD to 1.5 mAHD: three sigma layers
- -1.5 mAHD to -20.5 mAHD: 1 m vertical resolution
- < -20.5 mAHD: 2 m vertical resolution

Salinity and temperature was included within the model as density-coupled scalar constituents, thus supporting simulation of baroclinic density gradient forcing and the effect of vertical density stratification on turbulent mixing in the water column.

Bottom and friction was modelled using a quadratic drag law with a roughness length-scale parameterisation. Horizontal turbulent mixing was calculated using the Smagorinsky (1963) model for horizontal eddy-viscosity and scalar-diffusivity. Vertical turbulent mixing was calculated through coupling TUFLOW FV with the General Ocean Turbulence Model (GOTM, by Burchard and Bolding, 2000) using a second-order k-omega turbulence scheme.

A summary of the model configuration and parameterisation applied in this study is summarised in Table 4.5:

Table 4.5 Summary of TUFLOW FV model configuration and parameterisations

Model Configuration Description	Model/Value
Horizontal momentum mixing model	Smagorinsky
Horizontal scalar mixing model	Smagorinsky. Lower diffusivity limit of 1 m^2/s
Bottom drag model	Derived from application of the “log law”
Horizontal spatial order	Second order
Vertical spatial order	Second order
Vertical mixing model	2-equation *k-ω* with default parameters (GOTM library) Lower diffusivity limit of 3.0e-5 m^2/s

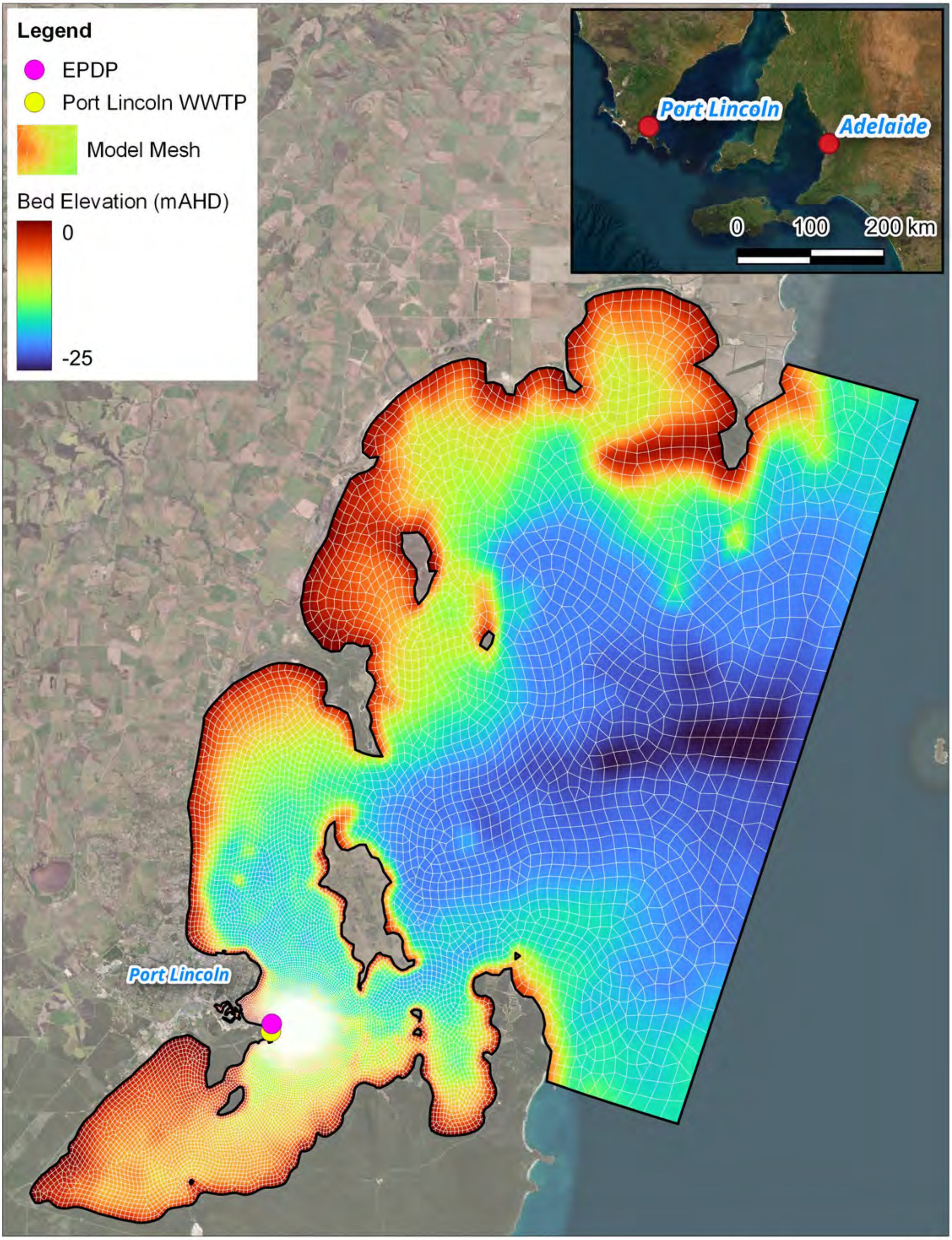
4.5.4 Environmental Boundary Conditions

In alignment with previous modelling, meteorological model forcing will be primarily based upon boundary conditions obtained from global NCEP CFSR model reanalyses (NOAA, 2012), with a 1-hour temporal resolution and a ~0.2-degree spatial resolution.

Doubell and James (2023) identified that the CFSR precipitation was overpredicted under certain conditions, contributing to divergent salinity predictions from field observations. Due to the pertinence of model predictive skill in salinity predictions for the discharge assessment, the mid-field precipitation forcing was globally applied across the model domain in accordance with the Bureau of Meteorology’s Port Lincoln rainfall observations (Station ID: 018192, refer Figure 3.5).

To ensure continuity of the rigorously calibrated SARDI Two Gulfs Model (TGM), and in alignment with previous EPDP modelling conducted by SARDI, the offshore boundary was forced using extracted model output profiles from the SARDI model. Forcing at the offshore boundary will include timeseries of water level, as well as time-varying profiles of temperature, salinity, and velocity/direction.

A summary of the model boundary conditions proposed to be used to force the mid-field hydrodynamic model is presented in Table 1.1.



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Mid-Field Hydrodynamic Model Extent and Bathymetry

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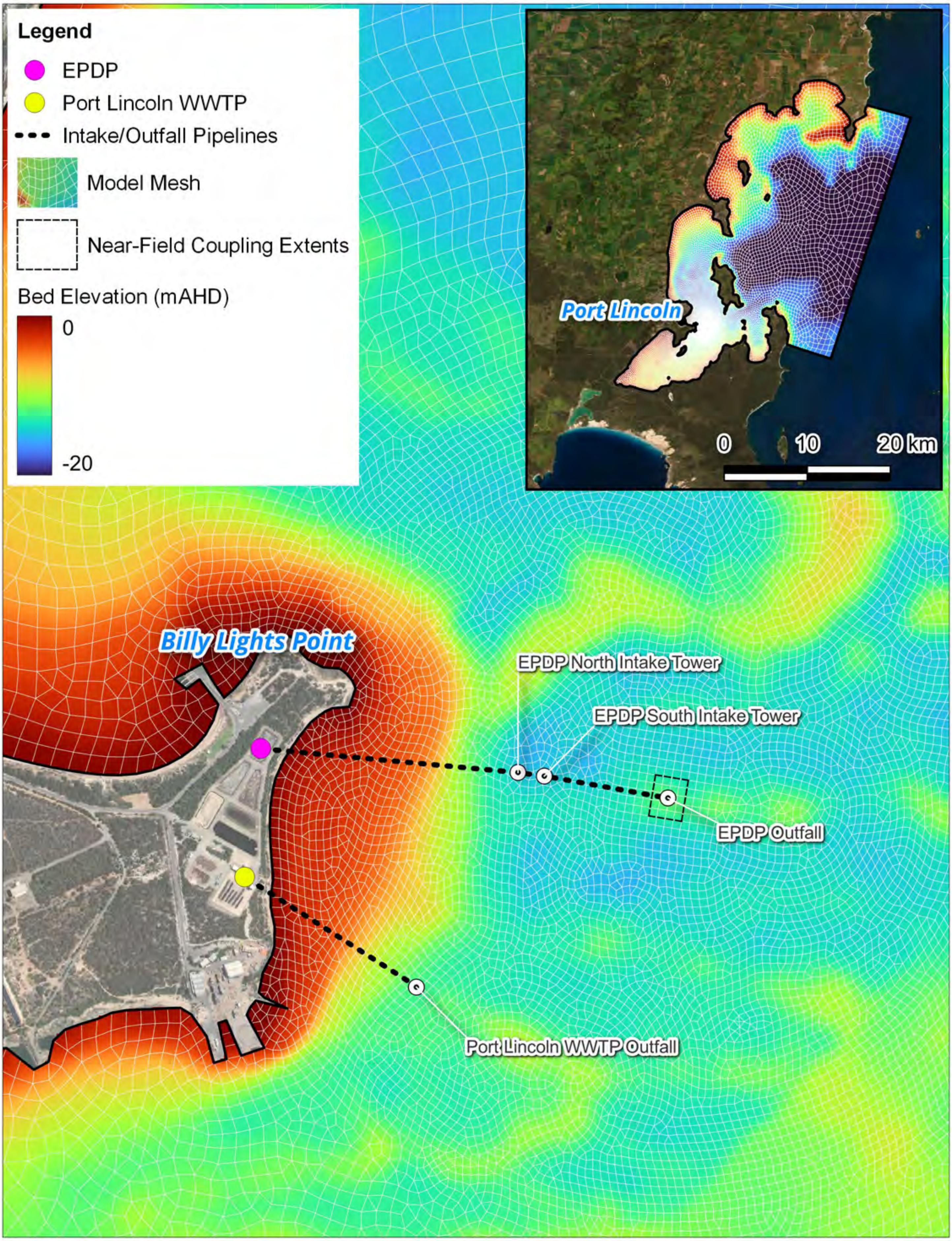

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Mid-Field Hydrodynamic Model Mesh Detail

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BMT endeavours to ensure that the information provided in this map is correct at the time of publication. BMT does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

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Table 4.6 Summary of environmental boundary condition inputs to be applied in the mid-field model

Category	Variables	Source	Comments
Meteorological	Wind speed/direction Air temperature Long wave radiation Short wave radiation Relative humidity	CFSR	
	Rainfall	Bureau of Meteorology	Station ID: 018192
Offshore Boundary	Water level Profiles of: • Temperature • Salinity • Water Velocity/Direction	SARDI	

4.5.5 Sediment Parameterisation

For the purposes of assessing the potential total suspended sediment impacts relating to the EPDP discharge, the mid-field TUFLOW FV model utilised the sediment transport module. Here, the discharged sediment fluxes are represented by a simplified single clay sediment fraction with a median particle size of 4×10^{-6} m and a constant settling velocity of 1.4×10^{-5} m/s. No ambient sediments are resolved in the mid-field model which as a result simulates SWRO discharge plume TSS concentrations above ambient in units of mg/L.

4.5.6 Port Lincoln WWTP Discharge

With the diffuser configuration of the WWTP outfall, the discharge is subject to advection and buoyancy driven turbulent mixing processing in the diffuser near-field. While a near- to mid-field coupling approach is not facilitated in this assessment, near-field modelling has been undertaken using the Updated merge three-dimensional sub-model within Visual Plumes (VPlumes; Davis, 1999). Here, VPlumes has been used to resolve the projected plume trajectory, and henceforth the port-by-port seeding locations in the mid-field model.

Based on near-field modelling results (Figure 4.9), the positively buoyant discharge condition sees impingement of the plume with the surface. The initial horizontal momentum of the jet also results in translation in the planform direction away from the diffuser. Based on these results, the mid-field model has adopted seeding in the top 1-m of the water column, at a distance of 5 m away from the diffuser. The WWTP model inflow locations relative to the WWTP diffuser and EPDP intakes are illustrated in Figure 4.10.

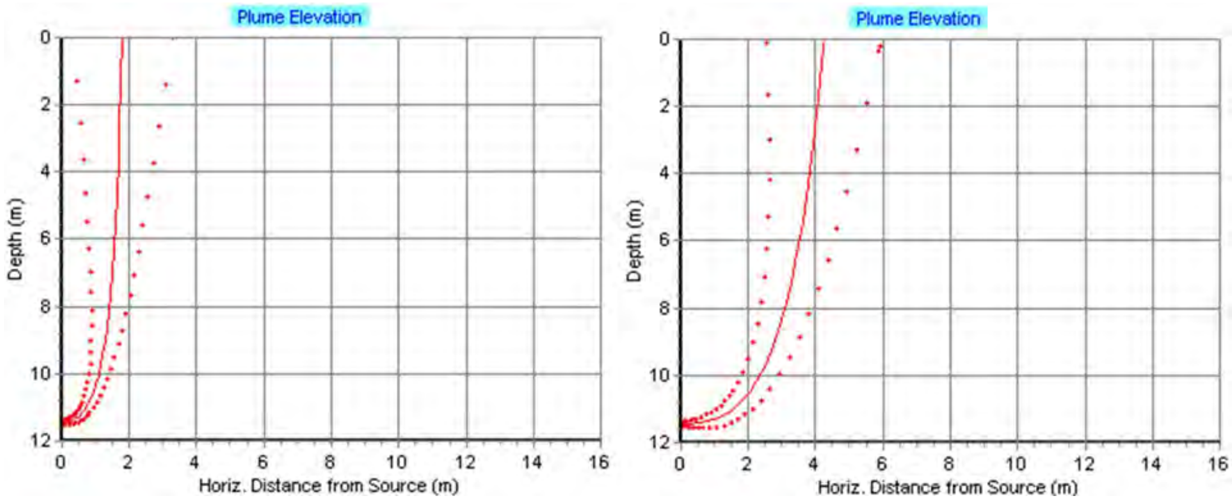


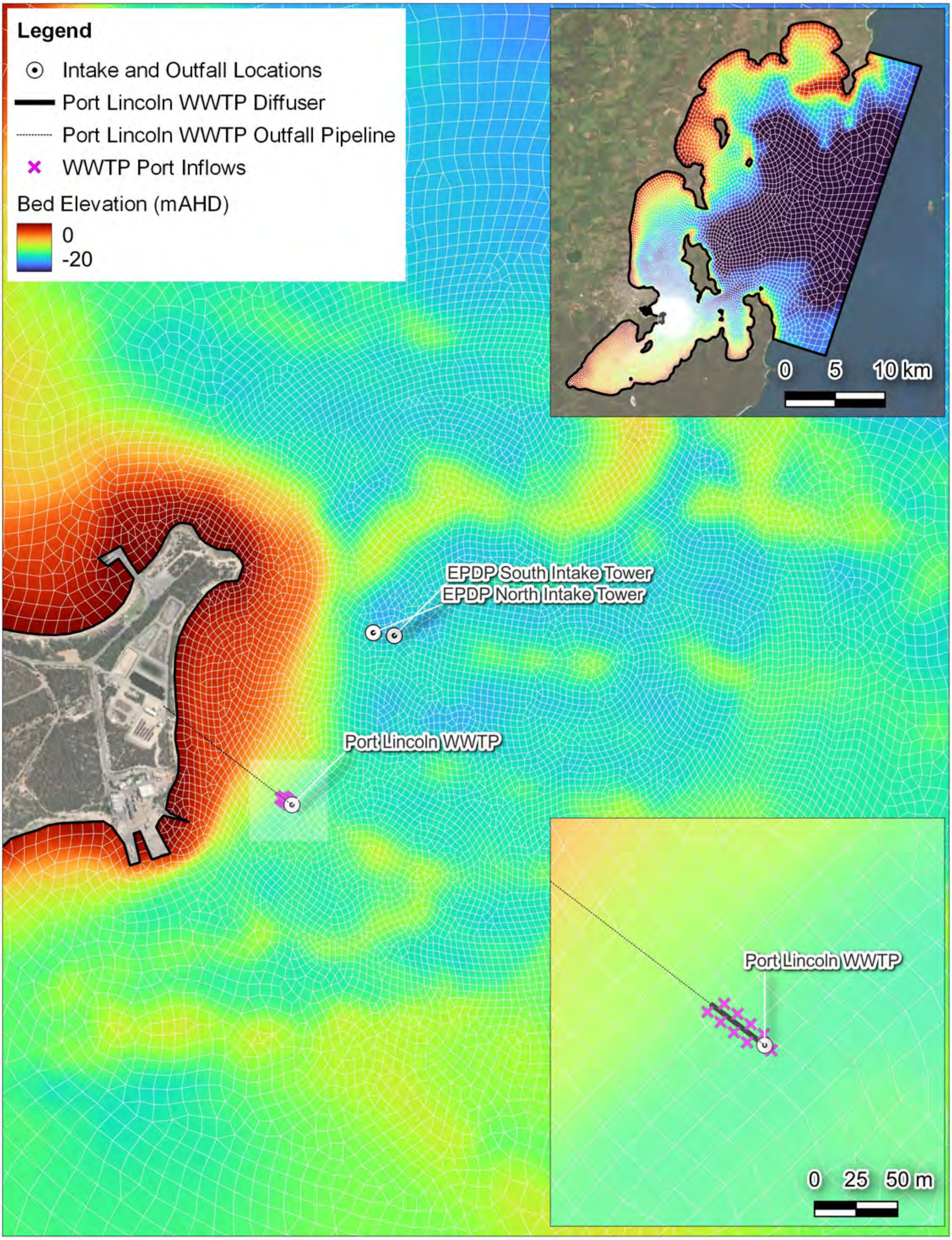
Figure 4.9 VPlumes buoyant WWTP plume trajectory predictions under quiescent ambient conditions. Left: 30 L/s flow rate; right: 80 L/s

In addition to the WWTP effluent discharge properties (flow rate, temperature, salinity, bacteriological counts) defined in Section 2.2.2, the effluent has also been assigned as a tracer in the mid-field model to facilitate the migration of the plume. For this assessment, two tracers have been assigned:

- A conservative tracer to derive the WWTP plume dilution contours;
- A decaying tracer supported by an exponential decay model to represent bacteriological count concentrations.

The replication of bacteriological behaviour with a decaying tracer is implemented to capture the die-off that occurs as function of salinity, temperature and solar radiation. Due to the effects of solar radiation, higher rates of bacteriological decay occur during the day than at night. For the purposes of this assessment, the decay rate will conservatively apply a night-based decay rate in accordance with Mancini (1978). Further, Mancini (1978) also demonstrated that lower decay rates occur in cooler water and therefore a conservative “winter” condition with a decay constant of 0.9 units/day has been conservatively adopted for the purpose of this study.

Both tracers are applied as a unit concentration, where the tracer concentrations are separately scaled to represent concentrations under typical WWTP operating conditions (undiluted bacteriological counts = 5,500 MPN/100 mL) and for upset operating conditions (100,000 MPN/100 mL). This approach assumes that the subsequent operating condition has been in-place for the entirety of the simulation. It is worthwhile to note that like approximation is likely to produce a conservative approximation for the upset condition, however the typical condition may be slightly under-represented as the discrete periods of upset conditions that would occur in reality are not accommodated.



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Mid-Field Model Schemetisation for Port Lincoln WWTP and EPDP Intake Short-Circuiting Assessment

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4.5.7 Model Validation

The hydrodynamic (TUFLOWFV) was validated against the metocean measurements made for the period of 1/8/2021 to 1/8/2022. Metocean moorings were deployed at the SAW1 and SAW2 as described in Section 3.6. ADCP and CTD instrumentation were mounted on seabed frames allowing for measurement of water level variation, current profiles, near-bed salinity and near-bed temperature.

Water Level

Figure 4.11 and Figure 4.12 show a comparison of water levels predicted by the model with measurements at two different locations (SAW1 and SAW2). The following model skill metrics were calculated; bias, root mean square error (RMSE), coefficient of determination (r^2), and index of agreement (IOA) and are reported in the figure titles and summarised in Table 4.7. These statistics indicate that the model performed well. It accurately reproduced both the phase and amplitude of water level variability.

Table 4.7 Model skill metrics for predicting measured water levels

Total Water Level	SAW1	SAW2
r^2	0.95	0.94
RMSE (cm)	8.57	8.76
Bias (cm)	0.51	0.12
Index of agreement (IOA)	0.99	0.99

Currents

The ADCP measurements at SAW1 and SAW2 were used to calculate depth-averaged current velocities which were subsequently resolved along the principal axis. The model skill at predicting the principal-axis current speed was then evaluated.

The main axis of the depth averaged currents is aligned in an east west direction (21.23 °TN) at SAW1 while depth-averaged currents at SAW1 and SAW2 are aligned in an east west to northeast direction (68.45°TN). The currents observed are predominantly tidally driven with maximum amplitude of 0.37 m/s and 0.31 m/s at measurement locations at SAW1 and SAW2, respectively (see Figure 4.13 and Figure 4.14).

Current amplitudes fall close zero every 14 days during “dodge” tides (a neap tide with minimum rise and fall). The dodge tide periods typically persist over the course of 2 to 3 days.

There is a good agreement between the measured and modelled depth-averaged currents in the model at measurement location SAW2 and slightly less so for SAW1. The model score statistics has been given in the plot titles and Table 4.8.

Direct comparison between model results and the ADCP located at SAW7 since March 2023 was not possible due to the unavailability of offshore boundary conditions from SARDI’s regional model. For this reason, a statistical comparison of predicted and measured current speed has been conducted. As shown in Figure XX, this comparison demonstrates that the model accurately predicts the current speed in the vicinity of Billy Lights Point.

Table 4.8 Model skill metrics for predicting measured depth-averaged current speed

Depth-averaged current speed	SAW1	SAW2
r^2	0.60	0.74
RMSE (cm/s)	5.93	3.31
Bias (cm/s)	2.06	-0.11

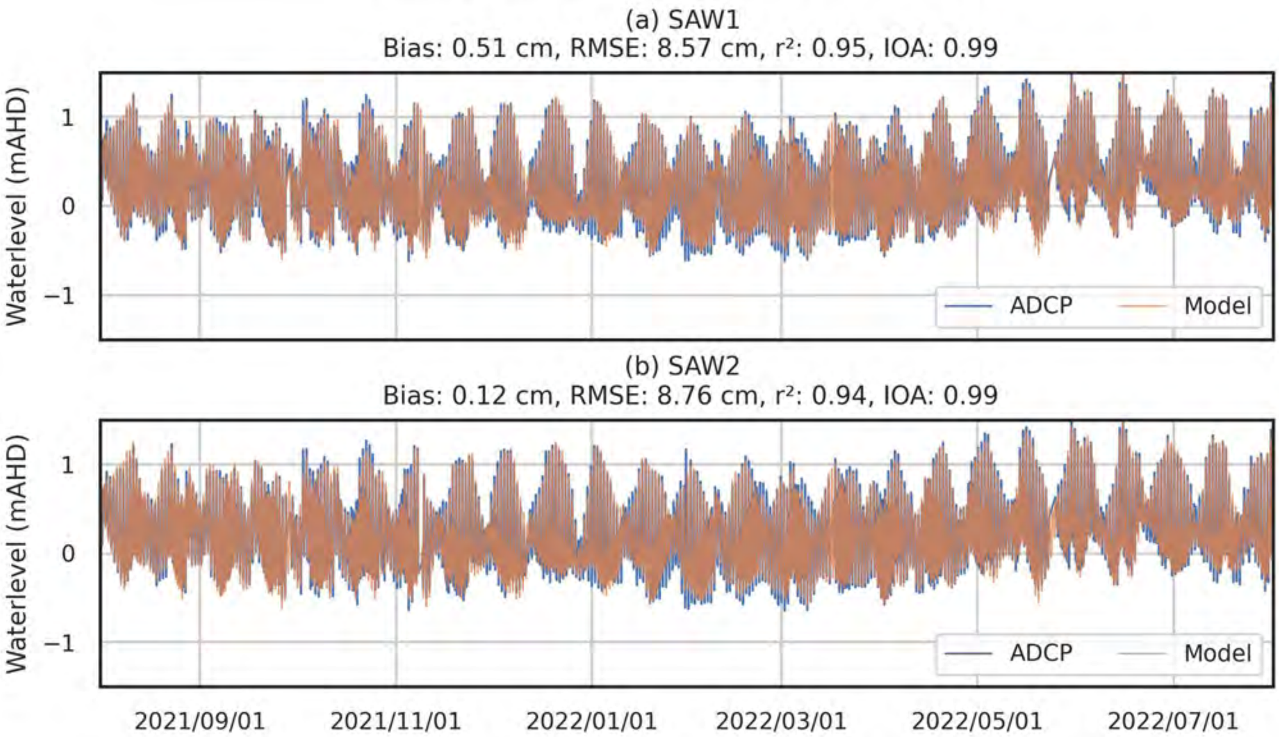


Figure 4.11 Comparison of predicted and measured water levels at SAW1 and SAW2 moorings

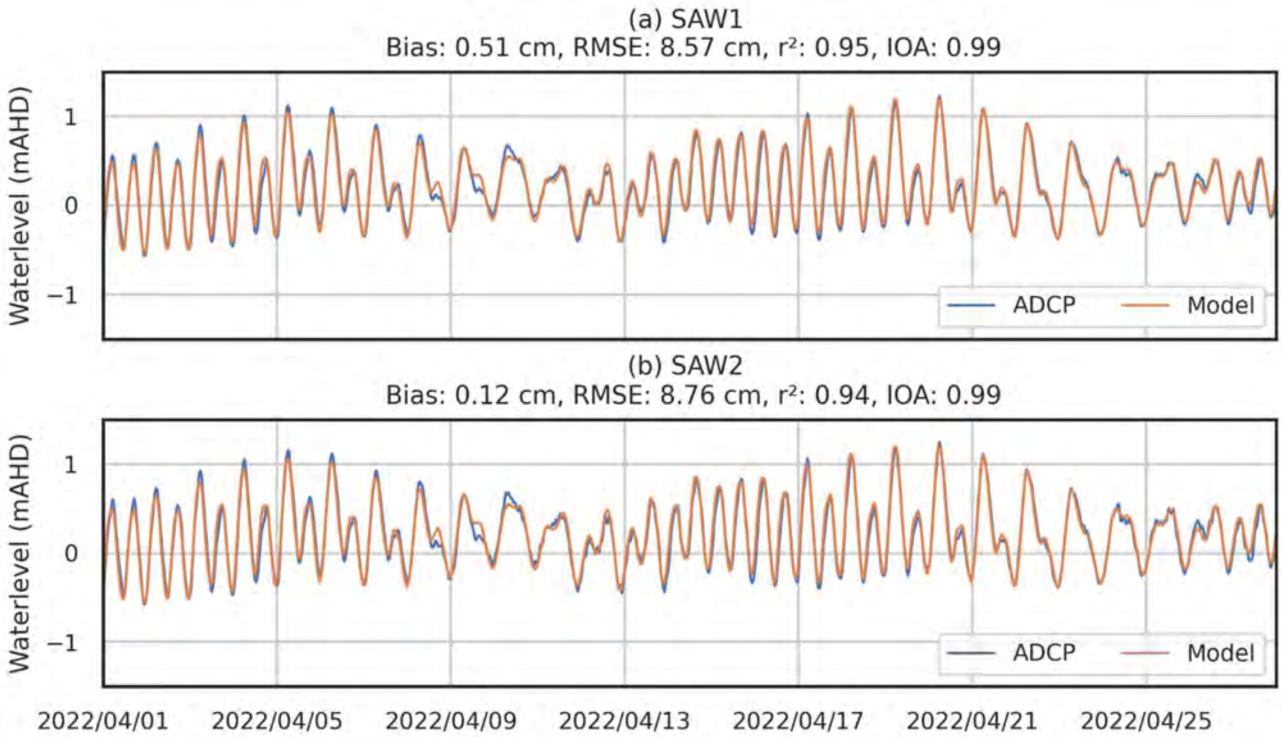


Figure 4.12 Comparison of predicted and measured water levels at SAW1 and SAW2 moorings during April 2022

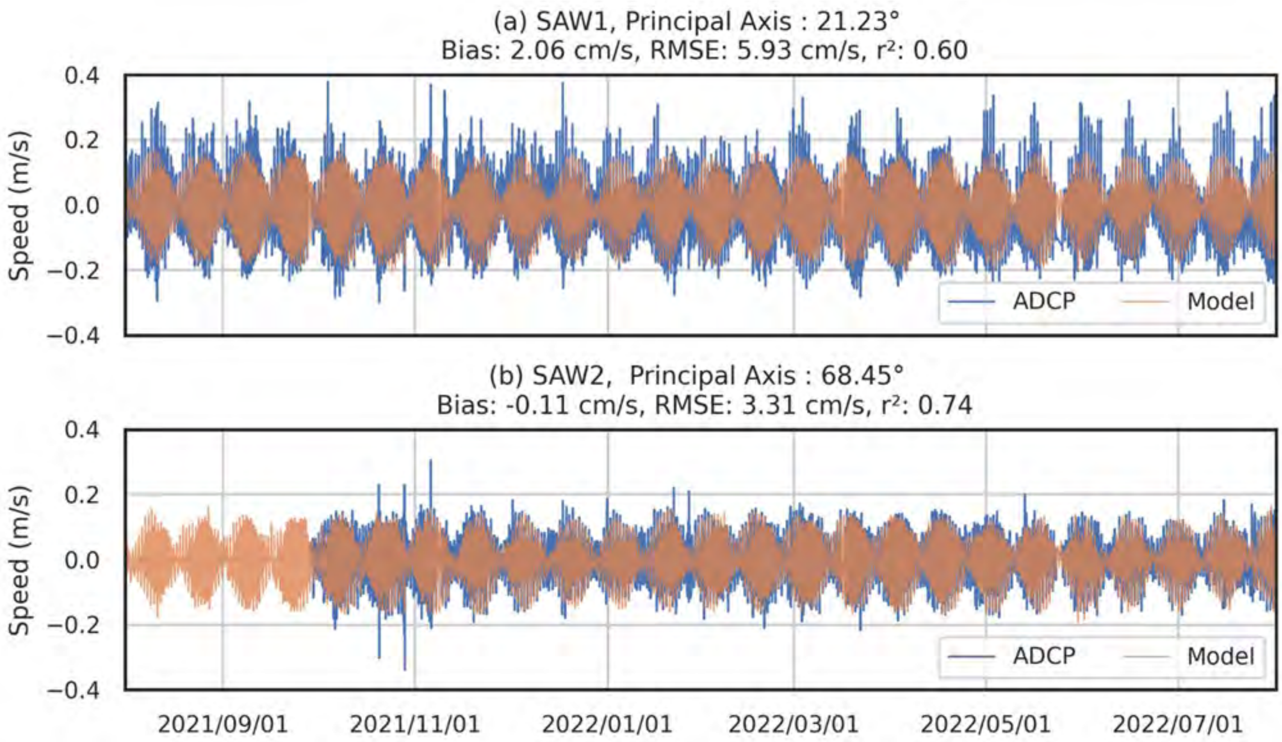


Figure 4.13 Comparison of predicted and measured current velocity at SAW1 and SAW2 moorings

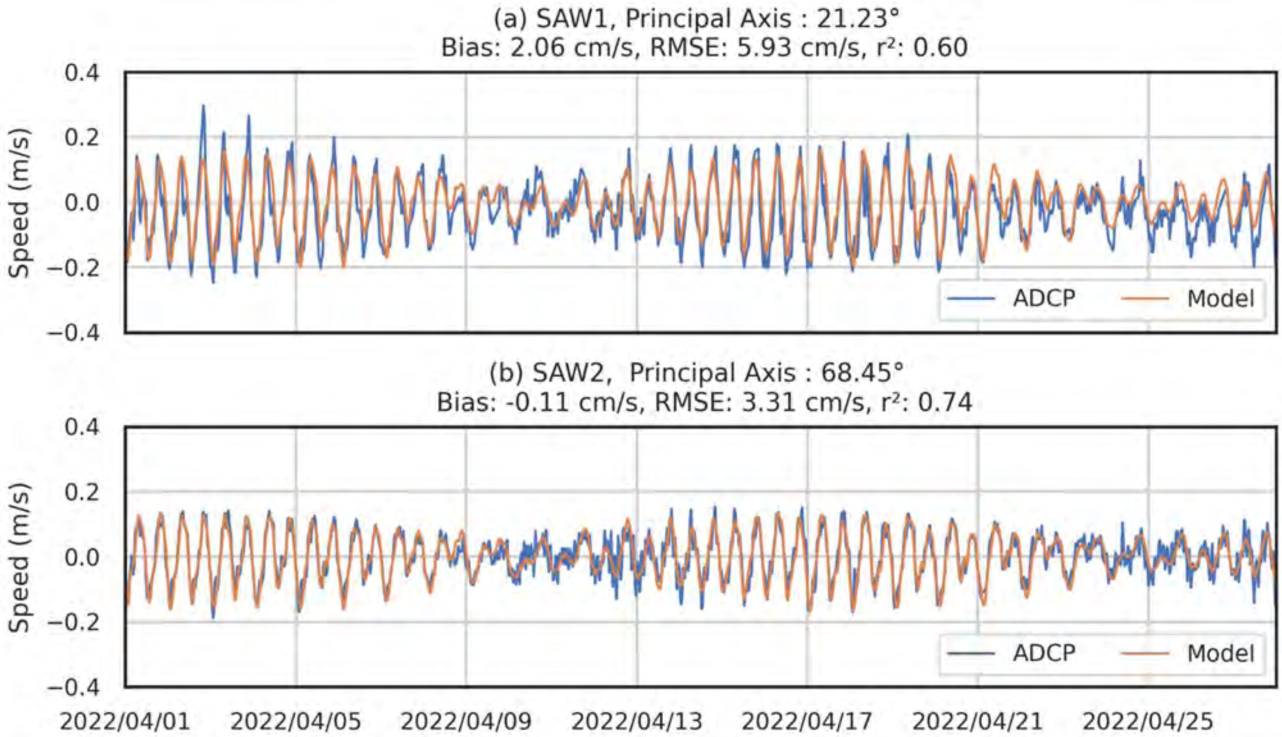


Figure 4.14 Comparison of predicted and measured current velocity at SAW1 and SAW2 moorings during April 2022

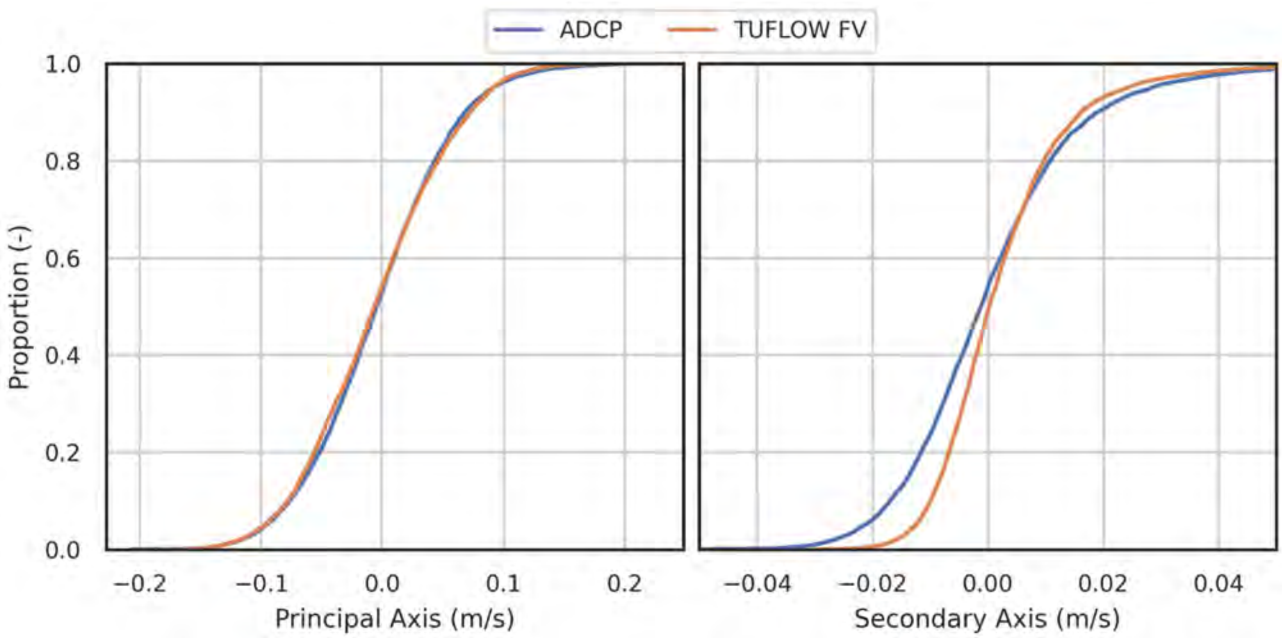


Figure 4.15 Statistical validation of modelled current speed against measurements at SAW7

Temperature

The prediction of water column temperature is an important skill for a hydrodynamic model undertaking outfall assessments. Temperature and salinity variations will influence stratification and control density-driven circulation patterns.

As shown in Figure 4.16 the temperatures at the seabed moorings have been measured and modelled within a range of 12°C during late winter months (e.g., August) to 24°C in later summer periods (e.g., February). Although there are only a limited number of vertical profiles available, it is preferable to have continuous time-series data for a thorough calibration of the model. For the model calibration process, only the measured temperatures near the bottom of the ocean at specific locations (referred to as SAW1 and SAW2) are used.

The validation results summarised in Table 4.9 show a very good agreement between the model's predictions and the observations over the course of a 12-month period.

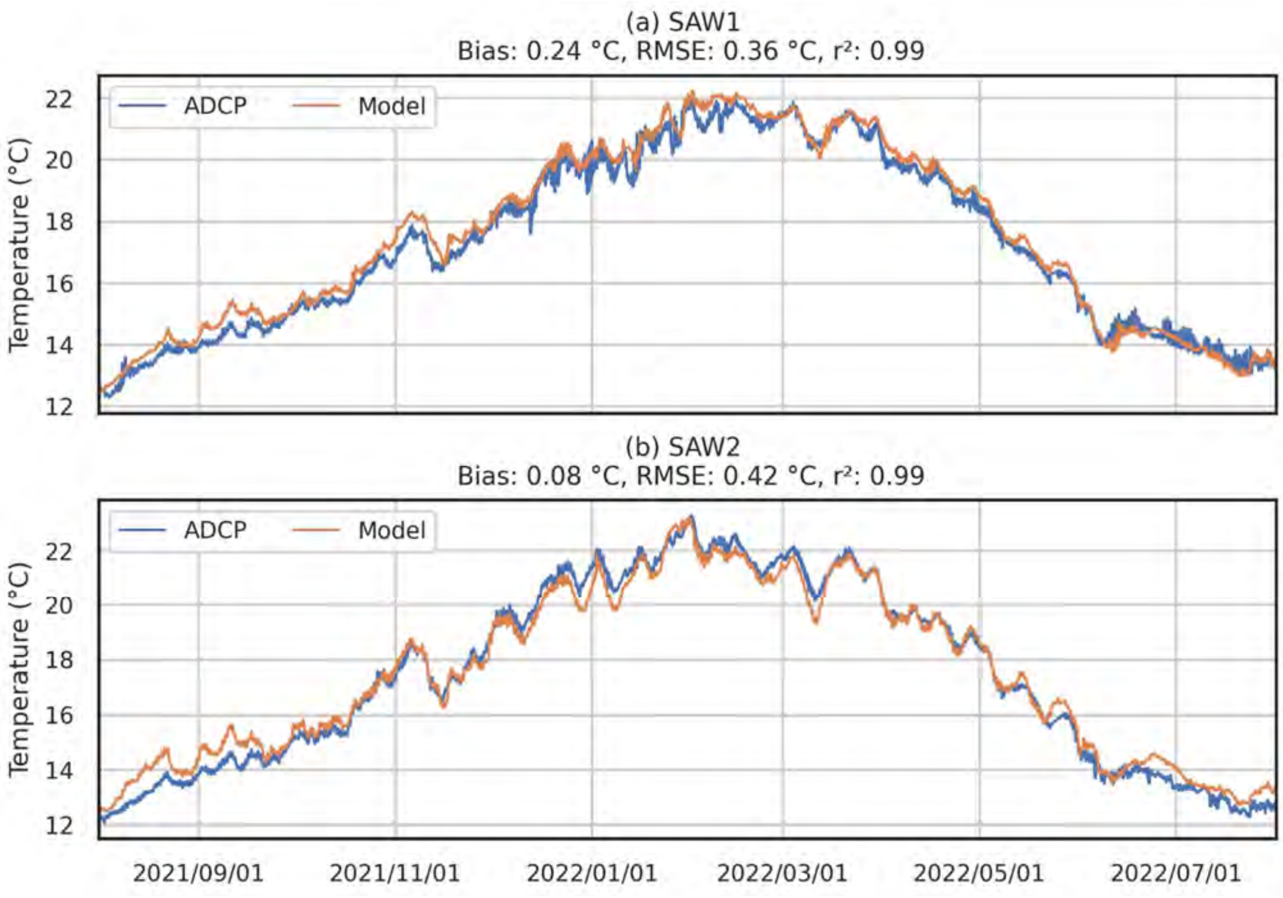


Figure 4.16 Comparison of predicted and measured near-bottom temperature at SAW1 and SAW2

Table 4.9 Model skill metrics for predicting measured near-seabed temperature

Seabed temperature	SAW1	SAW2
r^2	0.99	0.99
RMSE (cm/s)	0.36	0.42
Bias (cm/s)	0.24	0.08

Salinity

The prediction of water column temperature is of primary importance for a hydrodynamic model undertaking Seawater Reverse Osmosis brine dispersion assessments. Modelled salinity is extracted at the desalination plant intake locations to derive the properties of the effluent discharge. Thus, any inaccuracies in the predicted salinities will not only affect the vertical stratification and resultant vertical velocity and vertical mixing in the model but will also influence the accuracy of the estimated salinity of the SWRO effluent discharges.

A data assimilation process has been adopted to adjust the model salinity predictions to minimise the error against the continuous mooring measurements. The salinity adjustment is undertaken once a month when the hindcast simulation is restarted and ensures that the model predictions do not accumulate errors over the course of a 12-month simulation.

The predicted and measured salinity are compared in Figure 4.17 and show a good level of agreement, including the ability of the model to reproduce relatively short-term fluctuations in salinity observed in the measurements.

In assessing salinity levels at SAW1, measurements ranged from approximately 35.8 ppt to 37.28 ppt, averaging around 36.25 ppt over the measurement year. Meanwhile, SAW2 displayed a range from approximately 35.65 ppt to 37.58 ppt, with an average of approximately 36.41 ppt. These observations reveal annual salinity variations of 1.46 ppt and 1.93 ppt at SAW1 and SAW2, respectively. Such variations, indicating fluctuations of roughly 4% at SAW1 and 5.3% at SAW2, suggest the importance of evaporation driving the higher salinity levels in the inner bay.

The model skill metrics for salinity predictions are summarised in Table 4.10 and demonstrate a good level of predictive skill.

Table 4.10 Model skill metrics for predicting measured near-seabed salinity

Near-seabed salinity	SAW1	SAW2
r^2	0.93	0.92
RMSE (cm/s)	0.12	0.15
Bias (cm/s)	-0.06	0.03

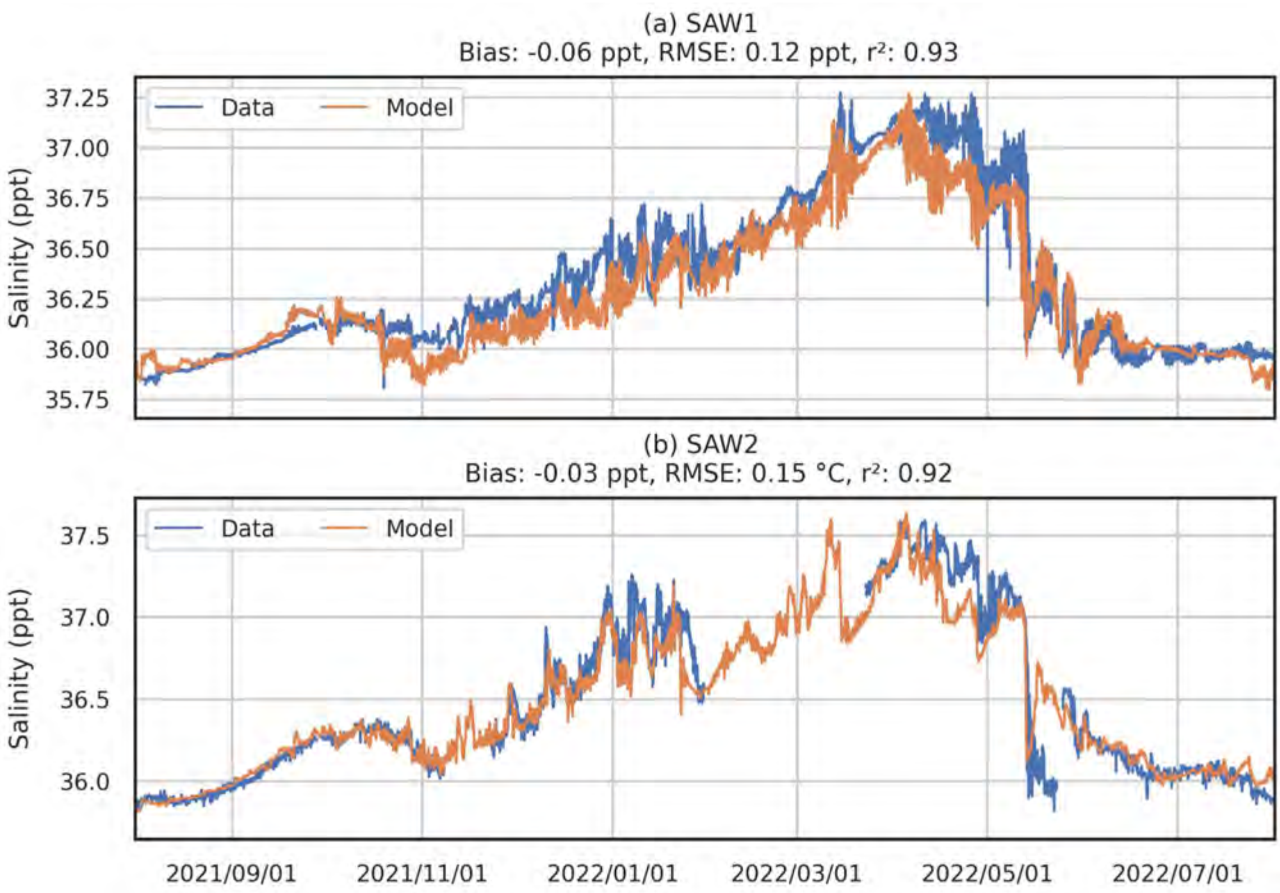


Figure 4.17 Comparison of predicted and measured near-bottom salinity at SAW1 and SAW2

4.6 Coupled Brine Dispersion Model

4.6.1 Linkage Technique

As previously illustrated in Section 4.3, outfall mixing processes occur over a broad range of length-scales. When the performance criteria are not clearly achieved by near-field simulations, linkage between near- and mid-field models is required. This is often needed because performance criteria for a mixing zone is in many cases specified at intermediate distances from the diffuser, typically 10s to 100s metres (i.e., transition between near- and mid-field regions).

Botelho et al. (2013) defined a series of characteristics required for the linkage between the near- and mid-field models, including:

- Effluent mass conservation – This is required to ensure the mass of effluent discharged by the outfall is conserved.
- Controllable linkage with nearfield predictions – It is necessary to ensure that the boundary condition flows (and hence dilutions and effluent concentrations) at the site of the diffuser are not artificially determined by the cell sizes and time steps of the hydrodynamic (mid-field) model for subsequent advection and dispersion through its domain.

- Controllable dynamic response to ambient forcing – An important requirement is to be able to dynamically vary, in a controlled fashion, the hydrodynamic model boundary condition for flow, dilution and effluent concentration. Primarily, this control is required to capture variations in the performance of diffuser in terms of effluent dilution as a result of unsteady ambient current magnitudes (and outfall discharge properties where these may vary).
- Hydrodynamic model grid and time step independence – This is required to ensure that grid and time-step related numerical artefacts are minimised or eliminated entirely, primarily to reduce associated predictive uncertainties. In addition, it is considered important to be able to apply the same methodology to different hydrodynamic models (or model configurations) and facilitate consistency of prediction without needing to retrospectively alter a grid dependent insertion method to suit.

Consistent with studies conducted on similar outfalls projects (Botelho et al., 2016, 2019; and BMT, 2019), the EPDP brine dispersion assessment uses a linked model framework. This technique is used for most discharge assessments undertaken by BMT as it addresses the drawbacks of previous approaches, the most significant of which was the need for implementing an artificial sink to remove excess constituent mass from the system (e.g., Botelho et al., 2013, BMT WBM, 2014). The methods applied in this study are free from this limitation.

4.6.2 Model Integration

Model integration was accomplished by mapping the dilution fields computed by the near-field CFD model as a function of the velocity field calculated by the mid-field model. The salinity and tracer masses and heat fluxes delivered by the discharge in each model time step was then appropriately distributed in the mid-field model domain (in three dimensions, not just at the seabed) according to the dilution map. This process is illustrated in Figure 4.18:

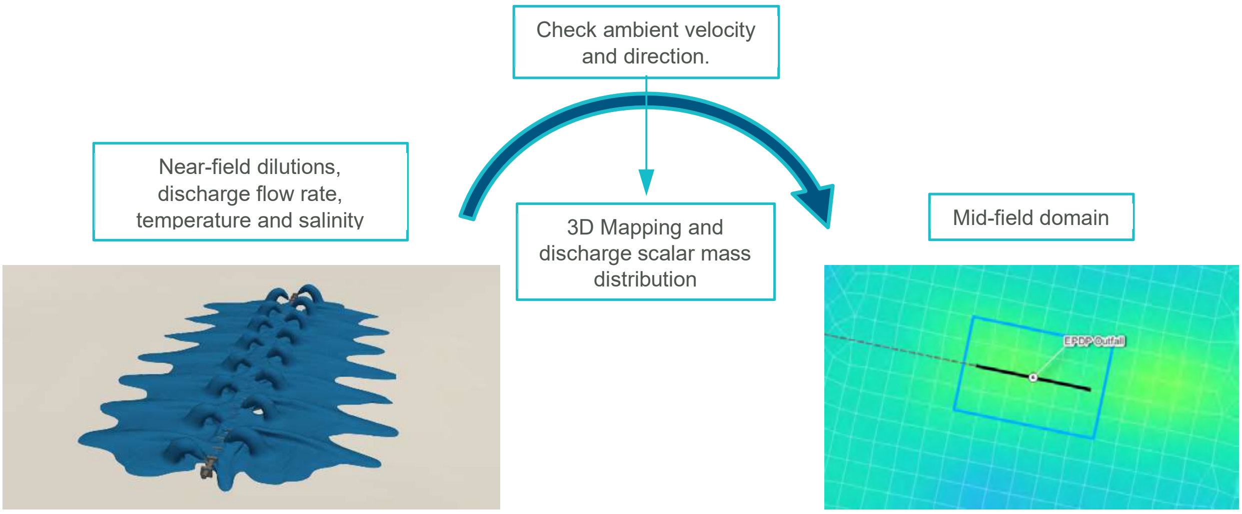


Figure 4.18 Schematic of the translation of the near-field effluent mass distribution into the mid-field model

The linkage technique presented above has two attractive features:

1. It provides a realistic three-dimensional depiction (map) of the plume shape (provided there is sufficient resolution) in the mid-field model. This is a major difference from Botelho et al. (2013), in which a single dilution value (as opposed to a complete three-dimensional field) was tabulated for each velocity percentile; and

2. The linkage is naturally mass-conservative and the mixing of the discharge with the ambient takes into consideration any existing effluent constituent mass, either previously discharged by the outfall or present as part of the ambient background. As already mentioned, previously adopted linkage techniques required the establishment of artificial sinks to balance background concentrations (e.g. Marti et al. 2011, Botelho et al. 2013) and the assumed dilutions did not account for mixing with brine discharged in previous time steps.

In order to facilitate the mid-field integration of the near-field CFD model results, volumetric aggregation of near-field model outputs to a mass-conserving grid equivalent to the mid-field model resolution was conducted. This process is summarised as follows:

1. Resample the near-field CFD model results on a uniform 0.5 m grid. This interpolation to a structured three-dimensional mesh was a necessary step to facilitate the proceeding integrations and transition the unstructured near-field CFD results to length scales compatible with the mid-field modelling.

2. Dynamic plume censoring. Due to the differing length scales and simulated processes between the near- and mid-field models, integration is typically implemented beyond the active mixing zone where length-scales between the coupled models become approximately equivalent (Morelissen et al., 2013). Here, this was achieved by omitting high concentrations in the active near-field mixing zone, nominally where dilutions < 50.

3. Volumetric aggregation. Finally, in order to facilitate the transition to length scales compatible with the mid-field modelling, in a mass-conserving approach the 0.5 m resolution results were aggregated and redistributed to an equivalent 20 m × 1 m (planform × vertical) resolution cell volume. This cell size and boundary condition positioning within the mid-field domain was performed such that there was minimal interpolation in the implementation relative to the mid-field mesh. The effect of the near-field volumetric aggregation is illustrated in Figure 4.19.

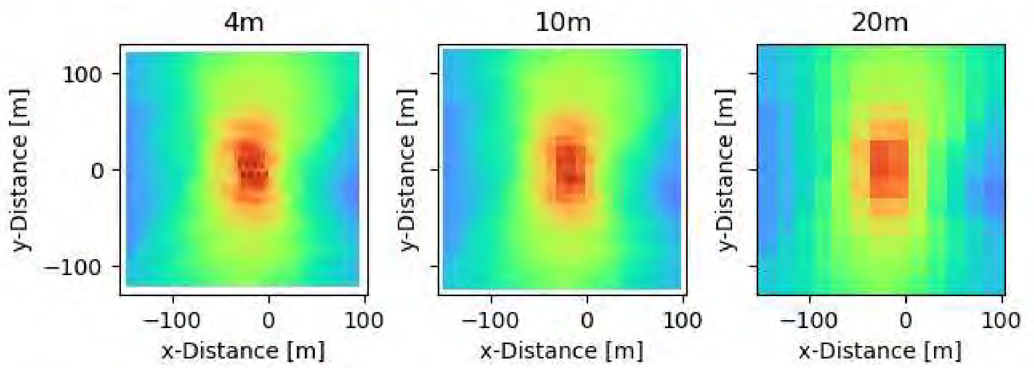


Figure 4.19 Illustration of near-field volumetric aggregation to coarser cell sizes. Depth maximum concentration shown

Following the process illustrated in Figure 4.18, the volumetrically aggregated near-field dilution fields were then temporally mapped by linearly interpolating for the corresponding mid-field velocity condition to form the mid-field nested boundary condition. To confirm the efficacy of this near-field pseudo-temporal simulation, the near-field and subsequent mid-field results were examined (Figure 4.20). Noting the numerical differences between the quasi-steady near-field CFD model and the temporally resolving (and thus brine accumulation resolving) mid-field model, the strong agreement in the predicted median salinity impacts in proximity of the diffuser provides affirmation of the validity of the near-to-mid-field coupling approach.

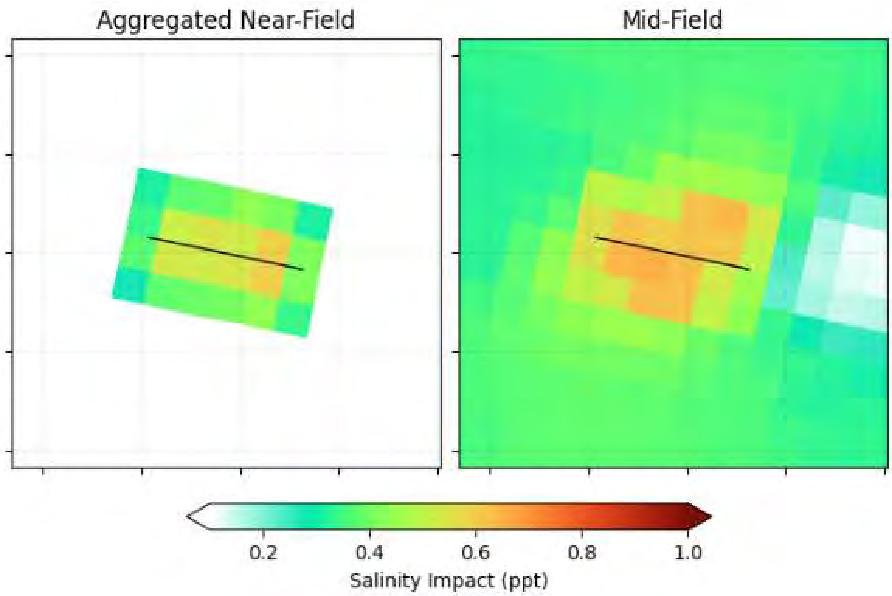


Figure 4.20 Comparison of 50th percentile predicted salinity impacts between the near-field pseudo temporal simulation (left) and the mid-field simulation (right).

4.7 Wave Model

Wave modelling has been undertaken in this study to inform the development of metocean design criteria (BMT, 2024b) and to support the coastal process assessments described in Section 6.

4.7.1 Model Description

SWAN (Booij et al., 1999) is a third-generation spectral wave model, which is capable of simulating the generation of waves by wind, dissipation by white capping, depth-induced wave breaking, bottom friction and wave-wave interactions in both deep and shallow waters. SWAN simulates wave/swell propagation in two-dimensions, including shoaling and refraction due to spatial variations in bathymetry and currents. This is a global industry standard modelling package that has been applied with reliable results to many investigations worldwide.

4.7.2 Grid Extents and Bathymetry

A set of three rectilinear grids have been developed to encompass the LOIs along with a large section of the Spencer Gulf. The opening to the Great Australian Bight was included in the model to capture the influence of wave energy outside of the Spencer Gulf. The eastern extent of the outer model was tested with a set of stationary wind-only simulations to confirm that waves within the vicinity of Port Lincoln were not sensitive to this selected extent.

The three grids are shown in Figure 4.21.

4.7.3 Boundary Conditions

Modelled wind data sourced from NOAA's CFSR has been used to drive the SWAN model.

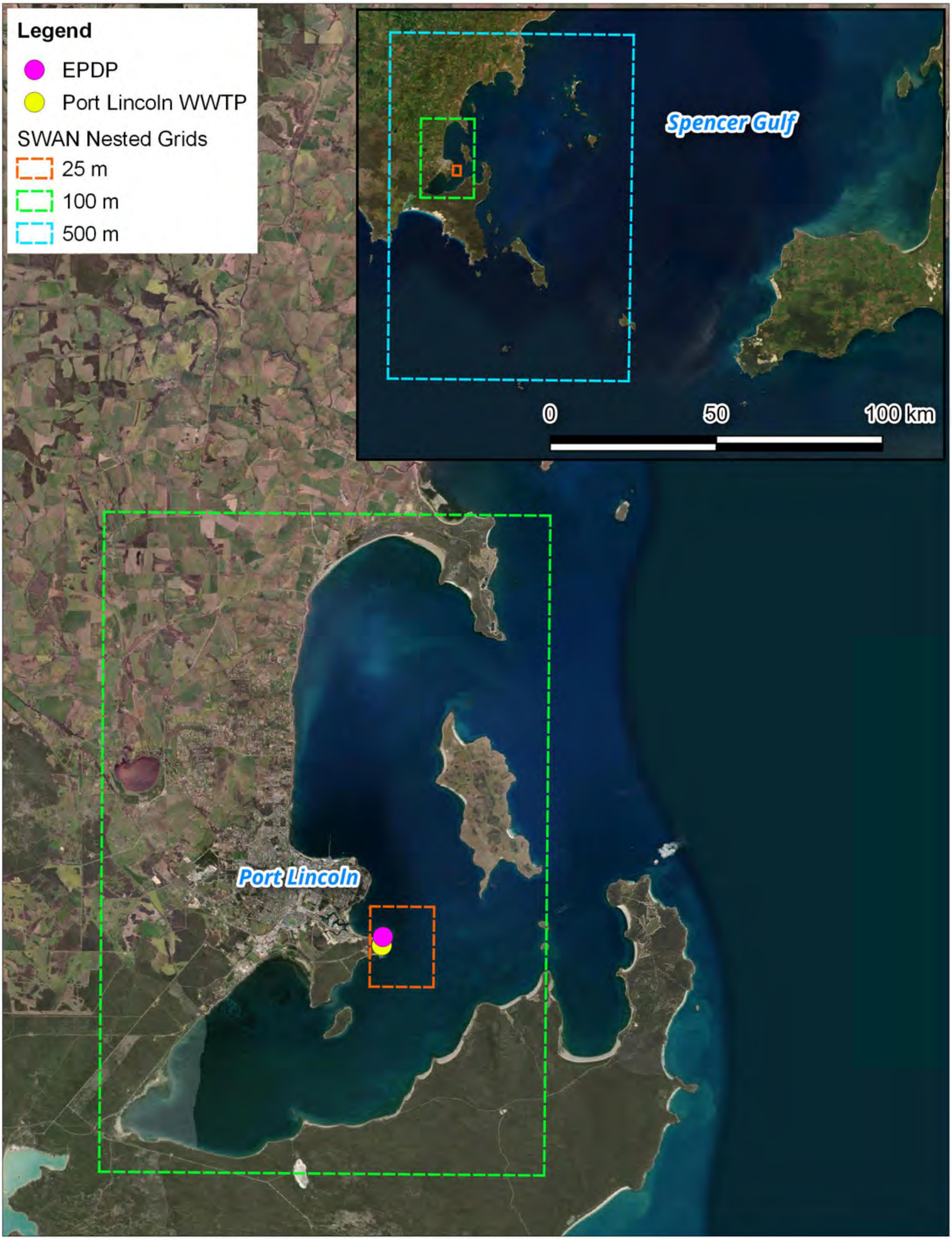
Water-levels were applied on all SWAN models at half hourly intervals, based on harmonic reconstruction of the tidal water-levels from SARDI's Two Gulfs Model.

Swell boundaries were applied to the outer wave model along the entire offshore boundary based on CSIRO's CAWCR wave hindcast.

4.7.4 Model Validation

The SWAN model was validated against measured ADCP data at SAW2 and SAW7 (which is the most relevant to the proposed EPDP development area).

Figure 4.23 to Figure 4.24 show how the SWAN model compares to the ADCP measured data. The SWAN model is noted to overpredict wave height at SAW2 located in the relatively sheltered waters of Proper Bay. At SAW7 (Billy Lights Point) the wave model exhibits only a slight over-prediction bias (of order 0.05m to 0.1m). The predictions at this location are suitably conservative for derivation of metocean design criteria.



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Spectral Wave Model Nested Grids

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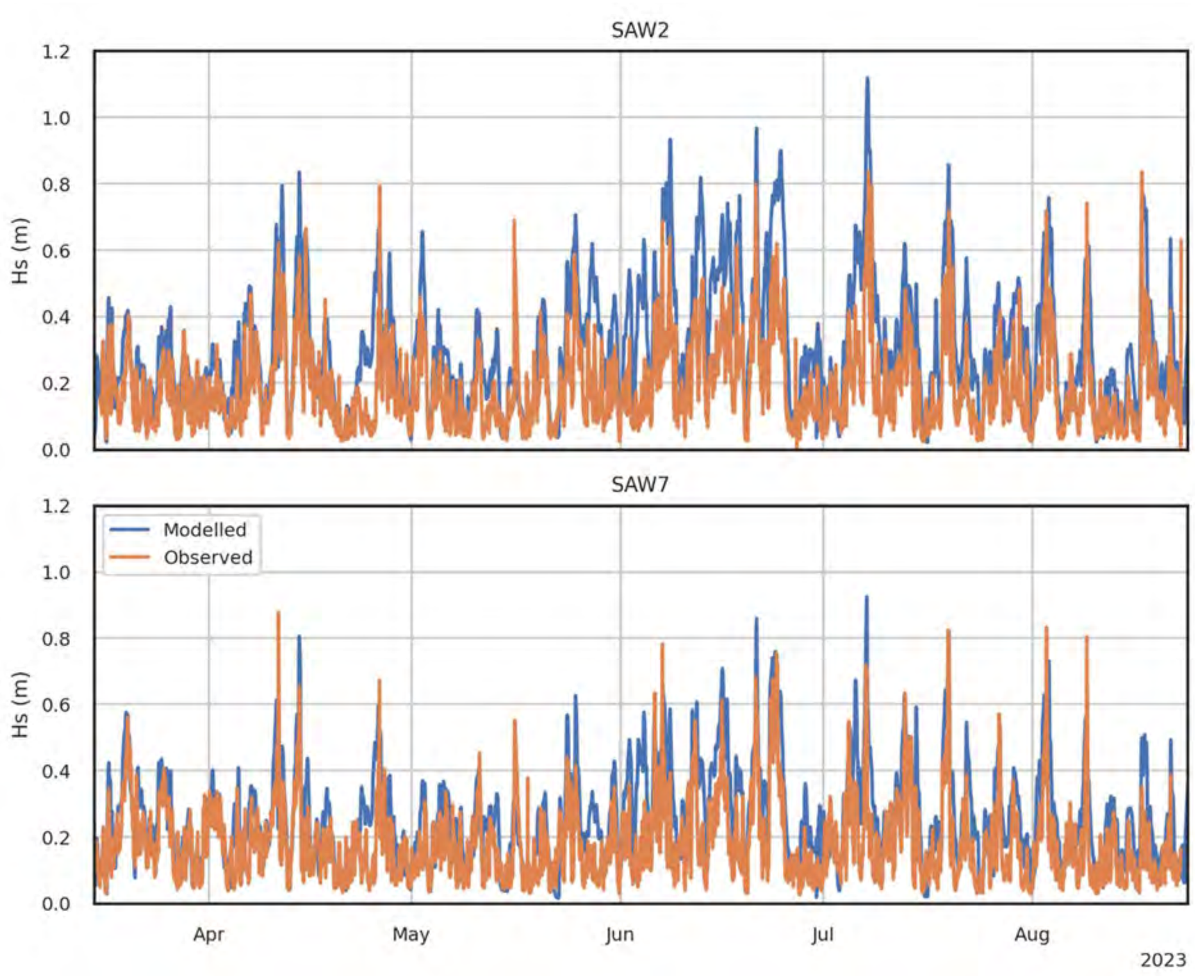


Figure 4.22 Significant Wave Height (Hs) comparison of SWAN modelled data and ADCP measured data

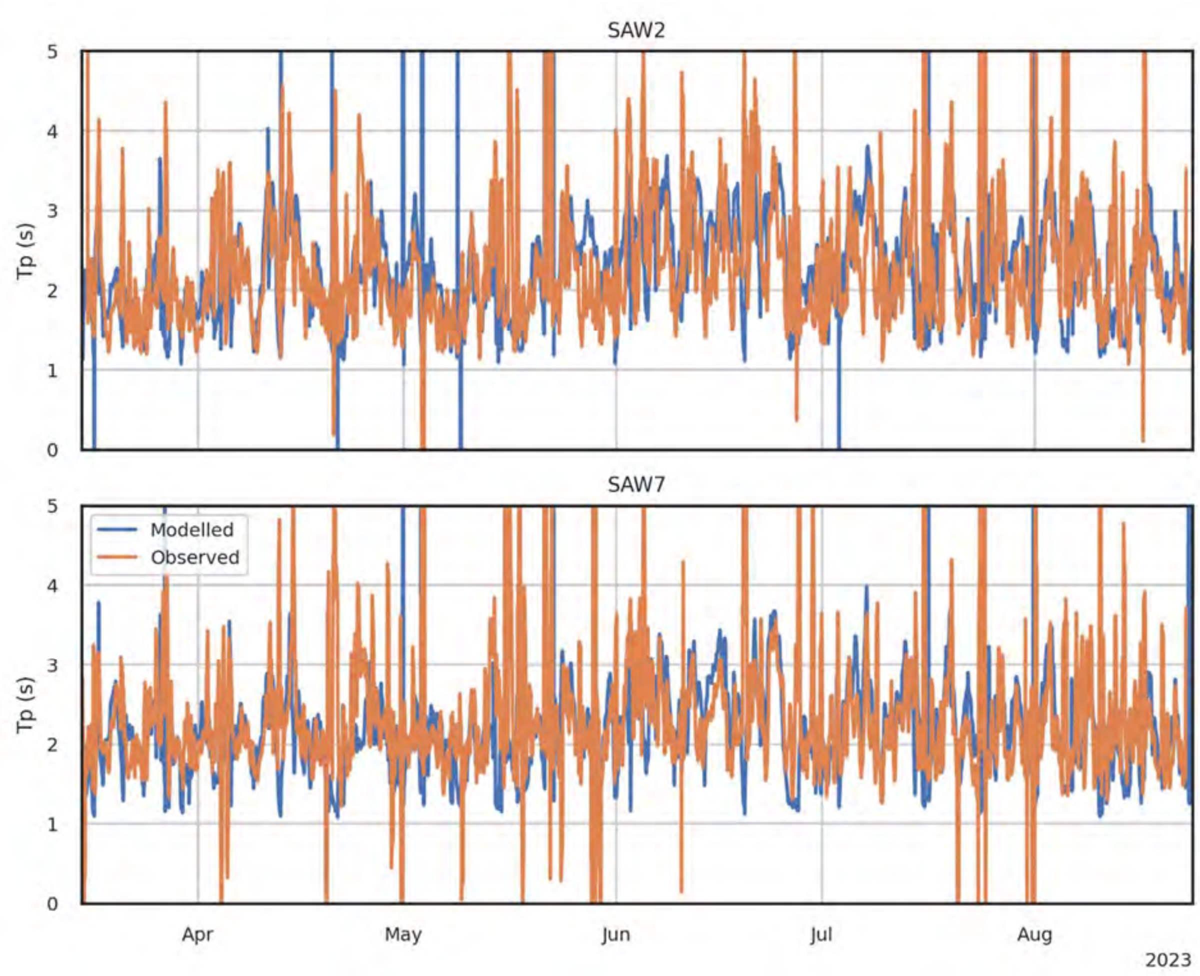


Figure 4.23 Peak Wave Period (Tp) comparison of SWAN modelled data and ADCP measured data

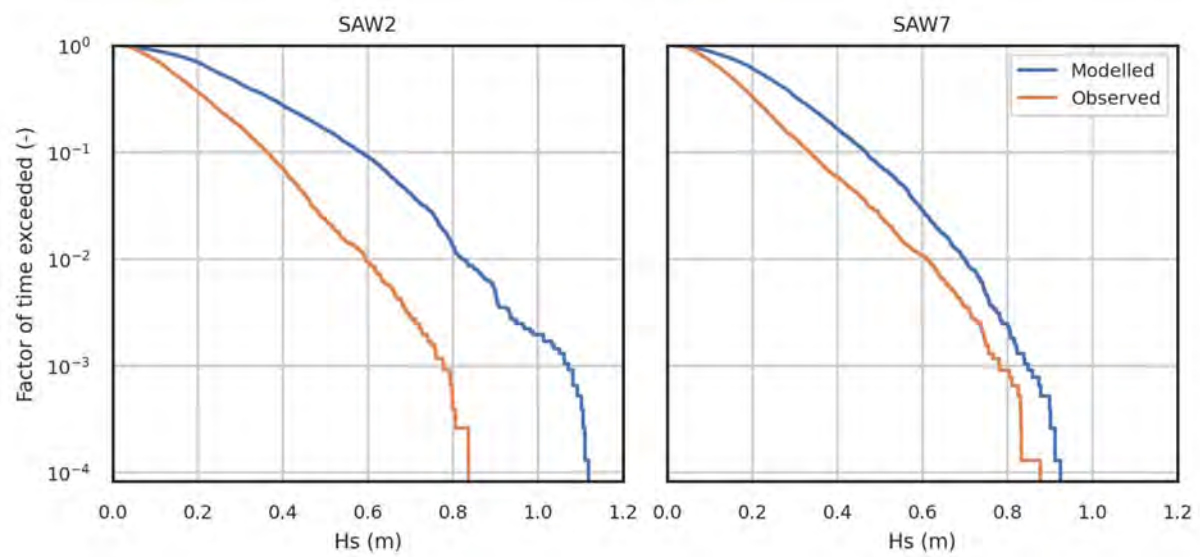


Figure 4.24 Validation of wave model predictions

5 SWRO Intake and Brine Dispersion Assessment

5.1 Objectives

The coupled brine dispersion modelling system described in Section 4 has been used to assess the environmental performance of the EPDP design (Section 2.1).

The following potential operational and environmental risk mechanisms have been specifically assessed in this section:

- Short-circuiting from the existing WWTP outfall to the proposed SWRO intake (Section 5.4)
- Short-circuiting from the SWRO outfall to the proposed SWRO intake (Section 5.5)
- Mid-field brine dispersion and potential for elevated salinity levels (Section 5.6)
- Elevated TSS due to the SWRO discharge (Section 5.7)

5.2 Assessment methodology

A 12-month simulation has been undertaken for the brine dispersion assessments.

A base case simulation was undertaken for the 12-month period from 1/8/2021 to 1/8/2022. The base case model predictions were shown earlier in the mid-field model validation (Section 4.5.7). The base case simulation included the existing WWTP discharge as detailed in Section 2.2.

A compatible developed case simulation was subsequently undertaken with the inclusion of brine intake and outlet boundary conditions.

Tracers were included in the WWTP and SWRO discharge streams to facilitate tracking of the respective plumes. SWRO impact salinity anomalies were calculated by subtracting the base case from the developed case salinity predictions.

5.3 Thresholds of Concern

For the purposes of compliance assessment against regulatory objectives associated with the EPDP operations, thresholds for the receiving environment relating to the SWRO brine outfall have been defined. Further, pertaining to the operational limitations for the EPDP intakes, recirculation limitations relating to the SWRO effluent and Port Lincoln WWTP discharge have also been defined.

5.3.1 EPDP Effluent

In accordance with the EPDP discharge properties defined earlier in Section 2.1.4, the SWRO brine reject stream is characterised by elevated levels of salinity, temperature and TSS, relative to the receiving environment.

Salinity

With the hypersaline discharge properties of the EPDP SWRO effluent, the identified target value to avoid salinity impacts in both the near- and mid-fields is that the brine effluent be diluted at least 40 times within a compact mixing zone. For the prescribed discharge salinity anomaly of +39 ppt above ambient (Table 2.1), this equates to a target limit of +0.975 ppt.

As discussed in Section 4.4.5 the nearfield dynamic mixing zone is 30 m from the EPDP diffusers based on the non-dimensional length-scales defined by Roberts (1997). Lower seabed dilutions are expected within this dynamic mixing zone but represent an intermediate condition prior to completion of the dynamic plume mixing processes.

Temperature

Due to the nature of the SWRO recovery process, a relatively small temperature surplus of +1°C above ambient (Table 2.1) is anticipated. Provided the 1:40 near-field dilution target is achieved, this temperature surplus would result in a discharge-associated temperature increase of +0.03°C within the near-field receiving environment, constituting negligible potential for thermally-induced impact. For this reason, potential environmental impacts associated with temperature elevations in the receiving environment are not considered in the analysis of model results.

Total Suspended Solids

A limit of Total Suspended Solids (TSS concentration) in the diluted plume that is no more than 10% above ambient is a threshold that should avoid visual plume impacts and impacts on light penetration to the seabed. Based on measured turbidity and TSS data a constant 1.4 mg/L TSS is assumed at the intake and will experience approximately 1.9-times volumetric concentration as part of the SWRO recovery and system backwashing process. The un-diluted TSS in the effluent stream is therefore modelled as 2.66 mg/L and upon discharge experiences nearfield dilution with the ambient seawater. On this basis, plume TSS levels above 0.14 mg/L in the mid-field receiving environment would exceed the 10% above ambient threshold.

5.3.2 EPDP Brine Recirculation

No operational criterion for limiting recirculation effects at the intake have been specified. Typical thresholds of concern for potential recirculation impacts are expected to range between 1% and 10% above ambient at the intake. A conservative 1% threshold for the brine re-circulation is adopted for this assessment, constituting a salinity anomaly of +0.391 ppt.

5.3.3 Port Lincoln WWTP Recirculation

With respect to the Port Lincoln WWTP discharge and the EPDP intake short-circuiting assessment, a 150 MPN/mL bacteriological count threshold has been applied to the results in accordance with the NHMRC trigger values (NHMRC, 2008; Paterson, 2022).

5.3.4 Summary of Applicable Thresholds

The thresholds of concern and/or target values are defined below for the various sources of potential impact.

Table 5.1 Thresholds of Concern

Risk	
WWTP bacteriological counts at SWRO intake	150 MPN/mL threshold has been applied to the results in accordance with the NHMRC trigger values (NHMRC, 2008; Paterson, 2022)
Elevation in salinity (ecological impact)	ΔS<0.975ppt, representing effluent dilution of 1:40.
Elevation in salinity at SWRO intake (recirculation impact)	ΔS <0.39 ppt, representing <1% recirculation of effluent.
TSS in SWRO plume	ΔTSS <10% change in ambient TSS concentrations

5.4 WWTP Plume Risk

The results assessing the potential for WWTP short-circuiting at the EPDP intake locations are presented below. These results are extracted from a 13-month simulation of the period from the 1/7/2021 to 1/8/2022 but have been presented for a one-month summer period (1/1/2022 to 1/2/2022) and a one-month winter period (1/8/2021 to 1/9/2021).

Based on a review of Port Lincoln WWTP effluent monitoring data (Email from Acciona, 23 January 2024) the median bacteriological count in the WWTP stream is found to be 5,500 MPN/100ml. This median value is taken to represent the typical concentration in the WWTP discharge stream under normal conditions. WWTP plume results scaled by the median value are labelled 'Typical' in the following plots.

An upper-range undiluted discharge stream concentration of 100,000 MPN/100ml has also been considered based on a review of the effluent monitoring data (Email from Acciona, 23 January 2024)). Where results for this upset condition are presented in this section they are based on simplistic scaling of the modelled unit tracer concentration. The results labelled as 'upset' conditions are therefore highly conservative and shouldn't be interpreted as representing statistical exceedance levels within the receiving environment. They are included here to demonstrate that there is still a margin of safety above the NHMRC threshold even under sustained upset conditions.

5.4.1 Timeseries

Profiles were extracted at the proposed EPDP intake riser locations and subsequently processed into timeseries results, representing:

- The vertically-averaged plume concentration at the intake level (-9.55 mAHD to -10.85 mAHD)
- The vertical-maximum concentration across the water column (typically the surface concentration)

The winter and summer period timeseries are shown in Figure 5.1 and Figure 5.2 respectively. The corresponding water level timeseries is shown in the top plot to provide context around tidal range, in order to highlight periods of spring tides and dodge tides. Bacteriological count timeseries for the north intake location is shown in the middle plot and the south intake is shown in the bottom plot. Given the two intakes are very close proximity to each other relative to the distance to the WWTP outfall, it is unsurprising they show very similar results.

The timeseries results exhibit a spring-neap tidal cycle pattern with the WWTP plume showing vertically well-mixed concentration profiles during spring tide periods and a stratified profile during neap (dodge) tides. During spring tide periods typical peak concentrations at the surface are in the range 1-3 MPN/100mL. During neap (dodge) tide periods peak surface concentrations reach higher values up to 10 MPN/100mL.

At intake level typical peak concentrations during spring-tides are around 1 MPN/100mL while during neap tides the modelled concentrations are very low (<0.2 MPN/100mL).

The timeseries results indicate that the WWTP plume is being advected primarily by tidal currents but is also influenced by non-tidal drivers such as wind and surges. Summer and winter timeseries are broadly similar in terms of bacterial count levels, however there is less vertical stratification of the WWTP plume evident during the winter period.

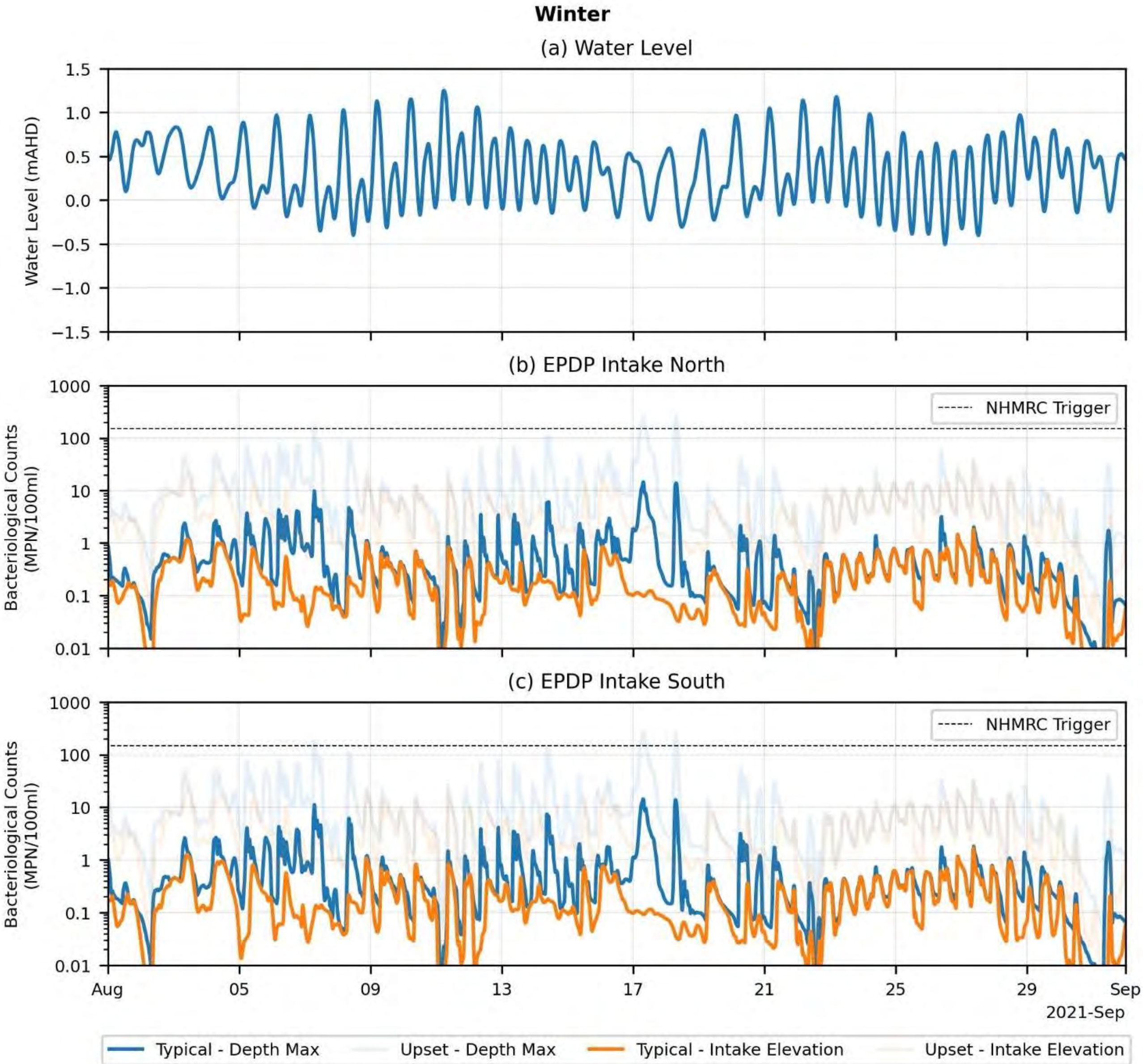


Figure 5.1 Winter WWTP plume bacteriological timeseries at the proposed EPDP intake risers

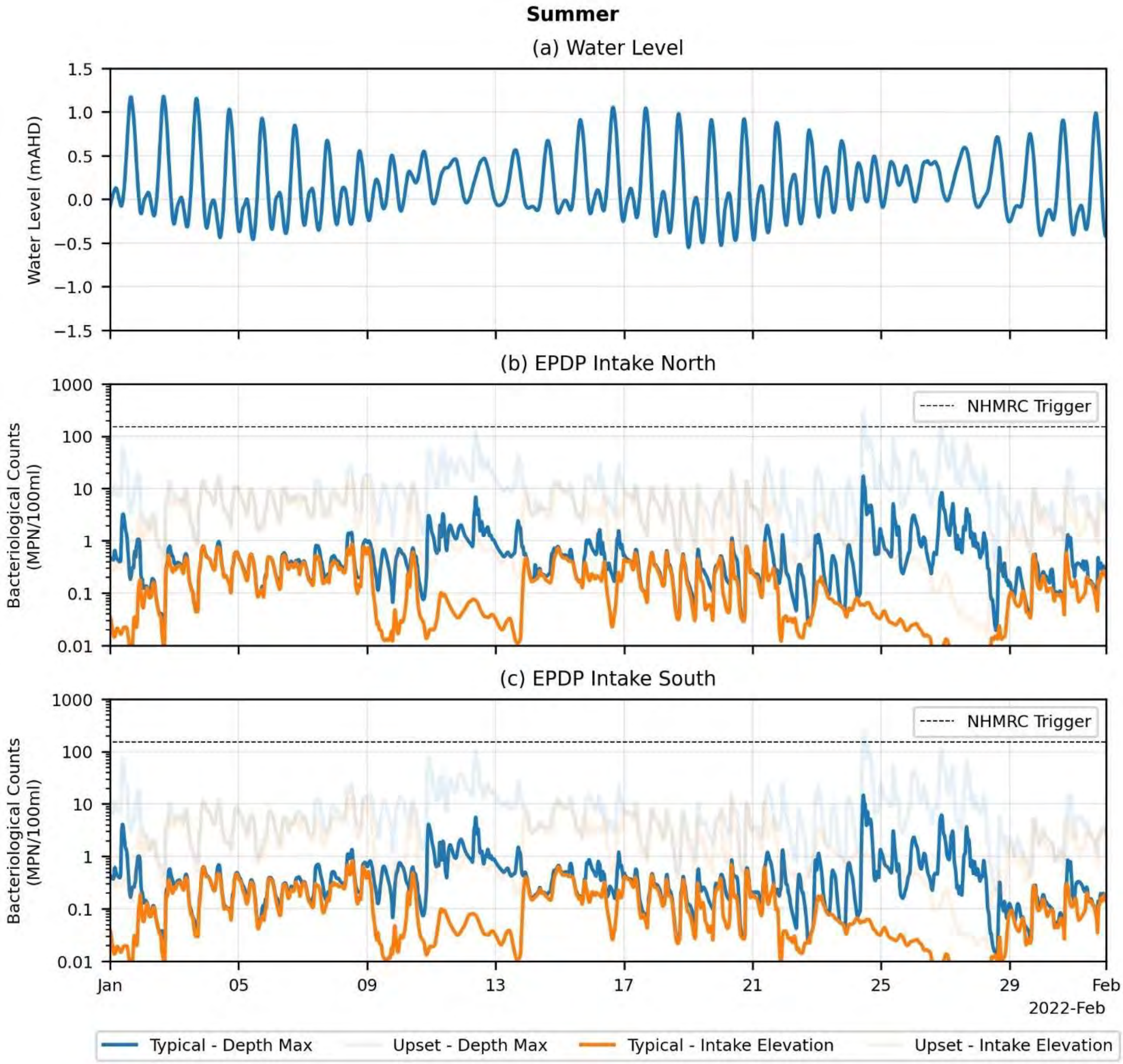


Figure 5.2 Summer WWTP plume bacteriological timeseries at the proposed EPDP intake risers

5.4.2 Profile Percentiles

Percentile statistics were extracted for the WWTP tracer concentration profiles at the EPDP intake locations. The tracer concentration scaled based on typical WWTP operating conditions, i.e. median bacteriological counts in the un-diluted discharge stream, are shown as percentile profiles in Figure 5.3.

The 50th, 90th, 95th, 99th and 100th percentile statistics are shown, however it is expected that the typical condition percentile profiles in Figure 5.3 would slightly under-predict plume concentrations as they don't account for the occasional occurrence of above-median conditions. The NHMRC 150 MPN/100mL bacteriological count threshold is shown on Figure 5.3. These results indicate that the risk of a threshold exceedance at the EPDP intake level is very unlikely.

5.4.3 Summary

This assessment has considered the risk of short-circuiting between the existing WWTP outfall and the proposed EPDP intakes. The assessment uses results of a base case simulation of the period 1/7/2021 to 1/8/2022. The WWTP outfall discharge was included in the base case simulation using measured flow rates supplied by SA Water. A conservative tracer and a decaying tracer were included in the model simulation of the WWTP discharge. The conservative tracer was used to derive WWTP plume dilution contours while the decaying tracer was scaled to represent bacteriological count concentrations. The mid-field model tracer concentrations were separately scaled to represent concentrations under typical WWTP operating conditions (undiluted bacteriological counts = 5,500 MPN/100mL) and for upset operating conditions (100,000 MPN/100mL).

For the purpose of this assessment the mid-field model results have been interrogated for a 1-month winter and 1-month summer period. Modelled plume concentrations have been presented as timeseries and percentile statistics. These results indicate that there is a very low likelihood of bacteriological count concentrations exceeding NHMRC thresholds at the proposed EPDP intake locations.

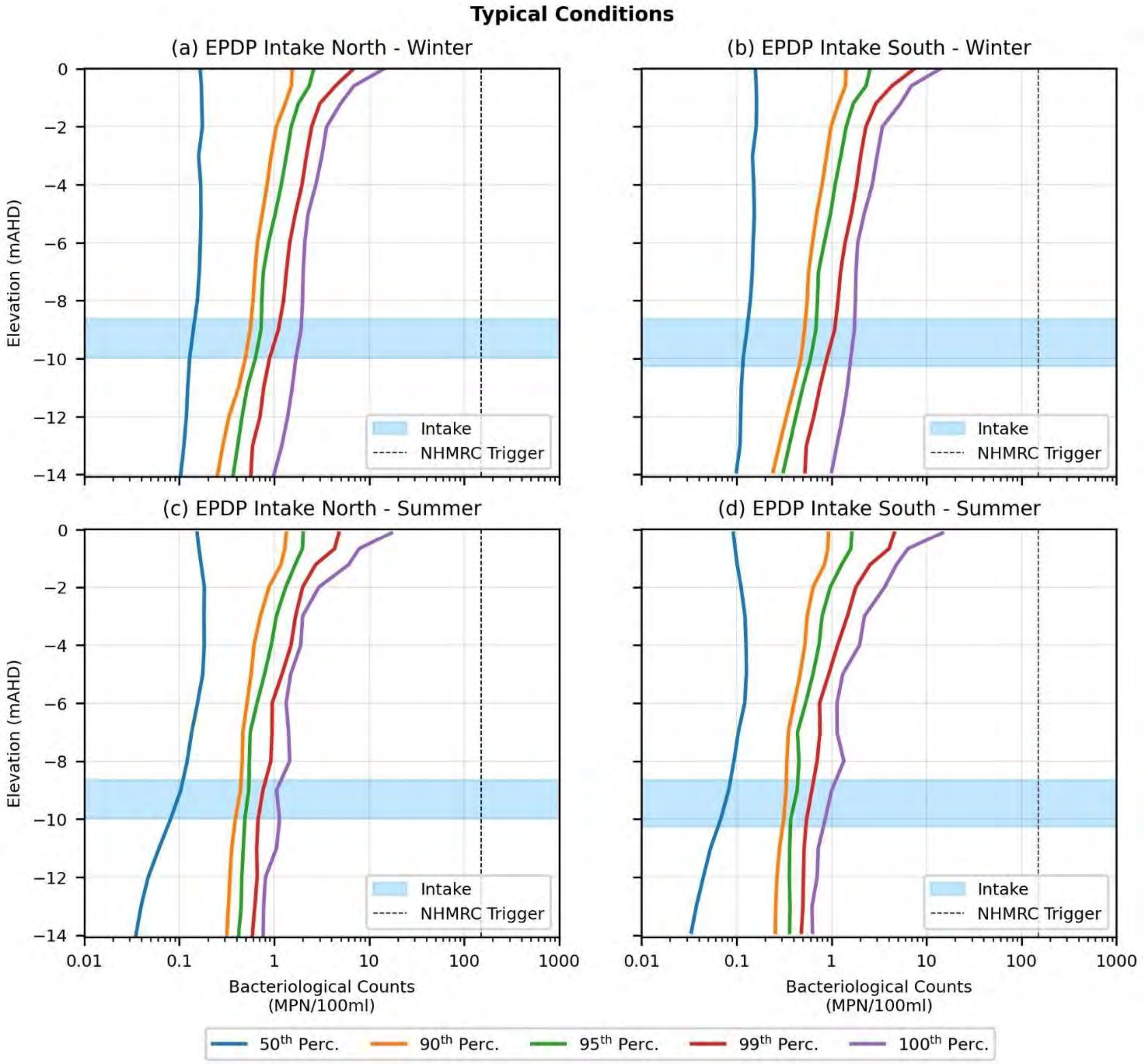


Figure 5.3 Percentile profiles of WWTP plume bacteriological counts at the EPDP intake risers

5.5 Brine Recirculation Risk

The results assessing the potential for SWRO brine short-circuiting at the EPDP intake locations are presented below. These results are extracted from a 13-month simulation of the period from the 1/7/2021 to 1/8/2022 but have been presented for a one-month summer period (1/1/2022 to 1/2/2022) and a one-month winter period (1/8/2021 to 1/9/2021).

The EPDP design assumptions were detailed in Section 2.1 and describe the intake riser, outfall diffuser and discharge stream properties.

Salinity anomaly (i.e. impact) due to the EPDP operations were derived from the instantaneous difference in salinity between the base case and developed case simulations (refer Section 5.2). The results presented below show the derived salinity anomaly.

5.5.1 Timeseries

Salinity anomaly profiles were extracted at the proposed EPDP intake riser locations and subsequently processed into timeseries results, representing:

- The vertically-averaged salinity anomaly at the intake level (-9.55 mAHD to -10.85 mAHD)
- The vertical-maximum salinity anomaly across the water column (typically the seabed concentration)

The winter and summer period timeseries are shown in Figure 5.4 and Figure 5.5 respectively. The corresponding water level timeseries is shown in the top plot to provide context around tidal range, in order to highlight periods of spring tides and dodge tides. Salinity anomaly timeseries for the north intake location is shown in the middle plot and the south intake is shown in the bottom plot. Given the two intakes are very close proximity to each other relative to the distance to the SWRO outfall, it is unsurprising they show very similar results.

The dense brine plume has highest concentrations at the seabed, with the intake elevation anomaly typically around 50% of the maximum value at the seabed under relatively well-mixed winter conditions. Under more heavily stratified summer conditions the intake elevation anomaly is somewhat lower and is typically around 20% of the maximum value at the seabed.

The timeseries results at the seabed exhibit a distinct spring-neap tidal cycle pattern with highest near-seabed salinity anomalies during neap (dodge) tide periods. During spring-tides typical peak salinity anomalies at the seabed are less than 0.4 ppt and reach up to 0.5 ppt during neap (dodge) tides. A similar spring-neap cycle pattern is evident at the intake-elevation. During spring-tides typical peak salinity anomalies at the intake elevation are typically less than 0.2 ppt and reach up to 0.3 ppt during neap (dodge) tides.

The 0.39 ppt salinity anomaly threshold representing 1% re-circulation of brine is shown as the horizontal line in Figure 5.4 and Figure 5.5. The predicted salinity anomaly at the intake elevation remains below this threshold during neap (dodge) tide periods indicating compliance with the re-circulation performance target.

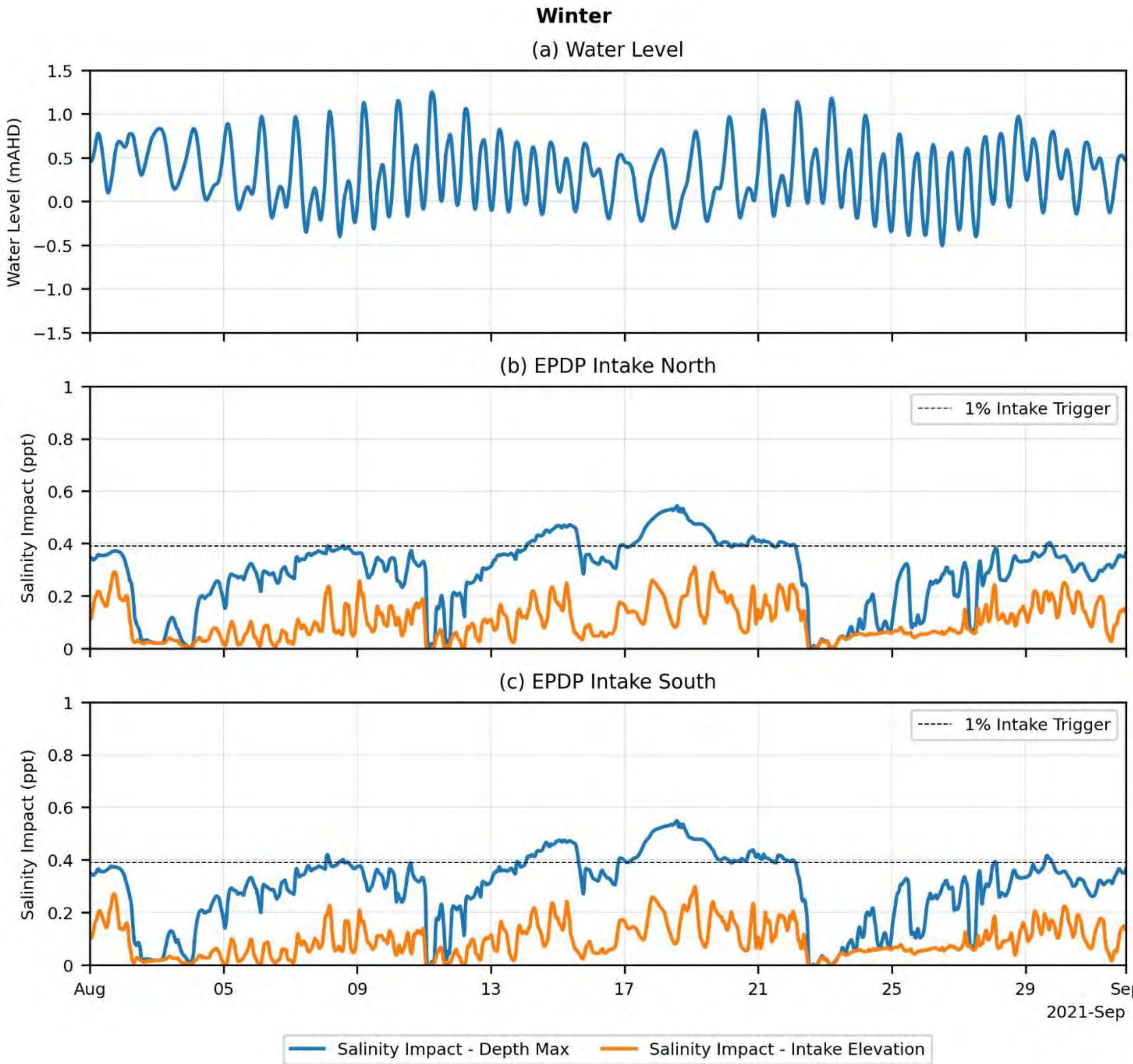


Figure 5.4 Salinity anomaly timeseries at the desalination plant intake during winter

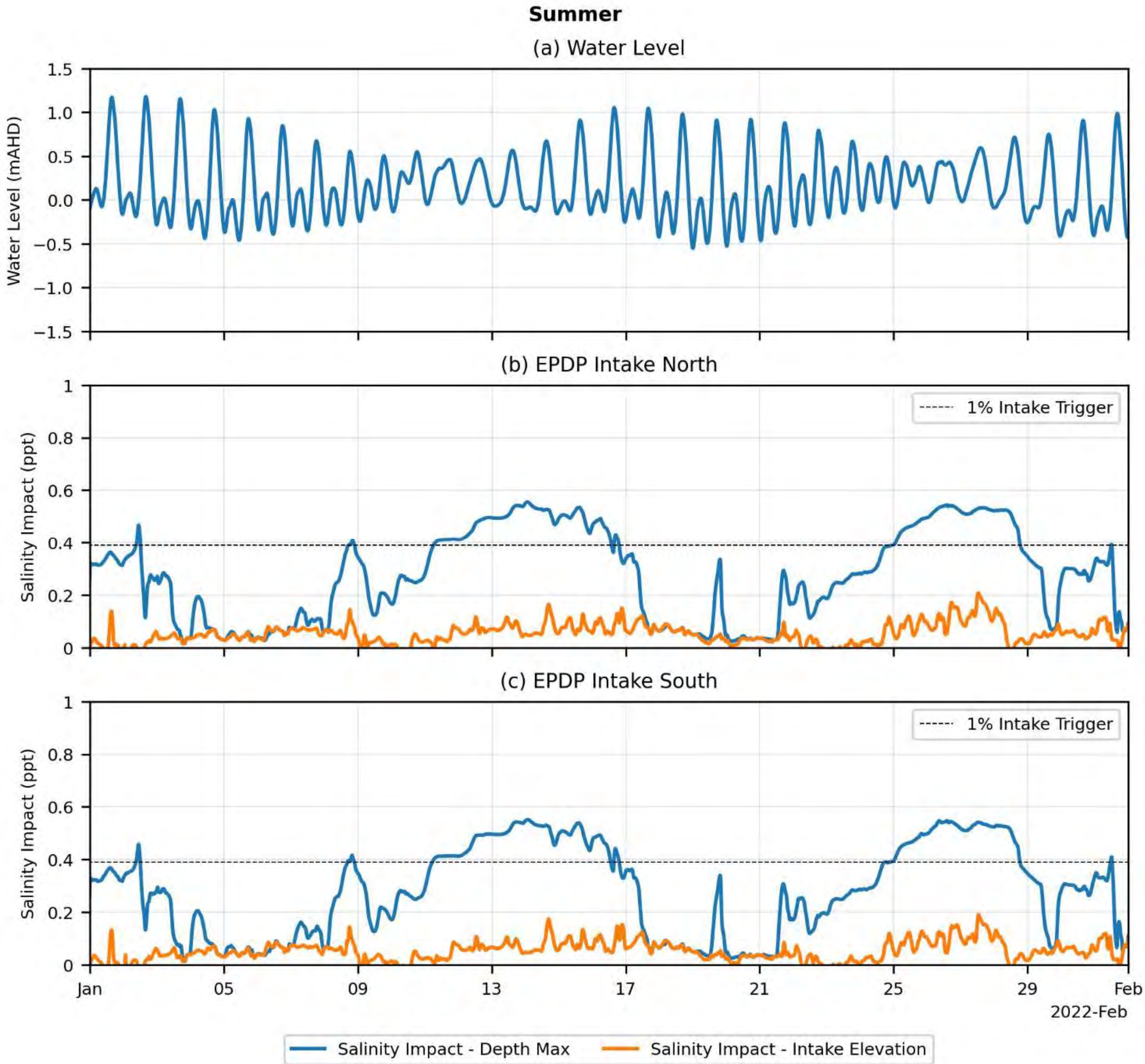


Figure 5.5 Salinity anomaly timeseries at the desalination plant intake during summer

5.5.2 Profile Percentiles

Percentile statistics were extracted for the salinity anomaly profiles at the EPDP intake locations. The 50^{th}, 90^{th}, 95^{th}, 99^{th} and 100^{th} percentile statistics are shown in Figure 5.6 for both summer and winter periods. The proposed intake elevation range is shown as the blue band and the 1% brine re-circulation threshold (set at 0.39 ppt) is shown as the vertical line.

The summer period exhibit stronger stratification of the salinity anomaly profiles than the winter period, which is expected due to the thermal and salinity stratification that seasonally develops in Boston Bay.

5.5.3 Summary

This assessment has considered the risk of short-circuiting between the EPDP outfall and the corresponding EPDP intakes. The assessment uses results of a base and developed case simulations for the period 1/7/2021 to 1/8/2022. The EPDP intake and outfall diffuser were included in the developed case using the coupled near-field and mid-field brine dispersion model methodology described in Section 4. Salinity anomaly (i.e. EPDP impact) was derived from the difference in salinity between base (existing) and developed (EPDP design) scenarios.

For the purpose of this assessment the mid-field model results have been interrogated for a 1-month winter and 1-month summer period. Modelled salinity anomaly concentrations at the EPDP intake have been presented as timeseries and percentile statistics. These results indicate that the proposed design is complying with the performance target of <1% brine re-circulation.

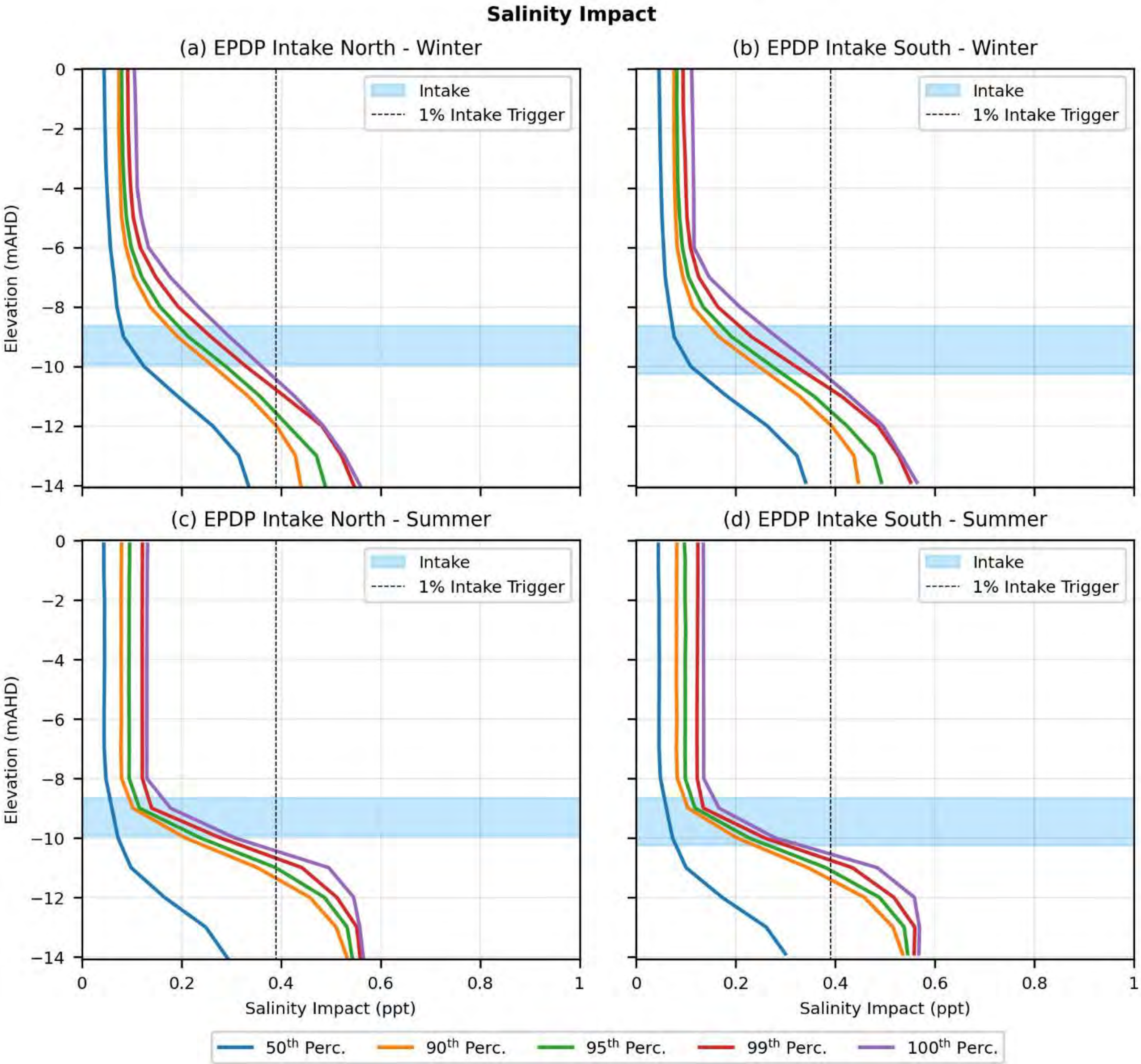


Figure 5.6 Percentile profiles of salinity anomaly at the EPDP intake risers

5.6 Brine Dispersion Risk

The results assessing the potential for brine accumulation in the mid-field receiving environment in the vicinity of Billy Lights Point are presented below. These results are extracted from a 13-month simulation of the period from the 1/7/2021 to 1/8/2022 but have been presented for a one-month summer period (1/1/2022 to 1/2/2022) and a one-month winter period (1/8/2021 to 1/9/2021).

The EPDP design assumptions were detailed in Section 2.1 and describe the intake riser, outfall diffuser and discharge stream properties.

Salinity anomaly (i.e. impact) due to the EPDP operations were derived from the instantaneous difference in salinity between the base case and developed case simulations (refer Section 5.2). The results presented below show the derived salinity anomaly at the seabed. Due to the relative density of the brine the near-seabed salinity anomaly is almost always the maximum value in the water column.

5.6.1 Percentile Maps

Percentile statistics (50th, 90th and 99th) were derived from the salinity anomaly results and used to produce maps of the brine plume footprint at the seabed. The 50th percentile statistic represents the chronic level of impact (expected 50% of the time), while the 90th and 99th percentile statistics represent the acute levels of impact that may occur for short periods of time. The percentile statistics were calculated for a 1 month period and the exceedance 50th, 90th and 99th percentiles represent 15 days, 3 days and 7.2 hours exceedance durations respectively within a 30 day period. It is important to note that percentile maps do not represent the instantaneous footprint of the plume but instead represent a statistical aggregation of the plume footprint over a period of time (in this case 30 days).

The winter period percentile maps are shown in Figure 5.7, Figure 5.8 and Figure 5.9 (50th, 90th and 99th percentiles).

The summer period percentile maps are shown in Figure 5.10, Figure 5.11 and Figure 5.12 (50th, 90th and 99th percentiles).

Zoomed in maps of these results at the diffuser are presented for 50th, 95^{th,} 99th percentiles and for both winter and summer in Figure 5.13. These results show that at the 99th percentile a salinity anomaly threshold of 0.978, representing 1:40 brine dilution is only exceeded locally within the 30 m nearfield mixing zone. This result may seem unexpected given that a worst-case dilution of 1:59 was predicted by the nearfield modelling (Section 4.4). However, it needs to be understood that the mid-field modelling study is a continuous unsteady simulation over a 12-month period and unlike the steady-state near-field model it considers the potential for salinity anomaly to build up gradually within the receiving environment such that the diffuser is operating within an elevated salinity background condition. Given this context the 99th percentile results from the mid-field model are expected to be higher than the worst-case dilution results from the near-field assessment.

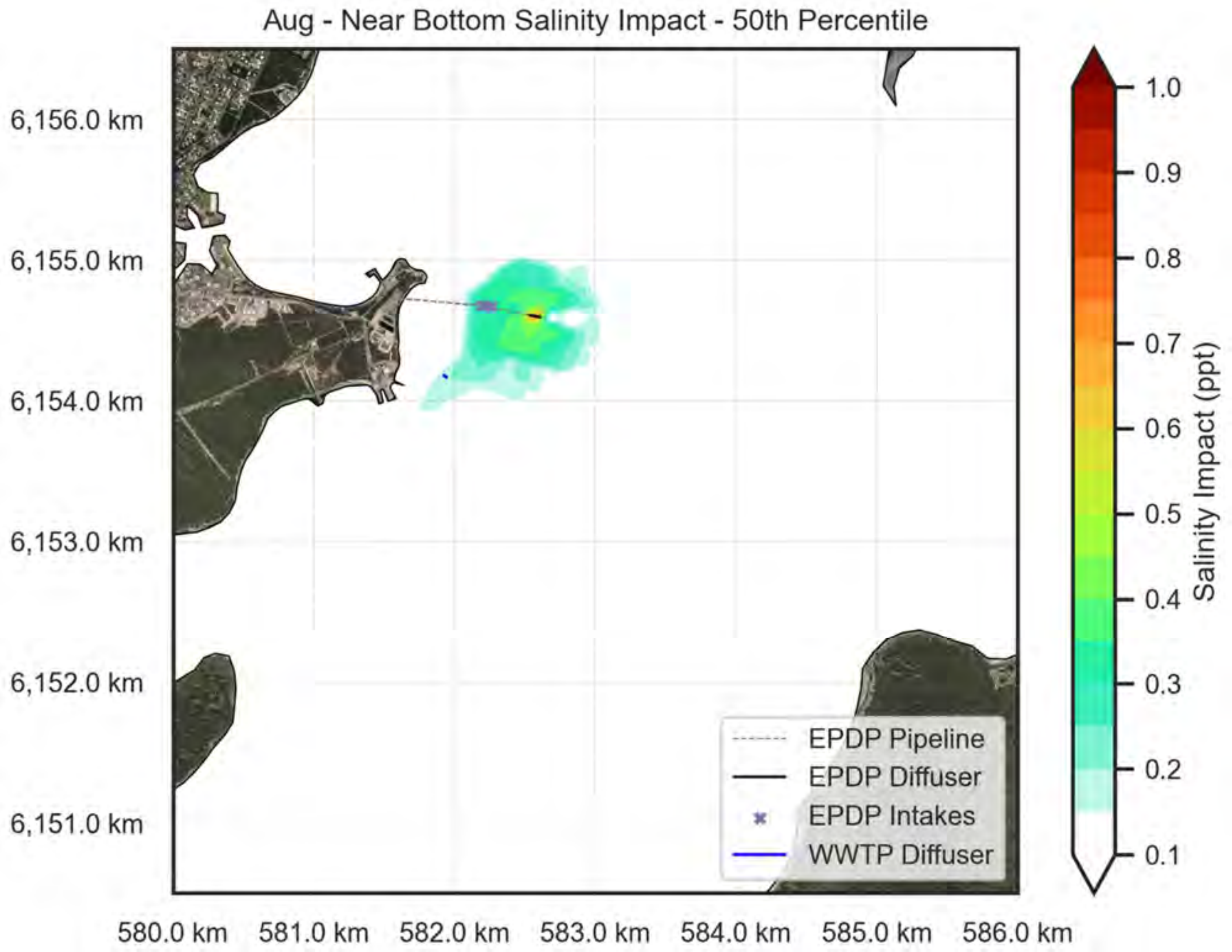


Figure 5.7 50th percentile map of seabed salinity anomaly for the winter assessment period

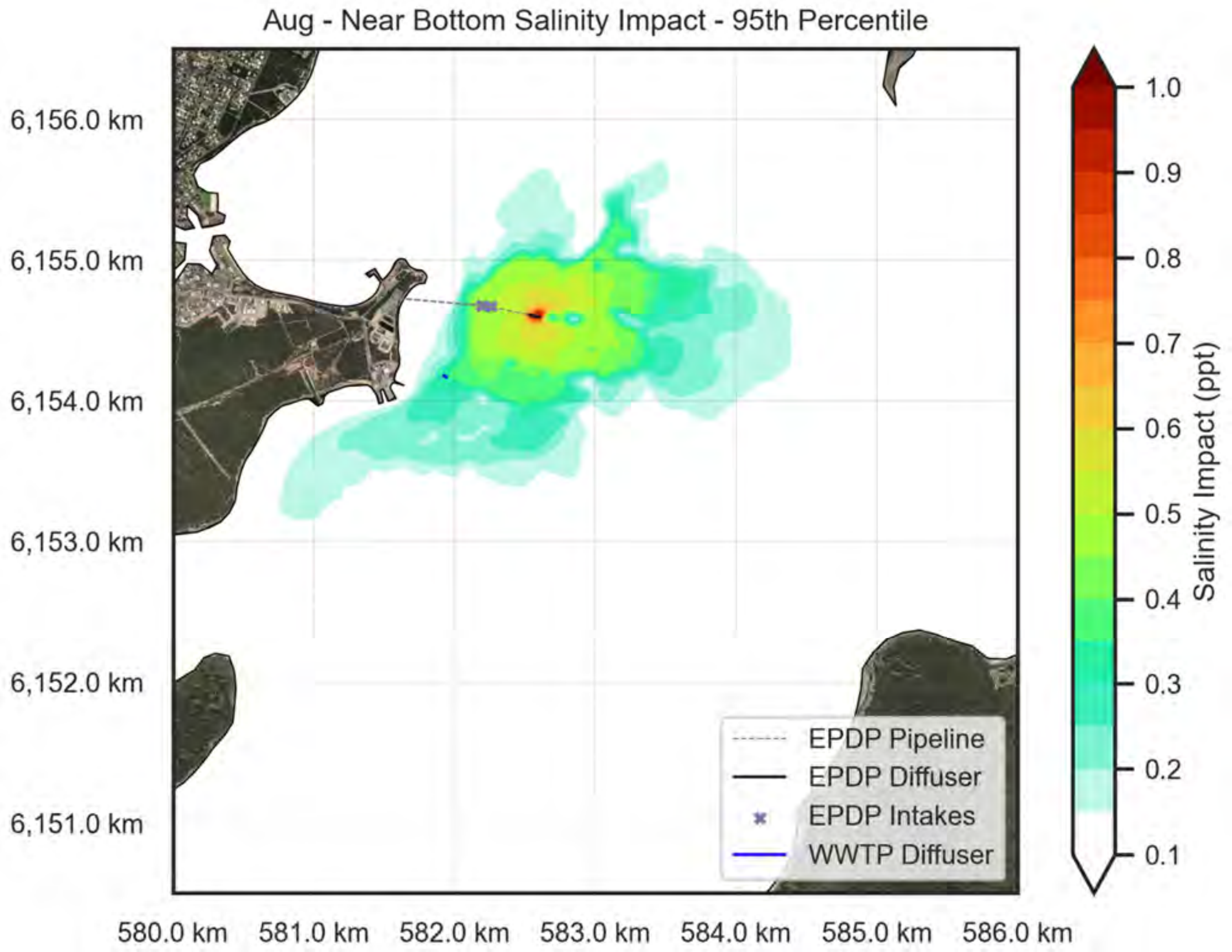


Figure 5.8 95th percentile map of seabed salinity anomaly for the winter assessment period

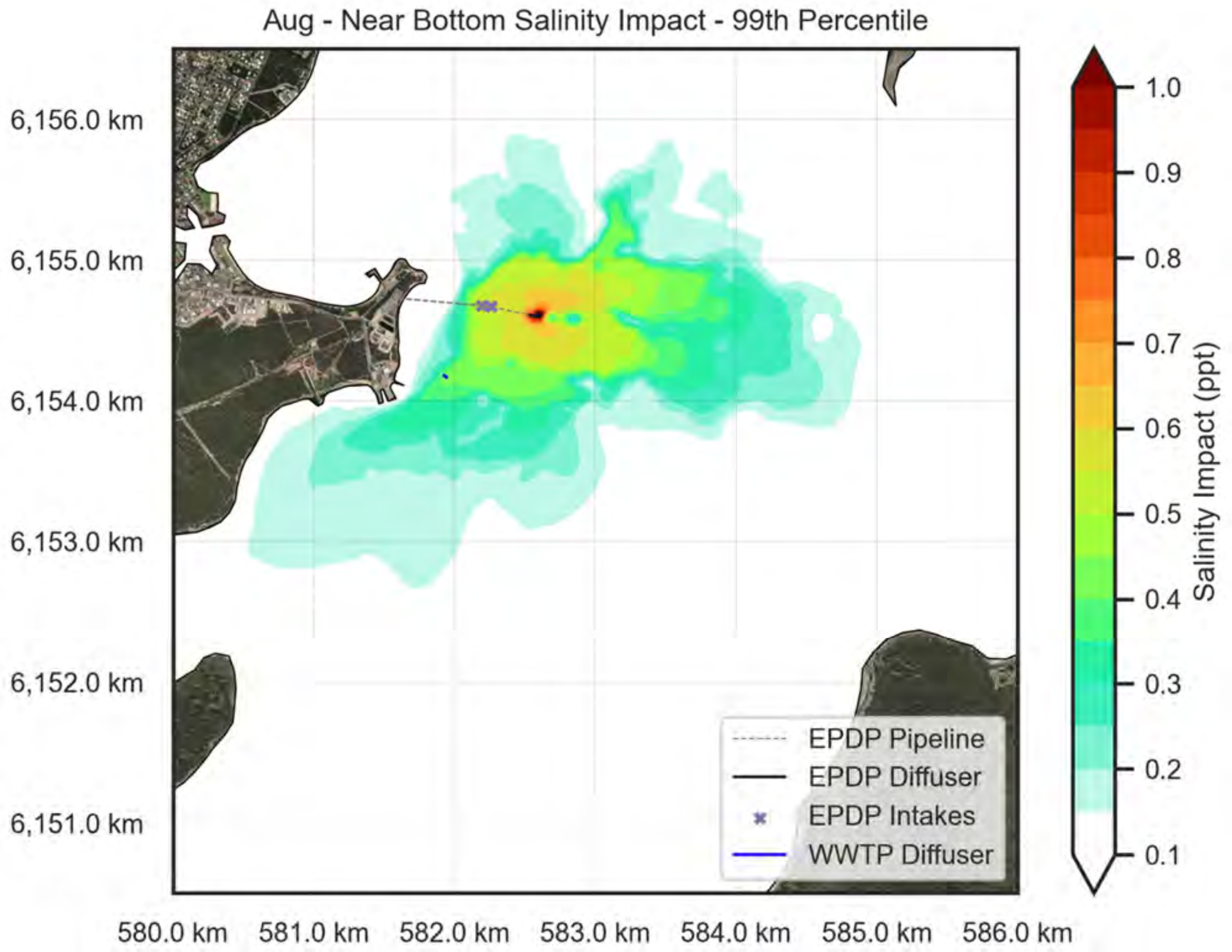


Figure 5.9 99th percentile map of seabed salinity anomaly for the winter assessment period

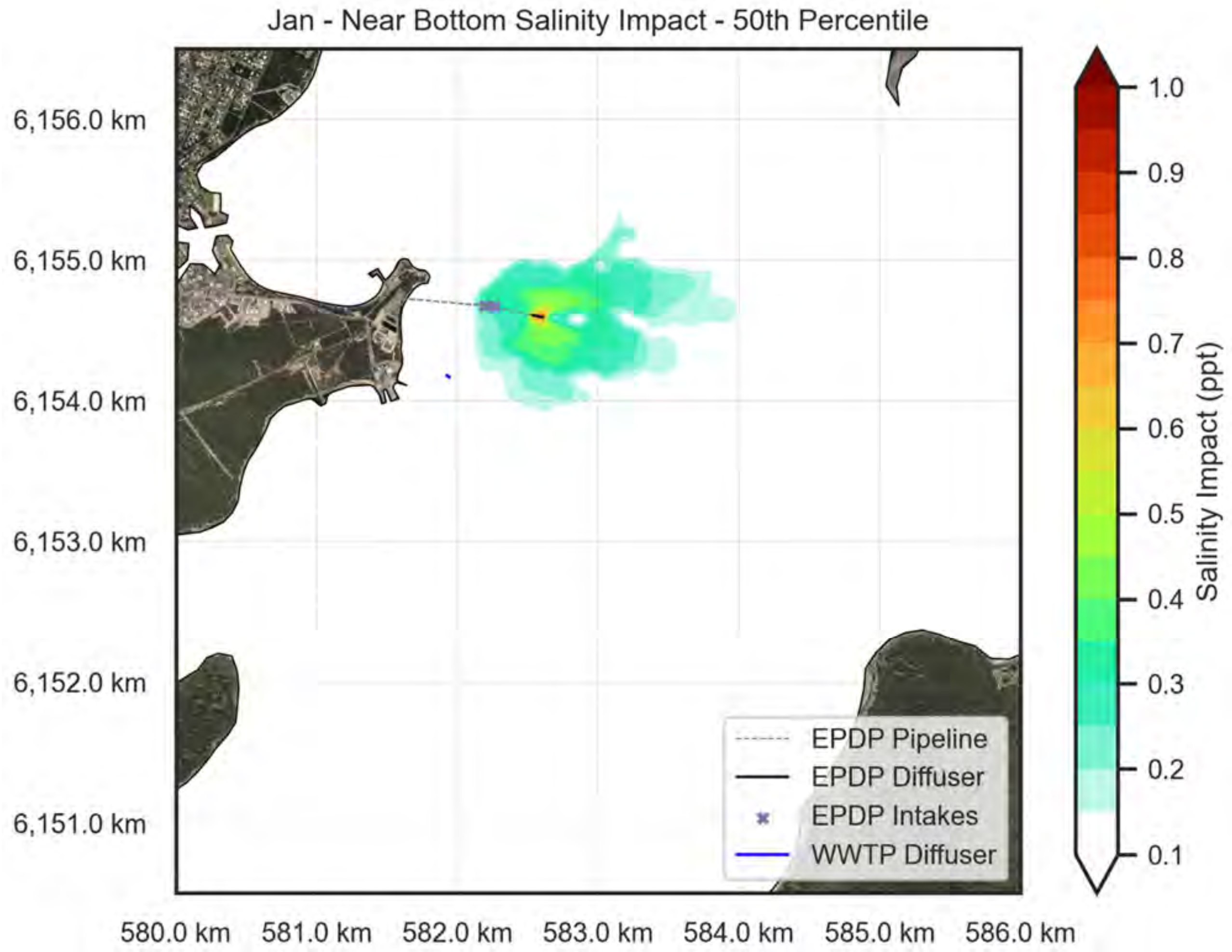


Figure 5.10 50th percentile map of seabed salinity anomaly for the summer assessment period

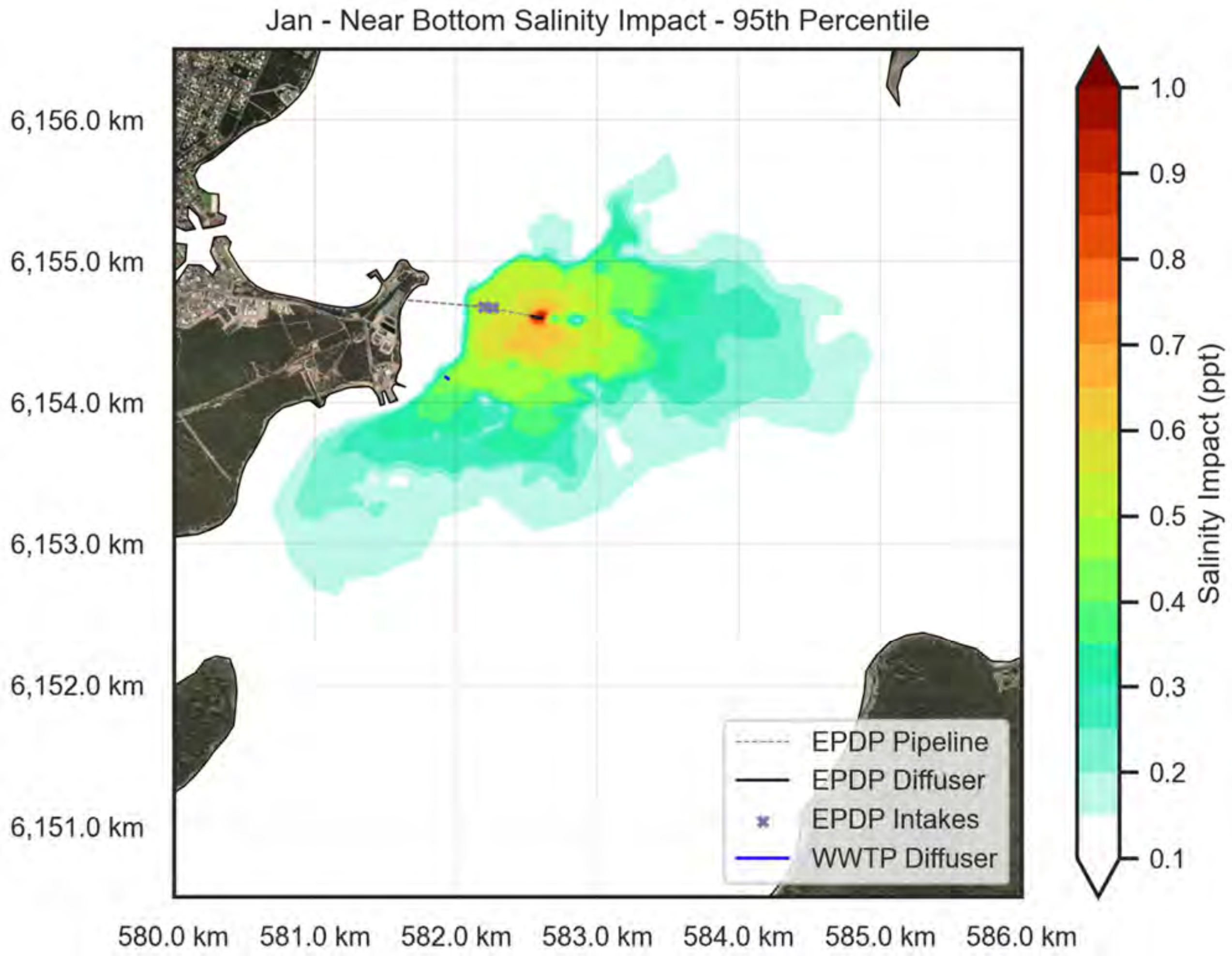


Figure 5.11 95th percentile map of seabed salinity anomaly for the summer assessment period

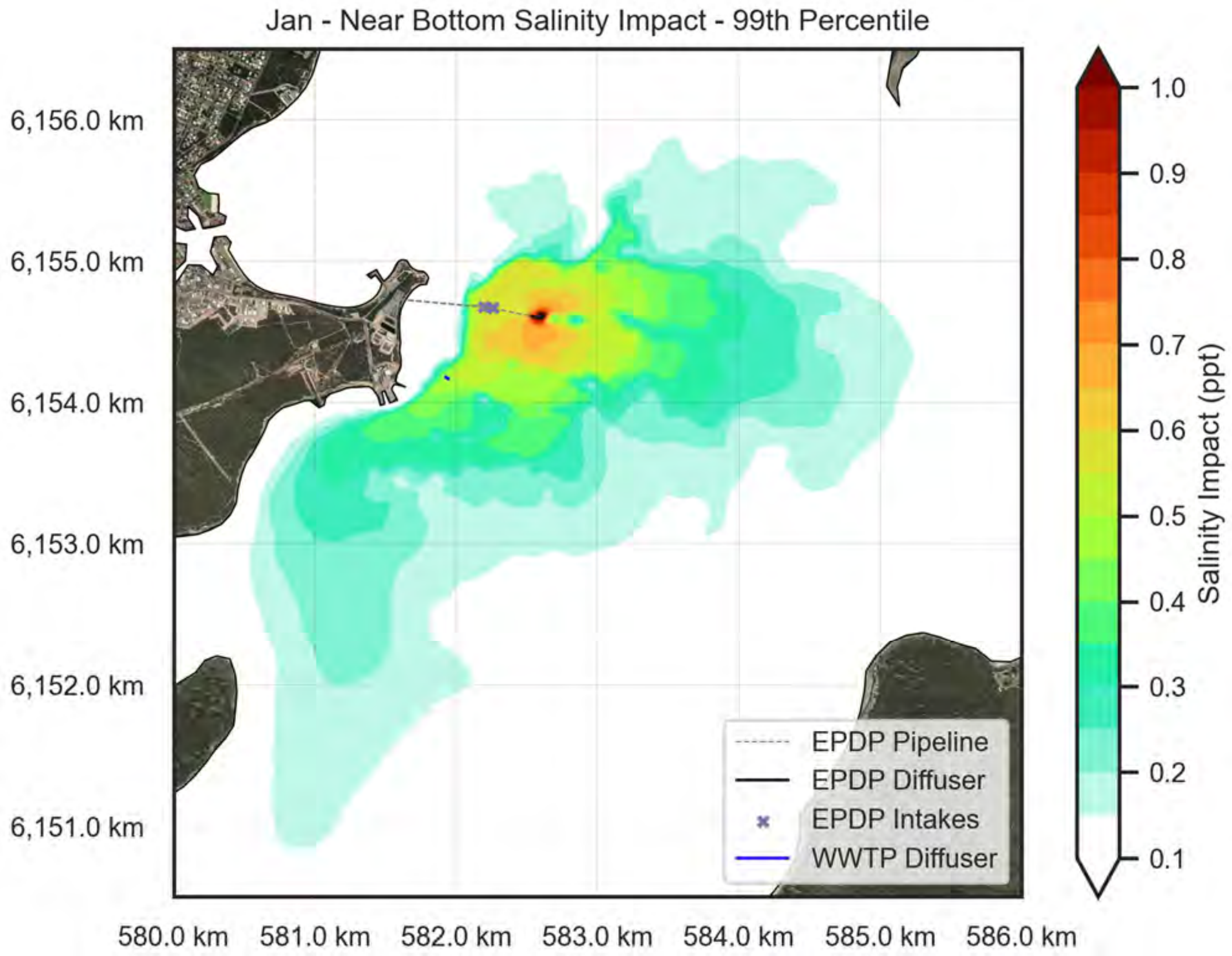


Figure 5.12 99th percentile map of seabed salinity anomaly for the summer assessment period

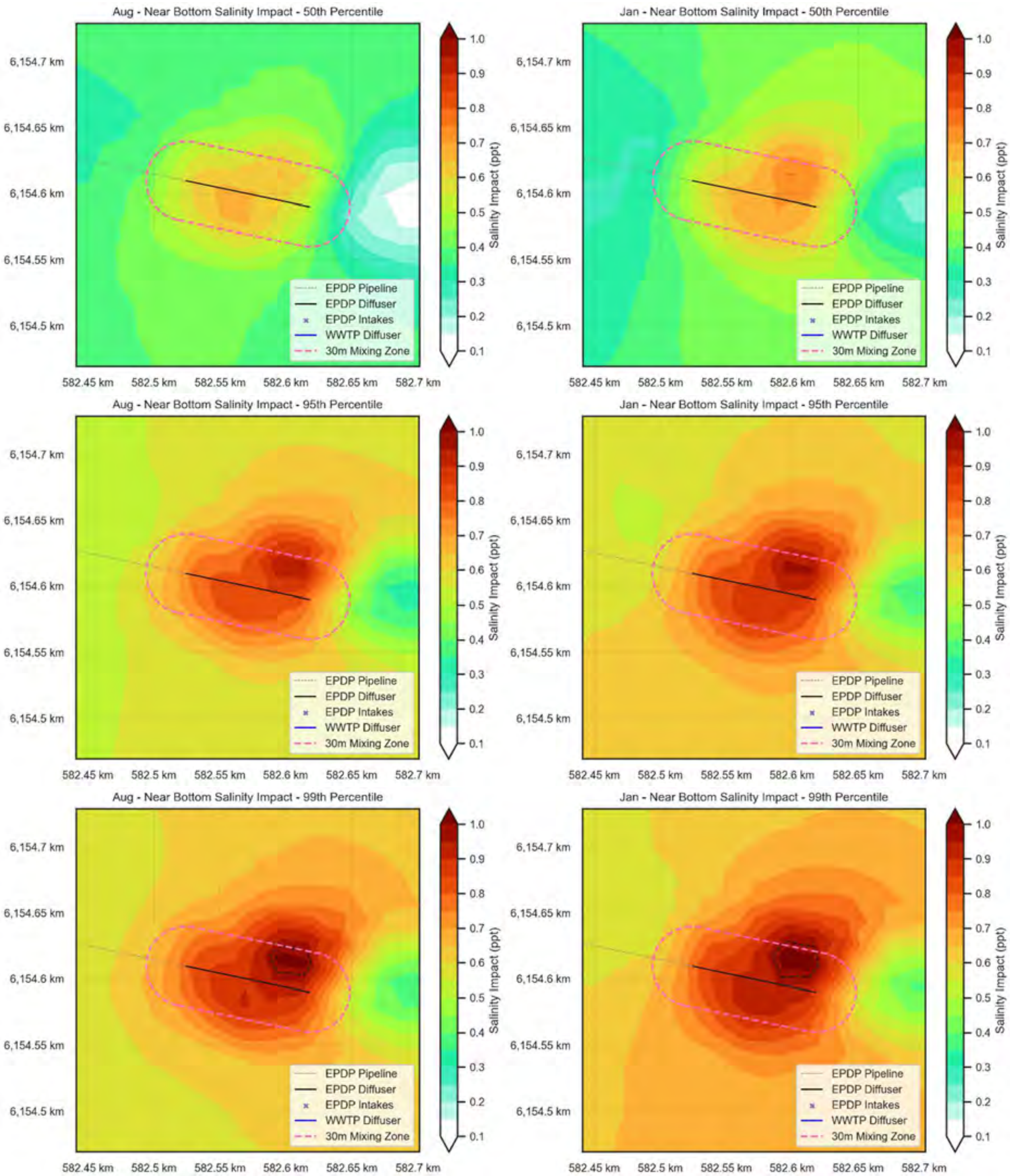


Figure 5.13 Near diffuser zoom of the percentile maps of seabed salinity
50th (top), 95th (middle) and 99th (top) percentiles, winter (left) and summer (right)

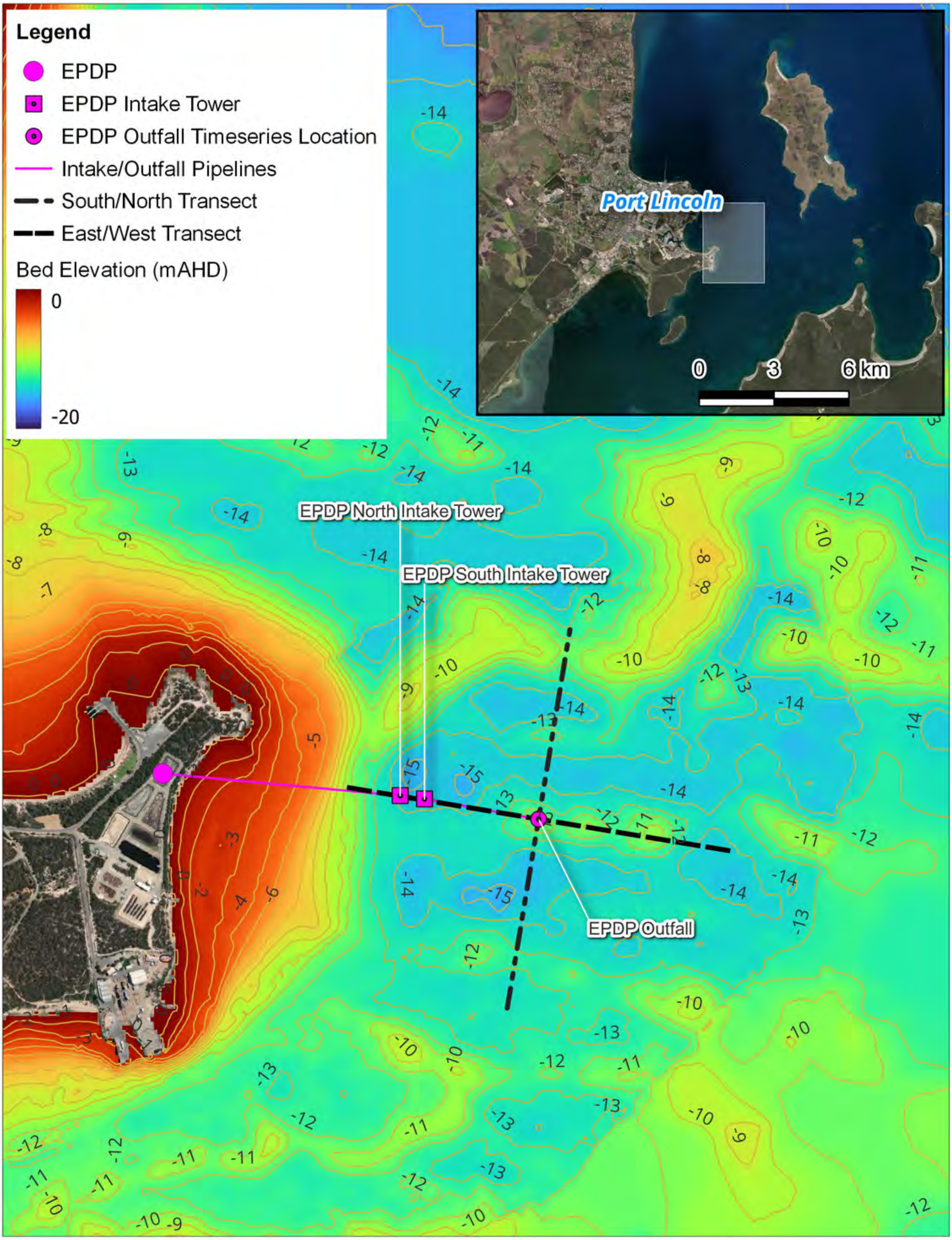
5.6.2 Cross-section Profiles

A more detailed presentation of the salinity anomaly distribution along transects in both the cross-shore and long-shore directions have been prepared to aid in interpretation of the model results. The cross-shore (east/west) transect and long-shore (north/south) transect are shown in Figure 5.14. Figures have been prepared that show the salinity anomaly distribution along these transects at various neap-spring periods.

The results of this analysis are provided in Figure 5.15, Figure 5.16, Figure 5.17 and Figure 5.18. Each figure includes:

- Top panel – time series of the tidal water levels for a 7 day window from the 12-month simulation. A 1 day window is shown in grey and represents the tidal cycle for calculating and presenting time-averaged cross-section profiles.
- Second panel from top – A Hovmuller plot showing the 7-day timeseries of salinity anomaly profiles at the diffuser centroid location.
- Third panel from top – A west to east (cross-shore) transect through the diffuser showing the 1-day time-average profile of salinity anomaly.
- Bottom panel – A south to north (cross-shore) transect through the diffuser showing the 1-day time-average profile of salinity anomaly.

The cross-section profiles show the tendency of the dense brine to pool in local bathymetric depressions surrounding the relatively raised diffuser location. Dodge tide periods show increased accumulation of brine compared to the spring tide periods.



Title:

Location of Salinity Anomaly Profile Transects

Figure: 5-14

Rev: A

BMT endeavours to ensure that the information provided in this map is correct at the time of publication. BMT does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

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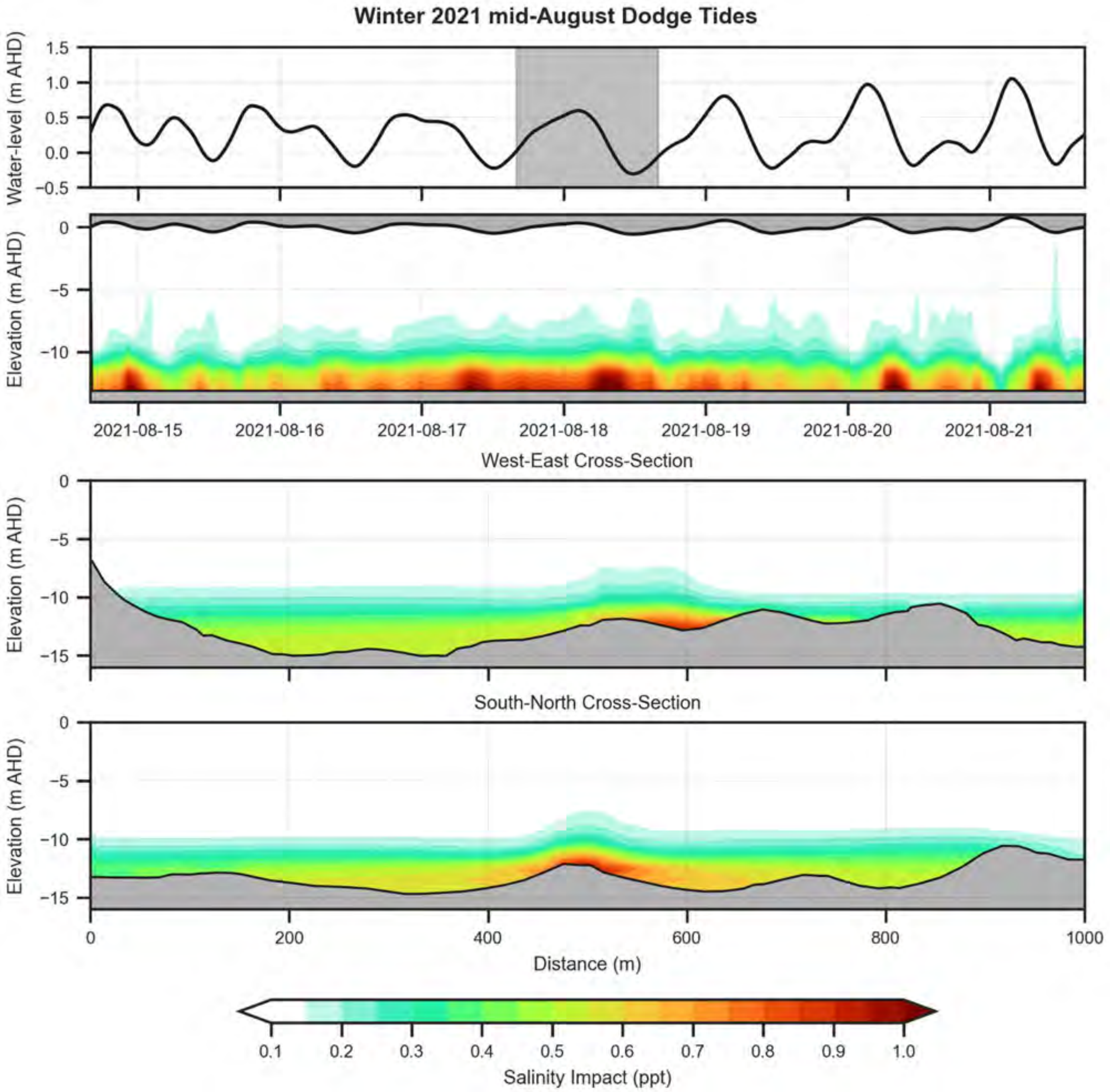

Figure 5.15 Salinity anomaly in the water column during mid-August 2021 dodge tides

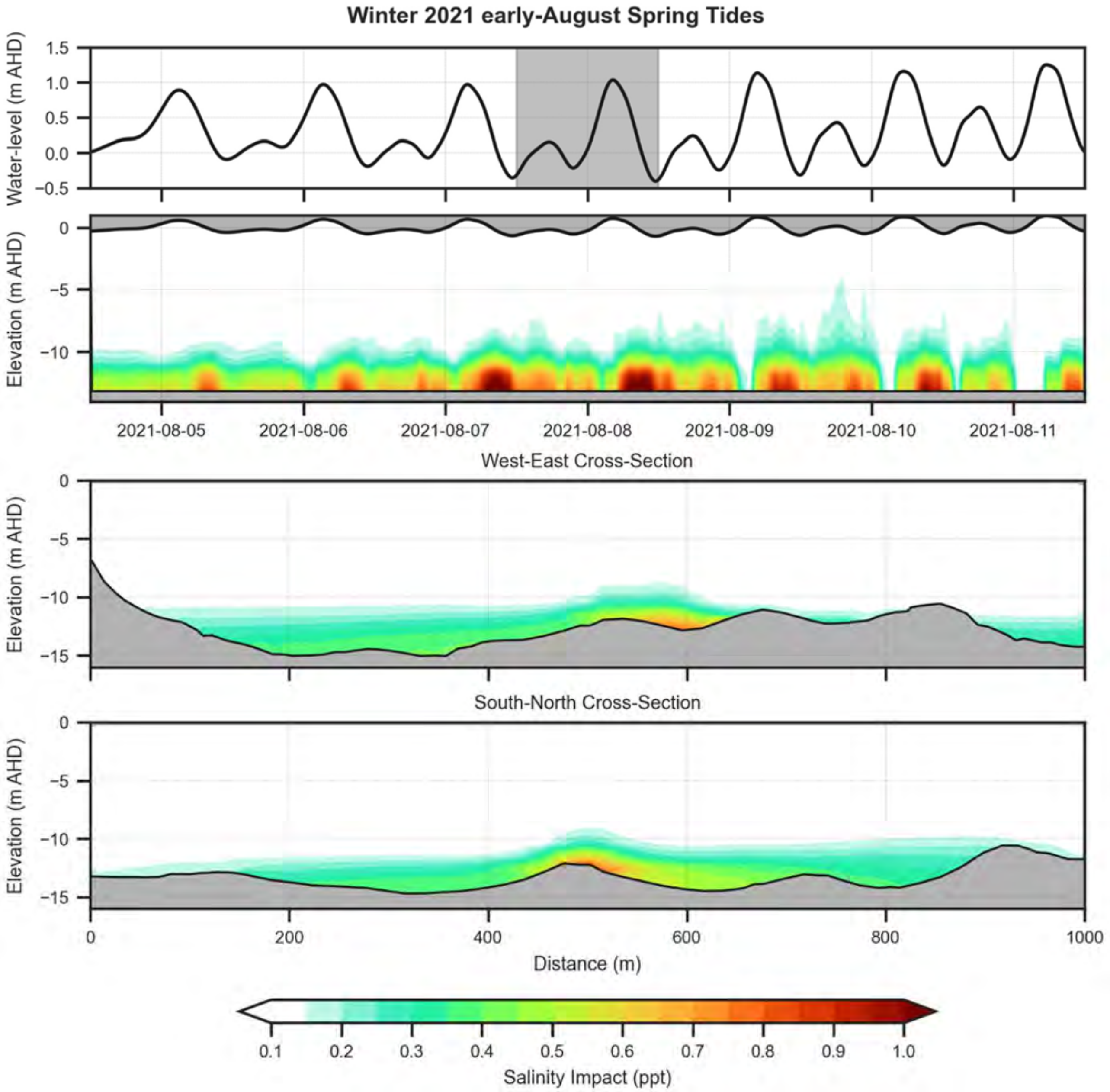

Figure 5.16 Salinity anomaly in the water column during early-August 2021 spring tides

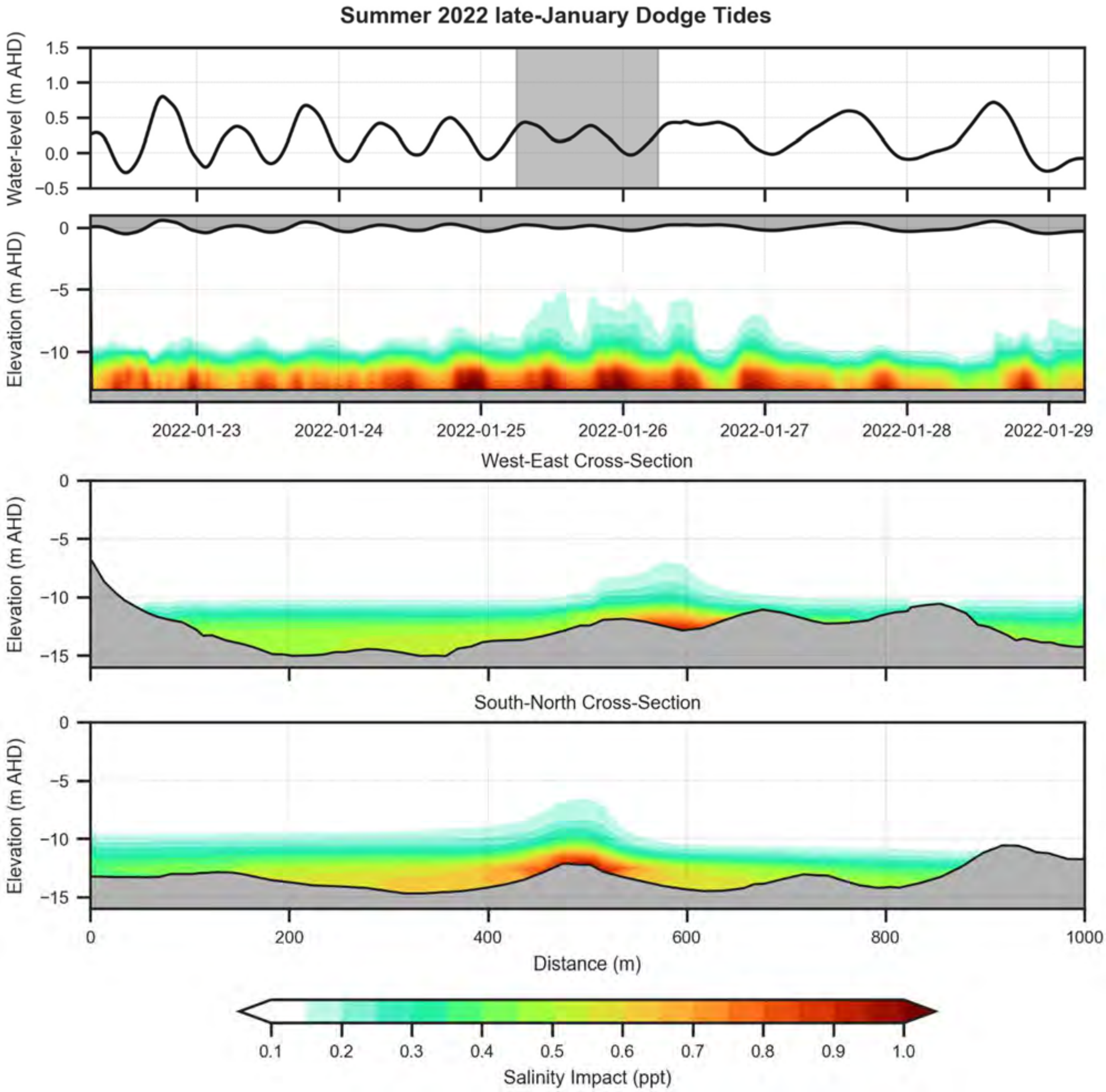

Figure 5.17 Salinity anomaly in the water column during late-January dodge tides

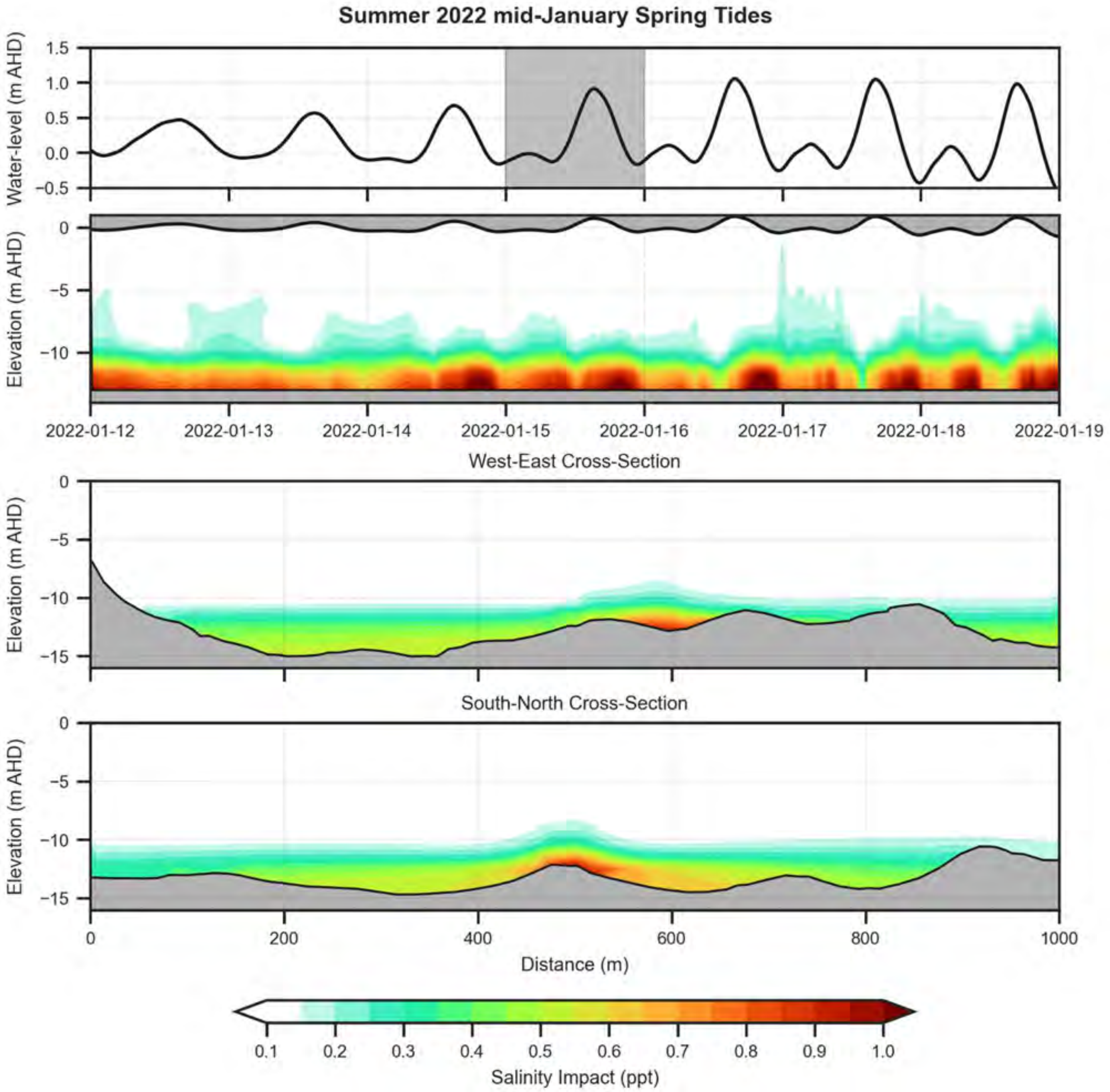

Figure 5.18 Salinity anomaly in the water column during mid-January spring tides

5.7 TSS Plume Risk

The TSS plume risk relating to the EPDP discharge stream in the mid-field receiving environment have been assessed against a performance criterion off <10% increase in TSS above background conditions. The following results are extracted from a 13-month simulation (1/7/2021 to 1/8/2022), where the results from the one-month winter period (1/8/2021 to 1/9/2021) are shown.

These results are extracted from a 13-month simulation of the period from the 1/7/2021 to 1/8/2022 but have been presented for a one-month summer period (1/1/2022 to 1/2/2022) and a one-month winter period (1/8/2021 to 1/9/2021).

The EPDP design assumptions were detailed in Section 2.1 and describe the intake riser, outfall diffuser and discharge stream properties. For the purposes of this assessment, a condition based on intake TSS concentration of 1.4 mg/L and corresponding un-diluted SWRO discharge TSS of 2.66 mg/L has been modelled. Regardless of the assumed intake TSS, the purpose of this assessment is to consider the potential for the discharged TSS to exceed 10% above ambient conditions.

The simulation is performed without modelling ambient sediment concentration, thereby presenting the TSS impact above ambient due to the EPDP discharge stream. The results presented below illustrate planform representations of the TSS plume for the temporal maximum concentrations over the top 1 m of the water column (Figure 5.19 and Figure 5.21) and bottom 1 m of the water column (Figure 5.20 and Figure 5.22).

Results indicate that the TSS plume has a greater tendency to distribute along the seabed, with no detectable surface plume present (concentrations <0.02 mg/L). Seabed TSS concentrations are highest, with localised concentrations in the order of up to 0.08 mg/L in the immediate vicinity of the outfall. These concentrations notably fall well below the <10% above ambient threshold (0.14 mg/L).

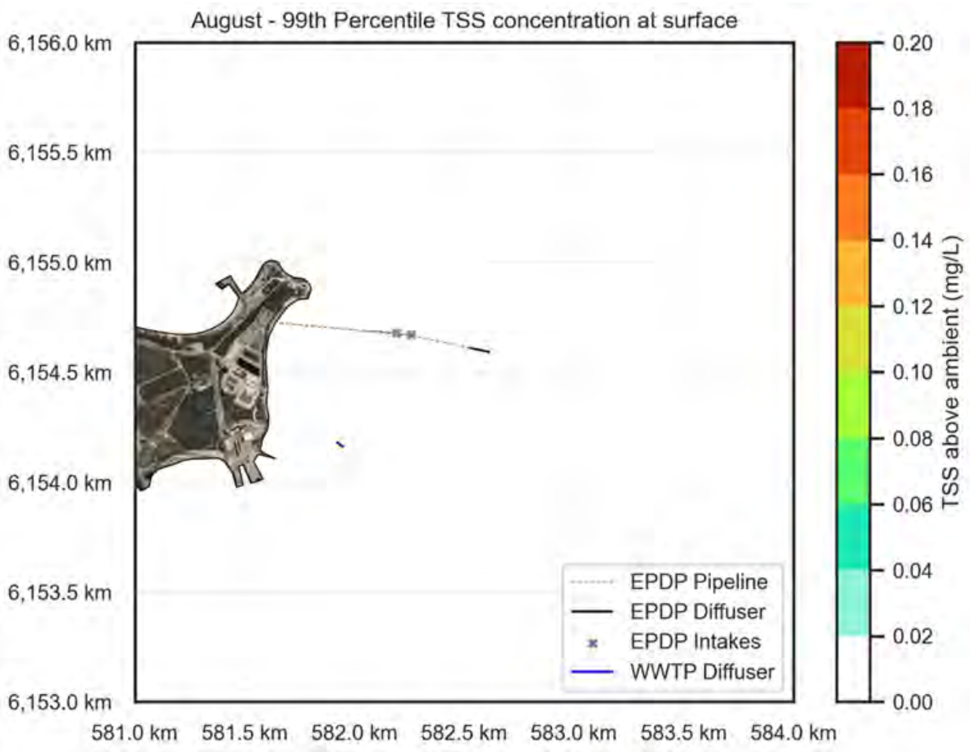

Figure 5.19 99th Percentile TSS concentration at surface (winter scenario).

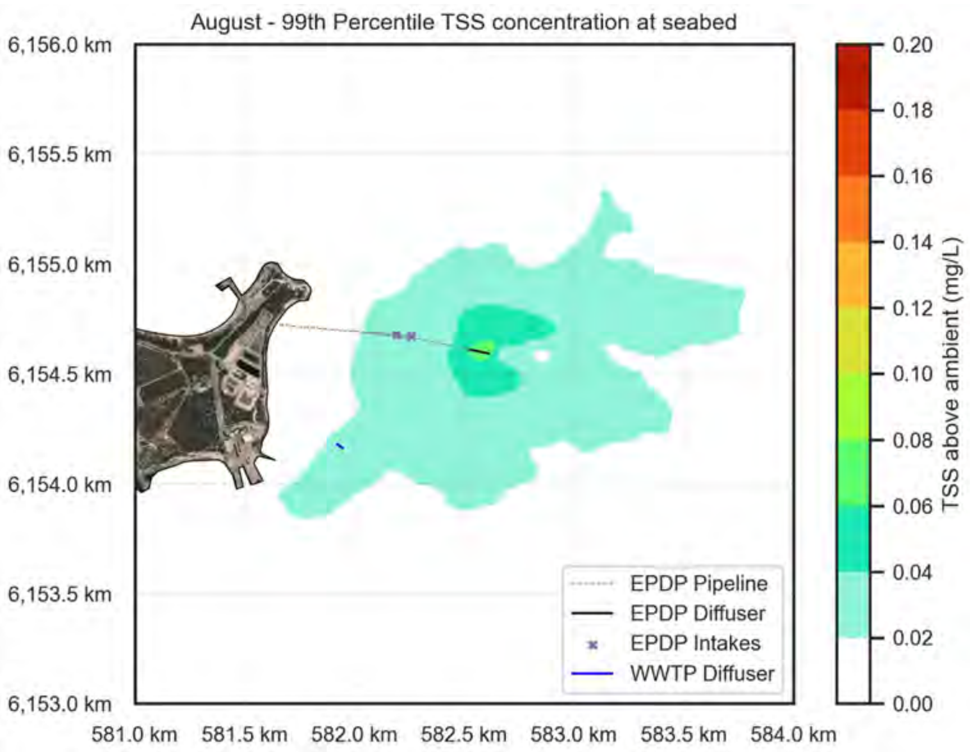

Figure 5.20 99th Percentile TSS concentration at seabed (winter scenario).

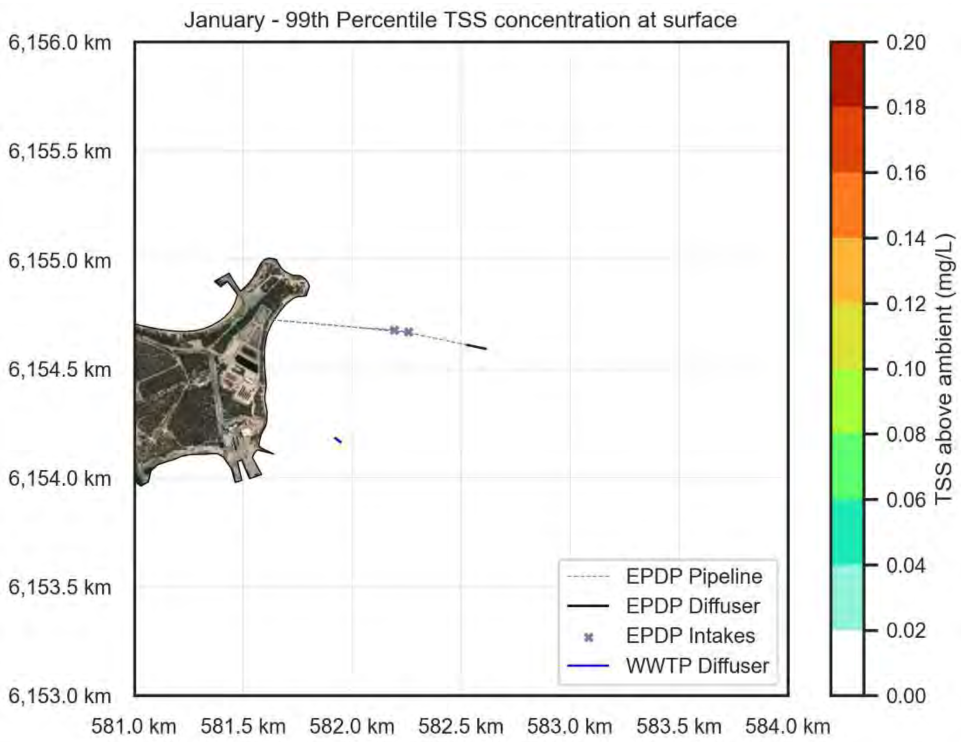

Figure 5.21 99th Percentile TSS concentration at surface (summer scenario).

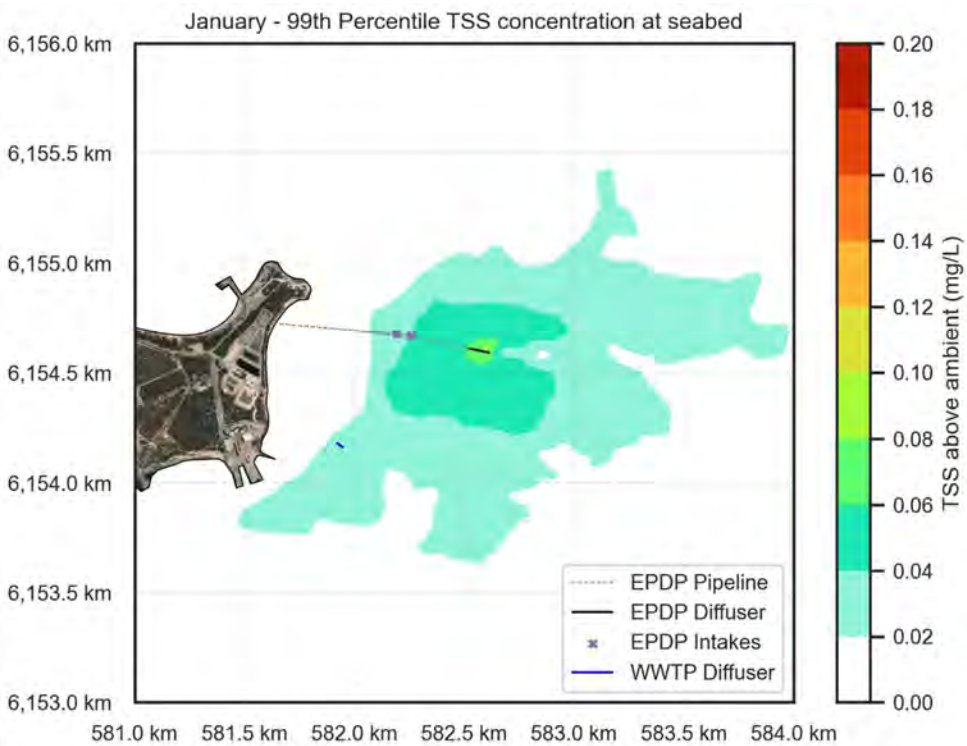

Figure 5.22 99th Percentile TSS concentration at seabed (summer scenario).

6 Coastal Process Assessments

6.1 Regional and Geological Description

The regional setting of the study area at Port Lincoln within Spencer Gulf is shown in Figure 6.1.

The following is a geological description of the Billy Lights Point study area (from Bourman et al., 2016):

At Billy Lights Point, a shore platform has developed in gneiss, a coarsely crystalline, banded metamorphic rock. The overlying, more weathered rock has been removed by coastal erosion, producing shore platforms of the Old Hat variety. This formation occurs where the contact between weathered and unweathered rock occurs in the intertidal zone and the 'brim' forms a shore platform on unweathered rock, while the 'crown' consists of weathered rock in the eroding backing cliff.

6.2 Metocean Climate

The following section describes the ambient and extreme metocean climate around the proposed development EPDP site which is important for contextualising coastal processes in the area.

6.2.1 Hindcast numerical modelling

The metocean conditions described in this section are based on modelling undertaken to develop metocean criteria for the engineering design of the pipeline structures, which is available in full detail in a separate report (BMT, 2024b). The metocean study focussed on three locations of interest for the provision of metocean criteria corresponding to the daylight location of the EPDP pipeline (“Inshore”), the centre of the intake inlets (“Intake”) and the centre of the outfall diffuser (“Outfall”).

Modelling of ambient and extreme hydrodynamic conditions (i.e., currents) were undertaken using a TUFLOW FV model based on the mid-field model described in this report (see Section 4.5). The extreme storm hydrodynamic conditions were based on individual short-term simulations of the top 50 storms based on residual water-level (i.e., storm surge) recorded at the Port Lincoln tide gauge. There were minor changes made to this version of the model to enable running historic periods (e.g., between 1979 to 2020) however the general model parameterisation has remained the same, and full details on this model setup are described in the metocean study report.

Ambient and extreme wave conditions were modelled using the SWAN model described in Section 4.7. The SWAN model was used to develop a 3-year hindcast (2021 to 2024) of waves in the area of interest, as well as a set of 50 storm event simulations representing the largest wave events from the 1979 to 2020 period. This selection is described in further detail in the metocean study report.

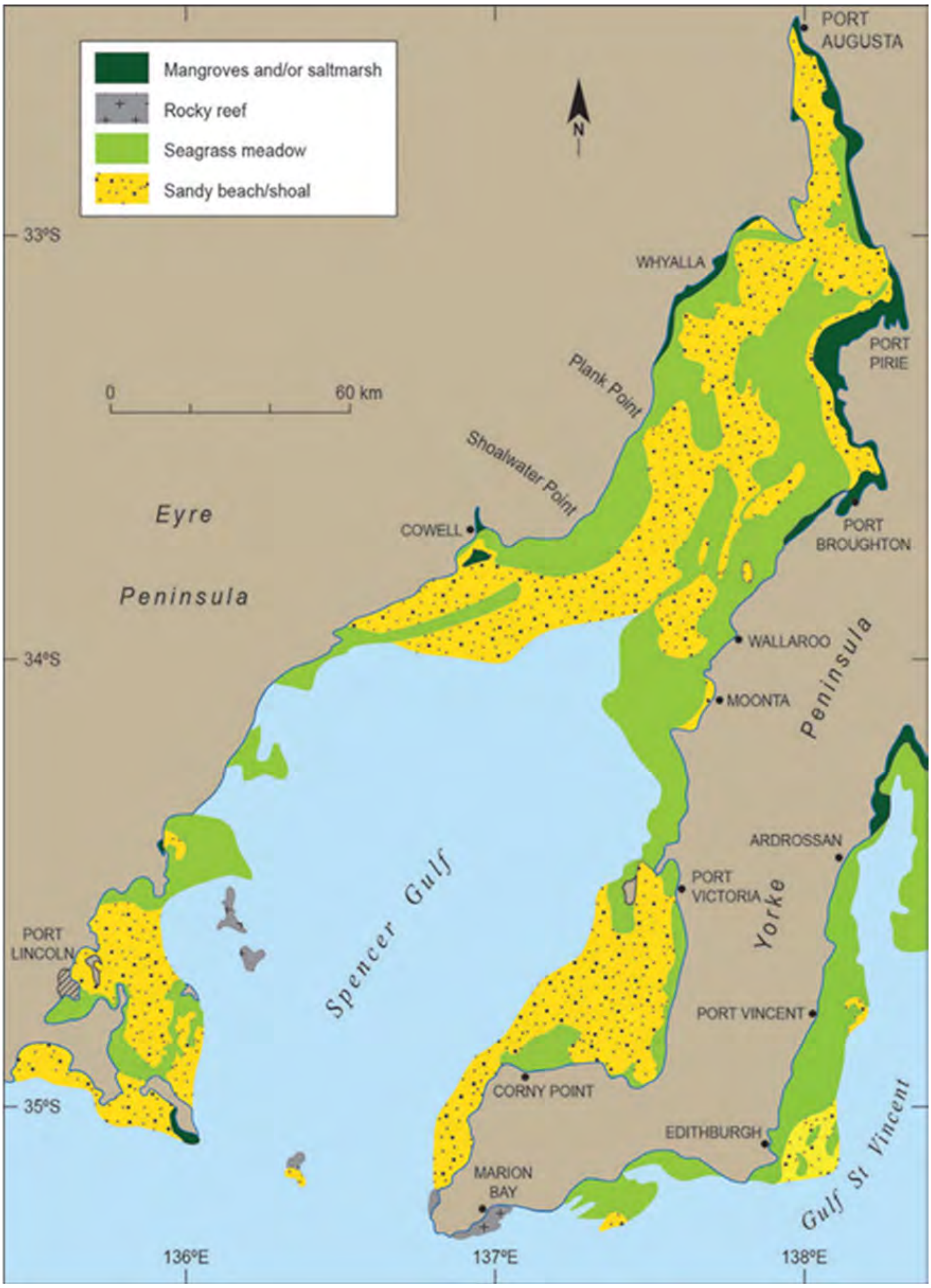

Figure 6.1 Dominant coastal environments of Spencer Gulf: rocky reefs, sandflats, seagrass meadows and mangroves. Source: Coastal Landscapes of South Australia 2016, Robert P. Bourman, Colin V. Murray-Wallace and Nick Harvey

6.2.2 Water-levels

Tides in Spencer Gulf are semidiurnal with non-uniform phase and amplitude increasing to the upper estuary (Ansell et al.1997). Tidal planes for Port Lincoln were presented earlier in the baseline coastal environment section, Table 3.1.

A unique feature of South Australian gulfs is the almost perfect compensation between semidiurnal principal lunar and solar tides, triggering particularly weak tidal flows during neap tides—a feature known as the dodge tide—that can last 2–3 days.

Regionally relevant sea-level rise projections have been extracted at Port Lincoln from the National Aeronautics and Space Administration's (NASA) Sea Level Projection Tool, which provides sea-level rise projections from the Intergovernmental Panel on Climate Change's (IPCC) 6th Assessment Report (2021).

For this project, projections from the SSP5-8.5 medium confidence scenario have been adopted which is a high reference scenario representing no additional climate policy. The projected sea-level rise for Port Lincoln is shown in Figure 6.2. A sea-level rise projection of 0.976m for the year 2124 has been adopted for this study (calculated using interpolation between the 2120 and 2130 projections).

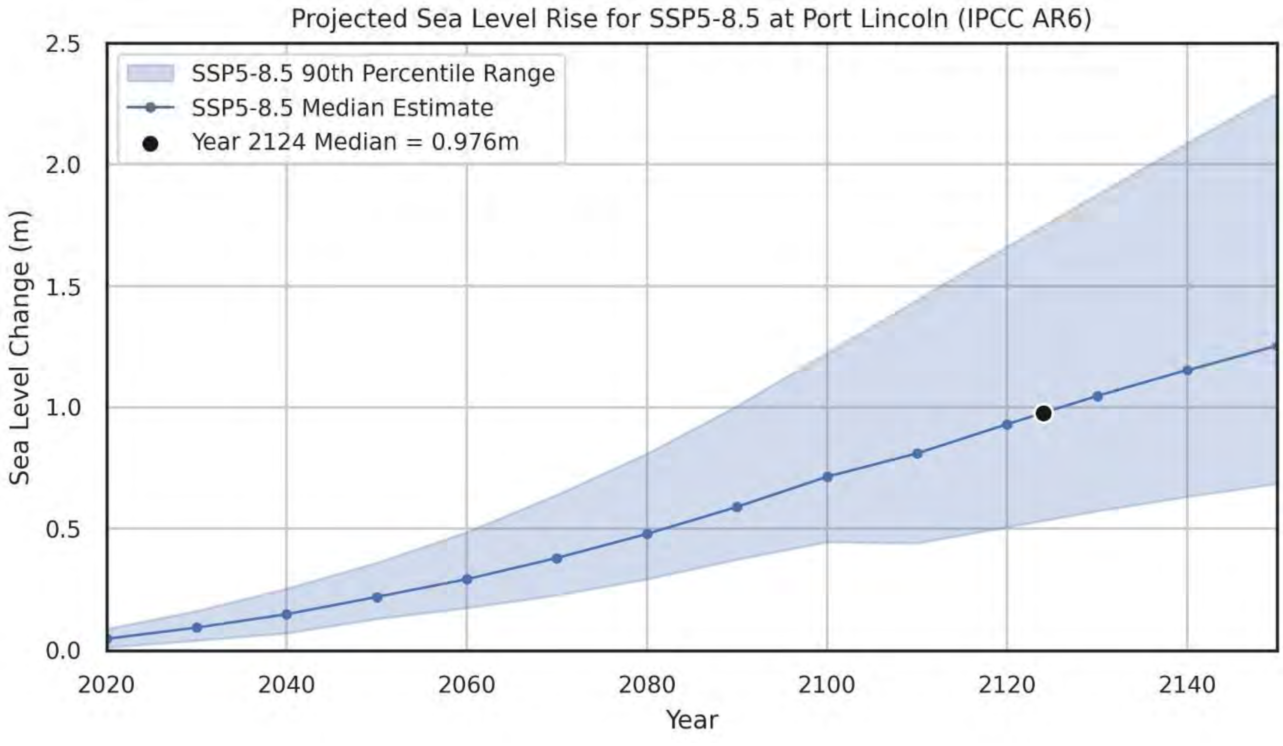

Figure 6.2 Projected sea-level rise at Port Lincoln for the SSP5-8.5 Medium Confidence Scenario (IPCC, 2021).

Strong storm surges are known to occur at Port Lincoln with many notable events recorded by the Port Lincoln tide gauge. Extreme water-level criteria were developed as part of the metocean study and are presented in Table 6.1.

Table 6.1 Extreme Still Water-levels (m rel. AHD)

Variable	Return Period (Years)			
	1	10	100	500
Present Day Extreme High SWL	1.59	1.87	2.06	2.12
Future (2124) Extreme High SWL	2.57	2.85	3.04	3.10
Present Day Extreme Low SWL	-0.76	-0.83	-0.98	-1.07

6.2.3 Waves

Wave conditions inside Boston and Proper Bay are characterised as generally mild fetch-limited wind-waves, with very little to negligible swell energy able to penetrate the bay. At the proposed EPDP development site, the longest fetches are from the north or south-west, thus the largest wave conditions tend to occur when winds align along these directions.

Spatial field examples of extreme south-westerly and northerly storm conditions are shown below in Figure 6.3, demonstrating these two directional modes.

Figure 6.4 shows wave roses of all-year and seasonal wave conditions (significant wave height vs mean wave direction) at the approximate location of the EPDP outfall diffuser based on the 3-year hindcast of wave conditions.

At the EPDP site, waves typically vary between 0.1 to 0.4m significant wave height with the occasional strong wind event able to cause wave heights of above 1.0m. There is a notable seasonal variation in both direction and magnitude of waves, with the more storm events and higher waves occurring on average during winter.

Omnidirectional extreme wave criteria developed as part of the metocean study are presented in Table 6.2.

Table 6.2 Omnidirectional Extreme Significant Wave Height (m)

Location of Interest	Return Period (Years)			
	1	10	100	500
Outfall	1.16	1.30	1.44	1.53
Intake	1.13	1.27	1.40	1.49
Inshore	1.01	1.12	1.23	1.30

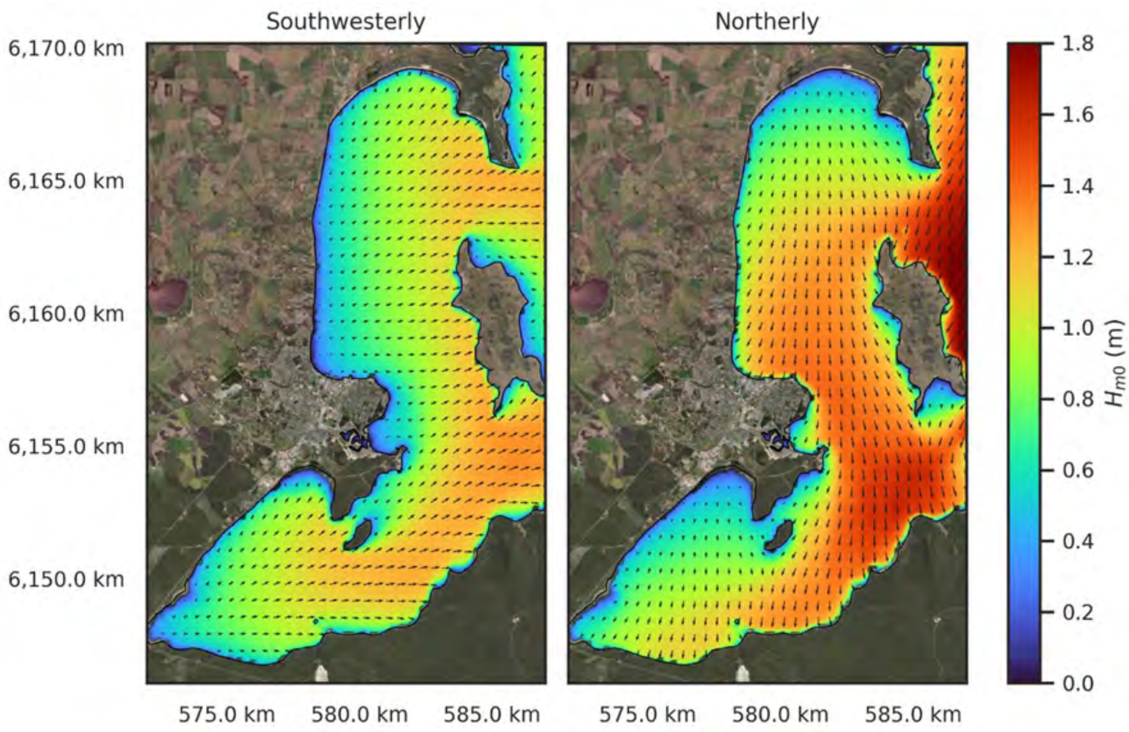

Figure 6.3 Example of typical storm modes in Boston and Proper Bay

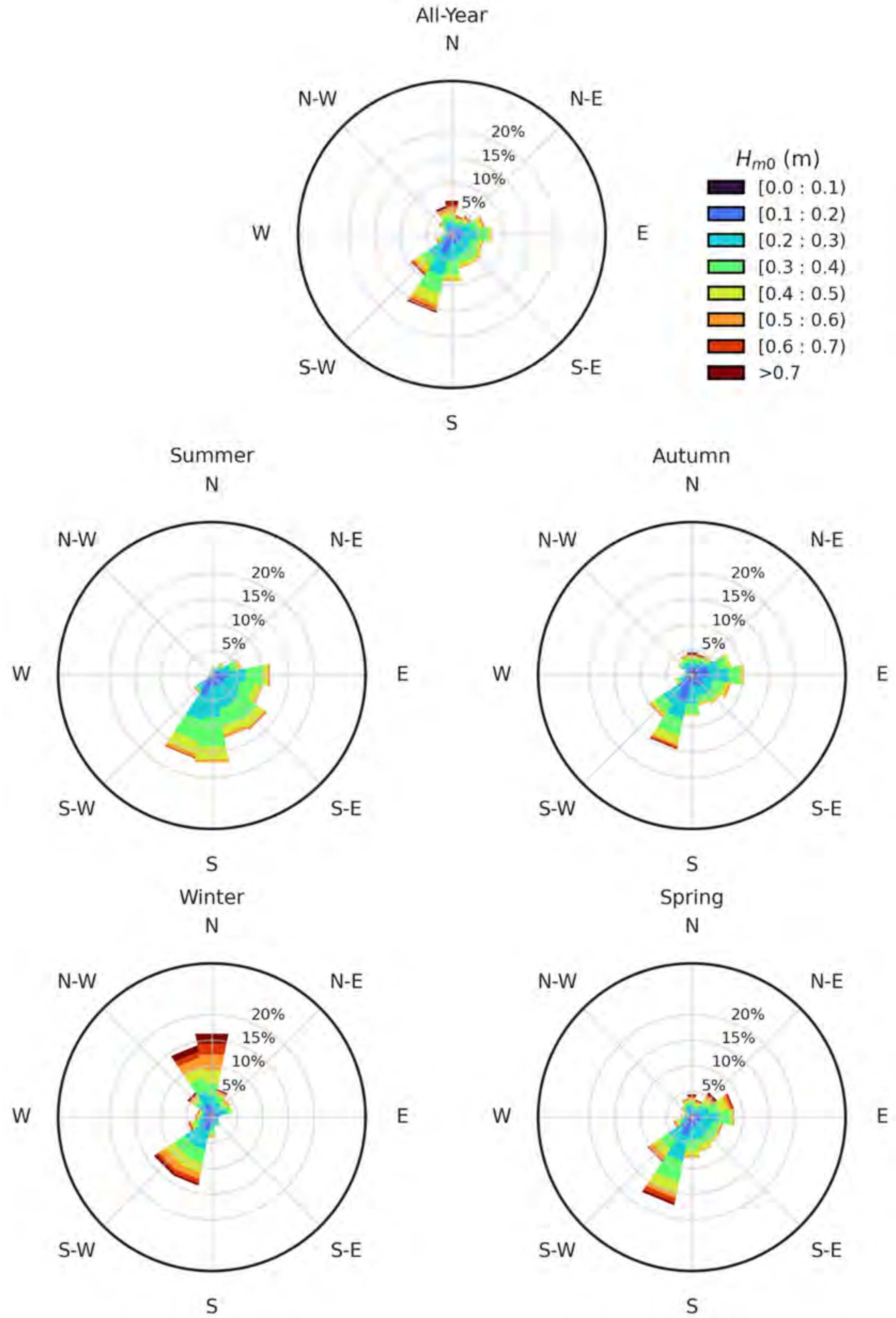

Figure 6.4 Ambient wave conditions - rose plot of all-year and seasonal significant wave height and direction at the EPDP Outfall Location (Source: SWAN Hindcast 2021 to 2024)

6.2.4 Currents

Current circulation within the Spencer Gulf can be divided into two distinct regions: the southern region, extending from the entrance up to Wallaroo, and the northern region from Wallaroo to the head of the Gulf near Port Augusta (Morris Jones E, 2010). The combined effect of the tidal and residual flow creates distinct subregions having limited connectivity as displayed in Figure 6.5.

Current speeds within Boston and Proper Bay are characterised by mild total current velocities that rarely exceed 0.2 – 0.25m/s (depth averaged). Short-term storm surges are known to occur when strong winds push water into the bay and can cause increased water-levels and significant local residual currents, particularly notable at the surface.

Figure 6.6 (Spring tide) and Figure 6.7 (dodge tide) show current velocity patterns during a typical spring tide and dodge tide. During the spring tide, current speeds exceed 0.2 m/s during the flood and ebb with both a north and south flow direction. Dodge tides result in sustained periods of very weak currents less than 0.1m/s for the entire tide cycle around the EPDP area.

Figure 6.8 (Surface rose) and Figure 6.9 (seabed rose) show rose plots of all-year and seasonal total currents, which shows that there is some seasonally observed in particularly the surface currents, tied to the strong seasonally of the wind climate (see Section 3.4). Due to the low overall strength of the tidal signal in Boston and Proper Bay, surface currents are quite strongly tied to the prevailing wind climate, however depth-averaged and seabed currents are typically constrained and show little variation in direction at the EPDP site beyond a usual north-east to south-west regime.

Extreme (total) current criteria were developed as part of the metocean study, taking into consideration both tidal and residual current flows. Table 6.3 presents the total depth-averaged current speed extreme criteria, with further detail available in the metocean study report.

Table 6.3 Omnidirectional Extreme Total Depth-averaged Current Speed (m/s)

Location of Interest	Return Period (Years)			
	1	10	100	500
Outfall	0.22	0.27	0.33	0.37
Intake	0.22	0.29	0.36	0.40
Inshore	0.35	0.47	0.57	0.63

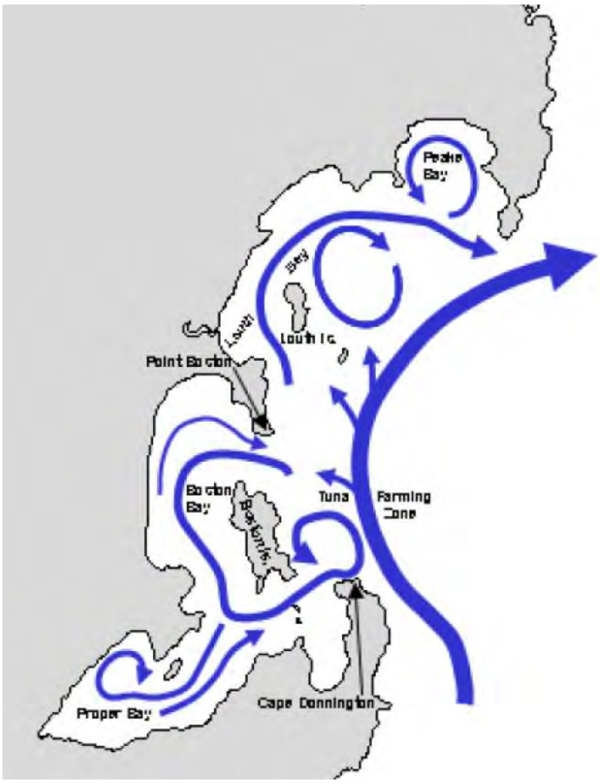

Figure 6.5 Typical residual current circulation in Boston and Proper Bay (Morris Jones E, 2010)

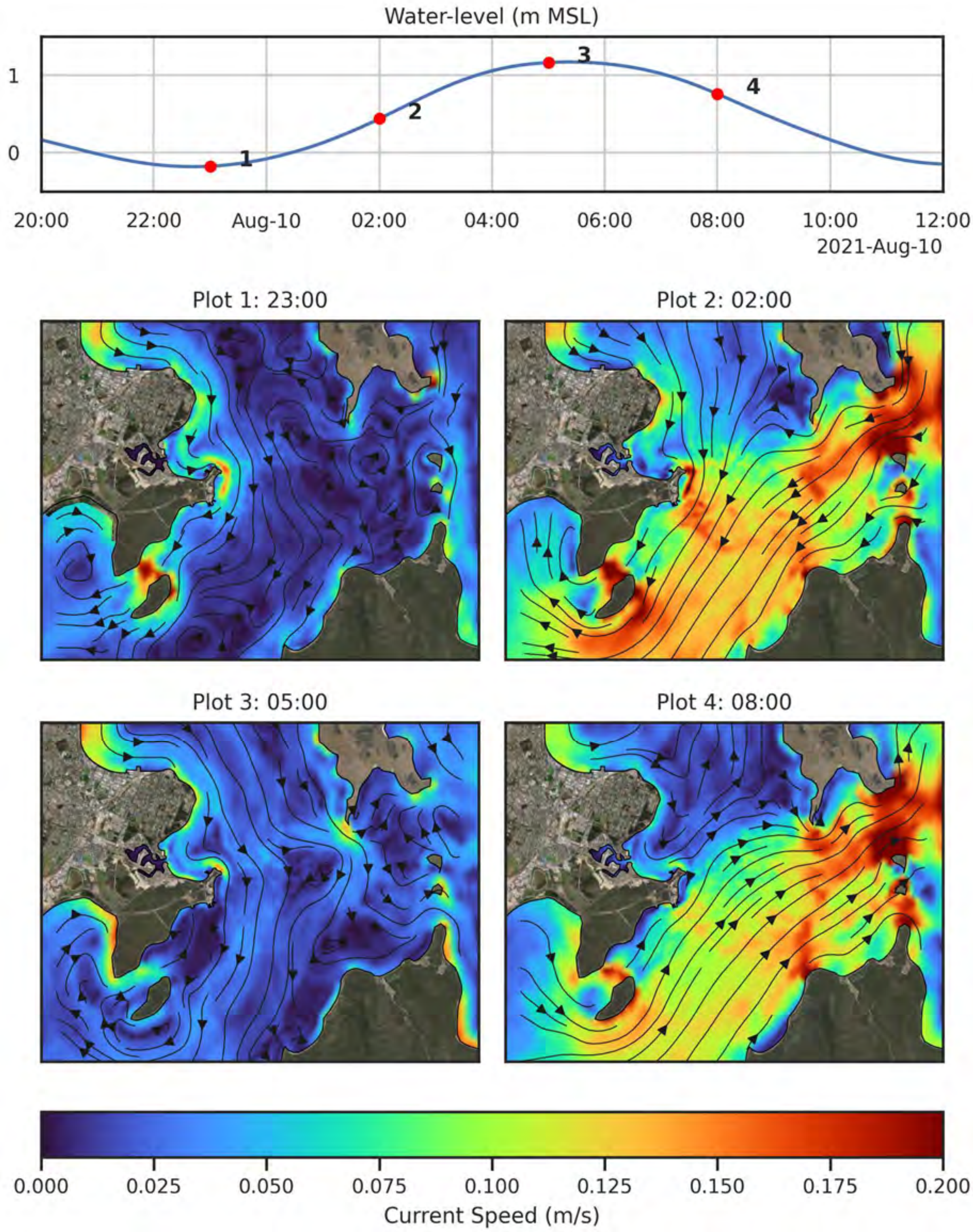

Figure 6.6 Example total depth-averaged current velocity during a typical spring tide (10th August 2021)

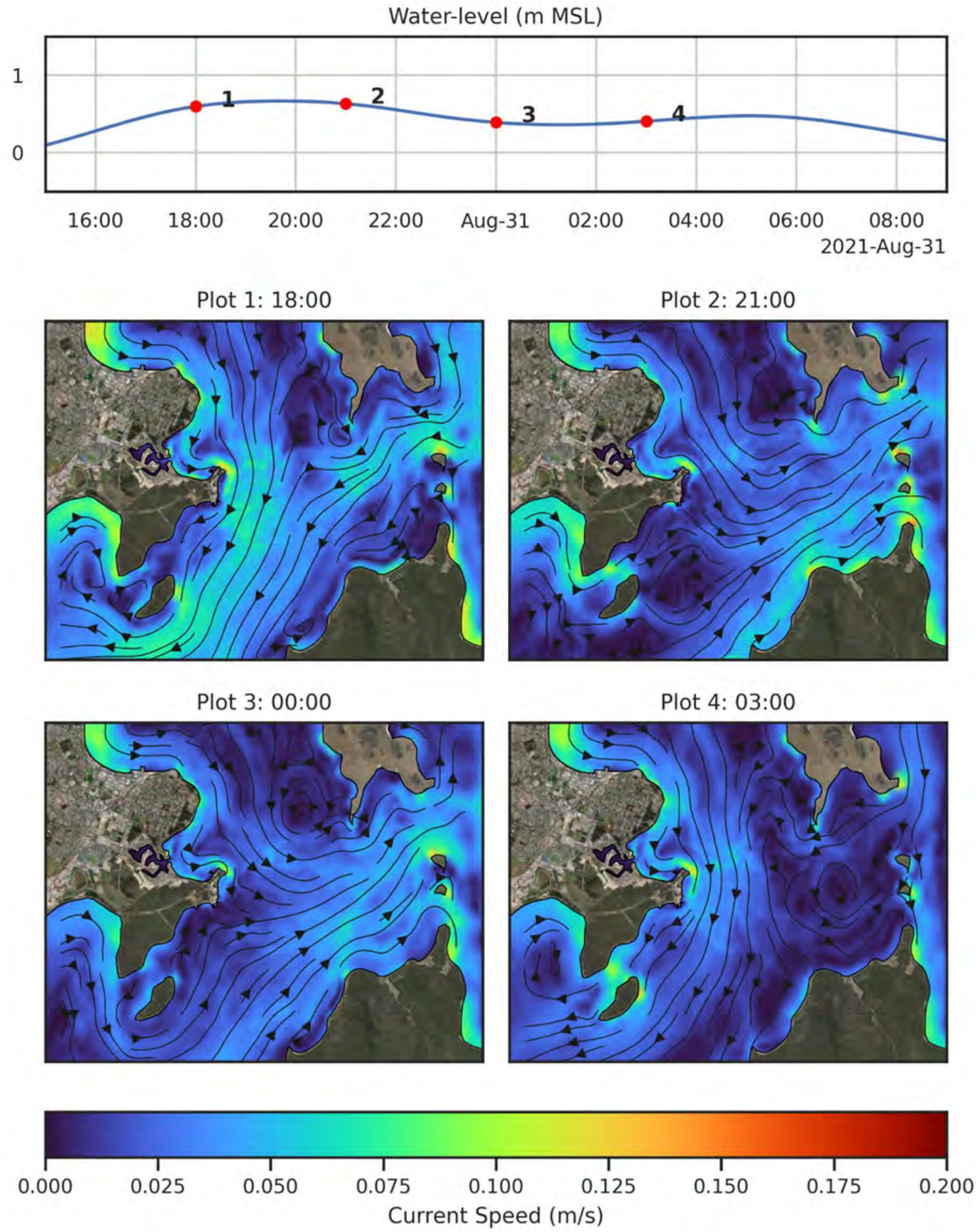

Figure 6.7 Example total depth-averaged current velocity during a dodge tide (30/31 August 2021)

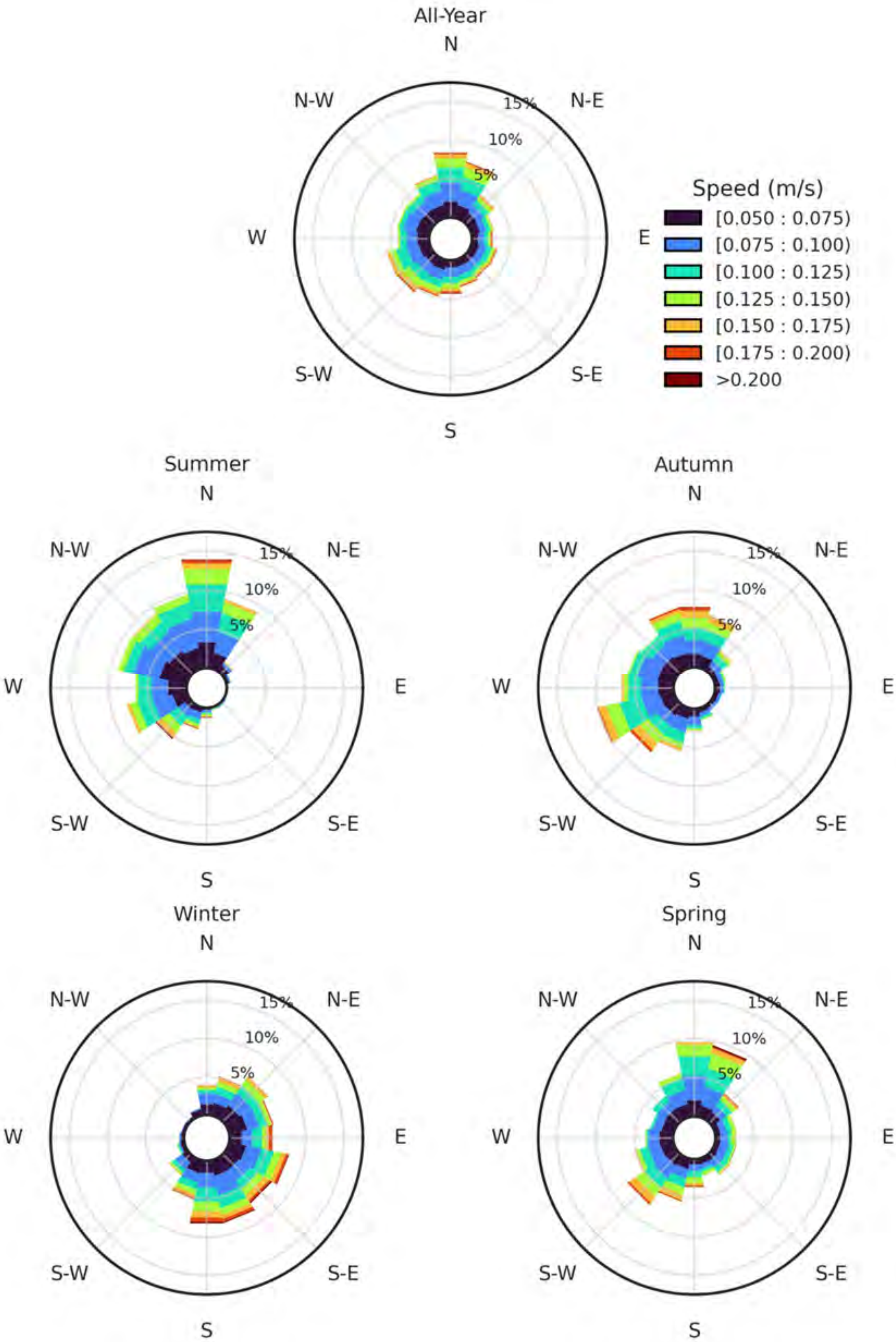

Figure 6.8 Ambient current conditions – rose plot of all-year and seasonal total SURFACE current speed and direction at the EPDP Outfall Location (Source: TUFLOW FV Hindcast 2021-08 to 2022-08)

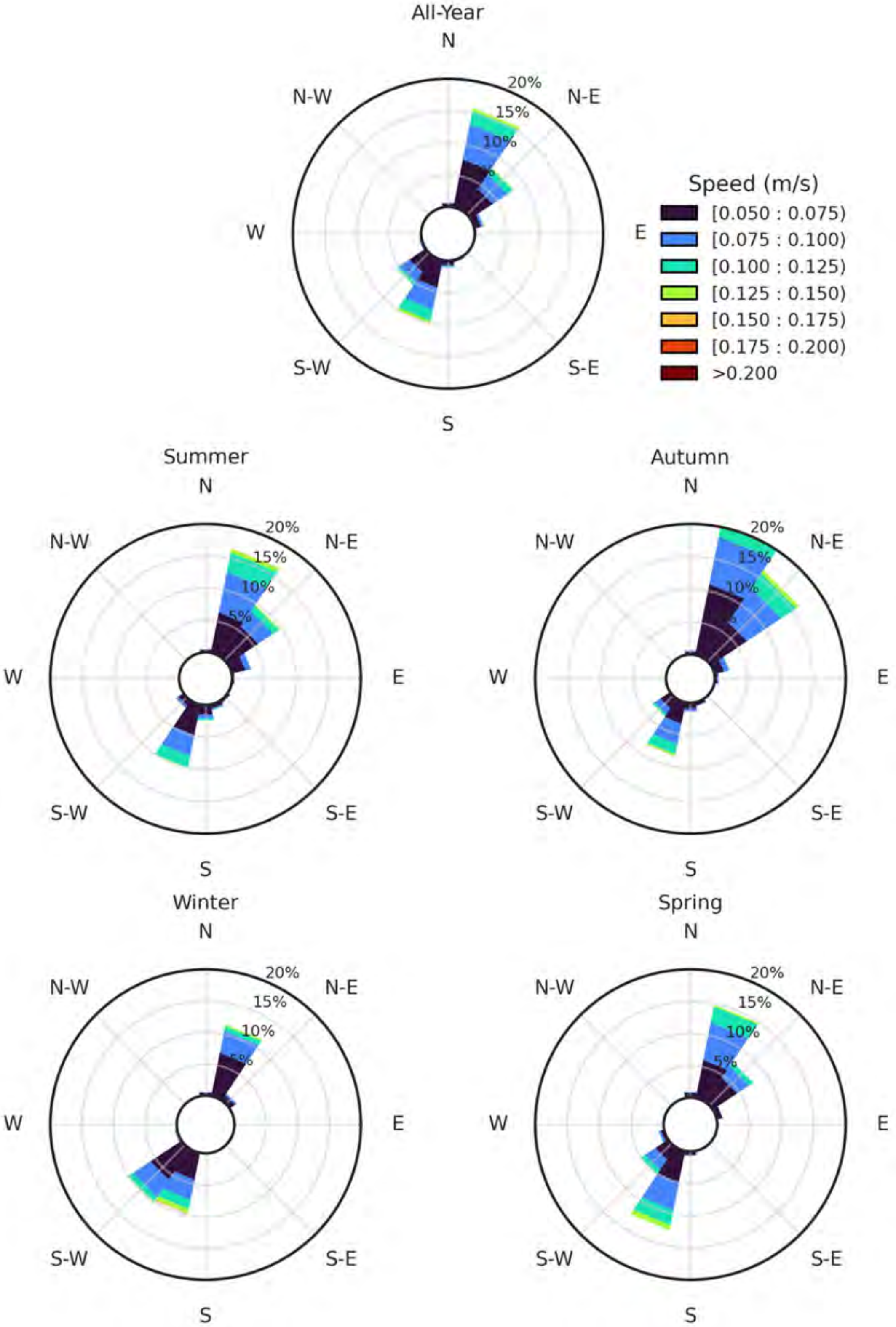

Figure 6.9 Ambient current conditions – rose plot of all-year and seasonal total SEABED current speed and direction at the EPDP Outfall Location (Source: TUFLOW FV Hindcast 2021-08 to 2022-08)

6.3 Sediment Transport

6.3.1 Regional Context

The east coast of the Eyre Peninsula is described in Coastal Adapt (https://coastadapt.com.au/)[1] as a sediment compartment extending from Shoalwater Point to Cape Catastrophe. Sediment for this coast is dominated by biogenic marine sediments mixed with older terrestrial sand dunes to form wide inter-tidal flats backed by beach ridge plains. Subtidal environment is composed by: Bare Sand 34.84%, Dense Seagrass 30.9%, Dense Seagrass Patches 0.05%, Granite Reef 17.41%, Heavy Limestone or Calcarenite Reef 7.91%, Low Profile Platform Reef 2.75%, Medium Seagrass 1.09%, Sparse Seagrass 0.83%, Unknown 4.43%.

Coastal Adapt concludes that shoreline within the compartment is stable although there are signs of coastal recession and that the sediment supply from biogenic and land-based sources is predicted to decline.

6.3.2 Geophysical Setting

In 2023 a marine geophysical survey was undertaken by Marine and Earth Sciences Pty Ltd (MES) to assist in the planning and design of the proposed desalination plant intake and outfall pipelines at Billy Lights Point. The geophysical study objectives were to map the seabed and subsurface geological features to assess installation conditions for the proposed water intake and outfall pipeline options. A Multi-Phase Echo Sounder and Side Scan Sonar survey, Sub-Bottom Profiling and camera drops were used to capture data for mapping seabed characteristics and sub-surface geological layers. Sonar reflectivity can be used as a proxy for sediment size characteristics since it is proportional to grain size for unconsolidated sediments where fine-grained sands produce the lowest intensity (darker imagery) while coarser material and outcropping bedrock produce the highest intensity reflection (brighter imagery) (MES, 2023).

The study found that the top layer of sediments is composed by predominantly fine to medium-grained sediment composition. In addition, the fact that there was no evidence of seabed forms or sand waves in the sonar images suggests that the seabed is not highly dynamic since that would indicate wave stirring and movement of sediment during storm wave events.

The Sub-Bottom Profiling acquired data for mapping geological layers across the study area and four main stratigraphic units were identified and mapped. Figure 6.10 shows an interpreted west to east section sub-bottom profiler data example which provides a representative stratigraphic profile for the whole survey area. In that picture there are four different structure layers:

- UNIT A - interpreted as a layer of recent unconsolidated reworked marine sediments.
- UNIT B - interpreted as layered sediments including buried paleo-dune features. The thickness of Unit B is generally between 8m to 10m.
- UNIT C - interpreted to be marine sediments with little internal structure
- UNIT D - interpreted to be the bedrock. Unit D is mapped outcropping in the nearshore

[1] CoastAdapt is an information delivery and decision support framework which was created when the National Climate Change Adaptation Research Facility (NCCARF) was commissioned by the Australian Government through the (then) Department of the Environment to build a coastal climate risk management tool.

Figure 6.11 show the appearance of the seabed near the outfall location with presence of scarce seagrass and fine sediments.

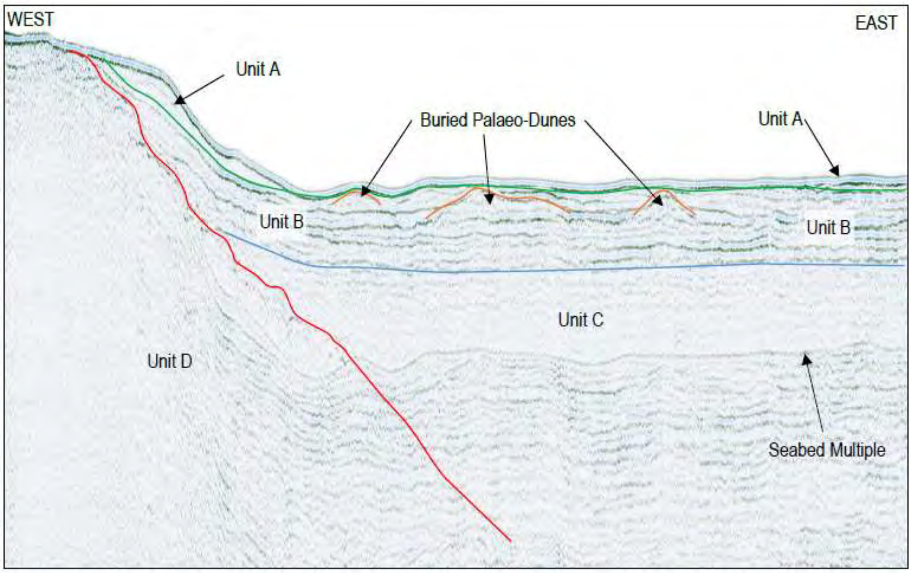

Figure 6.10 Sub-bottom profiler data example and general stratigraphic profile

Figure 6.11 Still image coming from a camera drop near the outfall location (Acciona, 2023)

6.3.3 Sediment Dynamics

Tidal currents by themselves are not typically strong enough to suspend and transport sediment in large volumes but become a major transport of sediments which have become suspended by waves. Figure 6.12 shows the critical depth-averaged velocities at initiation of motion and suspension for sediment with a median grain size (D_{50}) between 0.1 mm and 2 mm. As previously stated, medium marine sand is present at the proposed pipeline deployment site (D_{50} = 0.3 mm to 0.5 mm); the critical velocity to initiate sediment transport at a depth of 10 m (approximately depth of the outfall pipeline) is around 0.4 m/s and slightly greater than 0.4 m/s for the upper end of the range for medium sand grain sizes.

Current speeds near seabed are achieving values of 0.3 m/s for minimum return period of 100 year (Table 3.5). Hence, sediment transport under currents is only likely to occur during major coastal storm events seaward of 10 m depth.

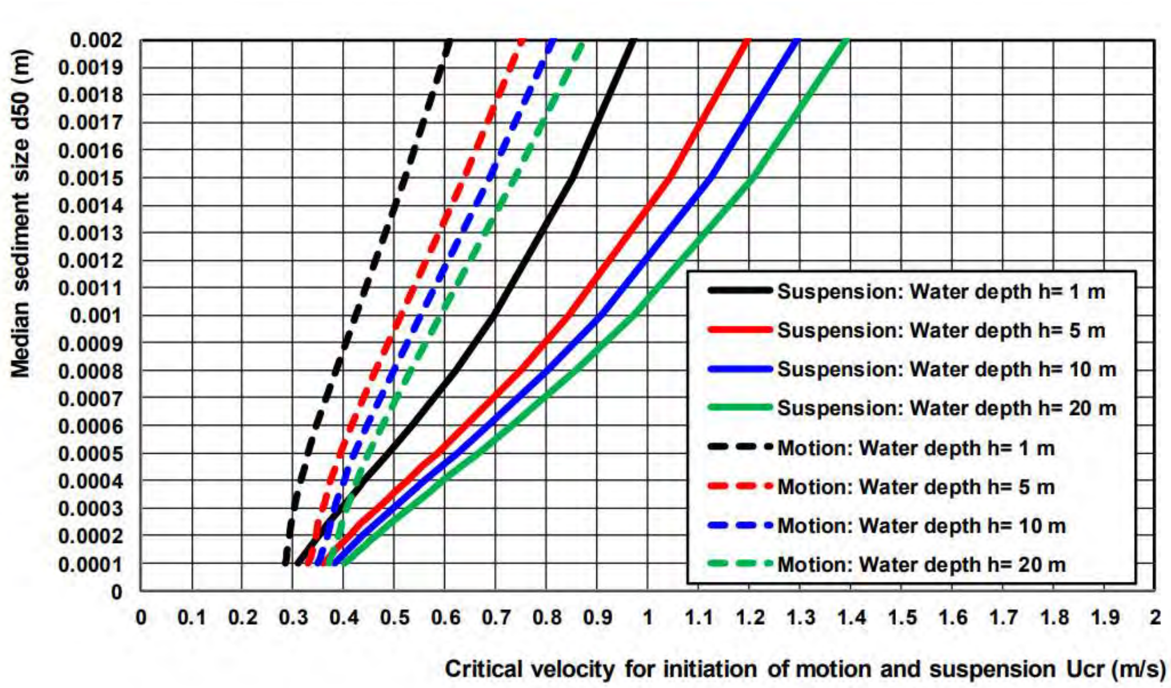

Figure 6.12 Critical velocity for initiation of motion (L.C. van Rijn, 1993)

Wave climate in the area of interest indicates that a significant wave height of 1.53m has a return period of 500 years (Table 6.2). Depending on the wave period, waves of this magnitude will generate maximum velocities of up to 0.35 m/s at the seabed in a water depth of 10m in the vicinity of the proposed infrastructure location. Hence, storm waves have little potential to induce sediment transport at the proposed area of interest.

ASR Marine Consulting prepared a report for a port development in Lipson (about 60km further north of Port Lincoln) where they estimated a long shore sediment transport with a gross rate of 350 m^3/m/year and net transport of 50 m^3/m/year.

However, due to its geographical location Lipson is far more exposed to wave action than Boston and Proper Bay. The project area lies in such a position that is sheltered from swell waves by the Lincoln National Park peninsula (Cape Donnington) and Boston Island and is only exposed to medium fetch wind waves from the northern and eastern directions. These features of Proper and Boston Bay classify the area as a very low energy setting, where sediment transport will be restricted to long term patterns of sediment migration.

Margvelashvili (2009) undertook a 3-D sediment modelling studies of Boston Bay and suggested that fine sediments are resuspended regularly and are derived from fresh sediment deposits or unconsolidated layers. The probability of sediment resuspension on the western side of Boston Island and in Proper Bay was the lowest in the model domain. (Morris Jones E, 2010) and that will be attributed to tidally-induced sediment transport.

This limited mobility of the seabed in this part of the bay is in line with the interpretation of the data acquired during the Sub-Bottom Profiling (see Section 6.3) where there was a thin layer of recent unconsolidated marine sediments (potentially mobile) on top of a 8-10m layered sediments which it would be less prone to motion (erosion).

6.4 Long term trends

6.4.1 Satellite imagery analysis

Google Earth offered several satellite pictures without sun-glare where it is possible to see the seabed. This allowed to infer the potential seabed change in some parts of Proper Bay by looking at the spatial distribution of the seagrass cover for different years. This is a qualitative and limited way of understanding the dynamics of the seabed around the project area. Figure 6.13 displays a satellite image for four different years, and it can be observed that the distribution of black parches of seabed (likely seagrass) and clear spots (sediment) has been repeated over time. This suggests that the shoreline to that depth (around 3.5m AHD) has not changed notably in the last 15 years.

The picture in Nearmaps (March 2023) displays a dense layer of seagrass for the first 300 m from the shore towards the North Intake tower. However, seagrass coverage seems to be decreasing if the seagrass distribution is compared for the last 2 surveys, the broad scale (1:100,000) mapping by CSIRO using satellite imagery in 1998 and the one carried out by University of Adelaide used Landsat images in 2021. Comparisons of satellite imagery between the two survey events showed a cover loss (also likely seagrass) in south-western Boston Bay and south-eastern Proper Bay (Figure 6.14).

Figure 6.13 Satellite images for the area of interest for years 2008, 2011, 2016 and 2020

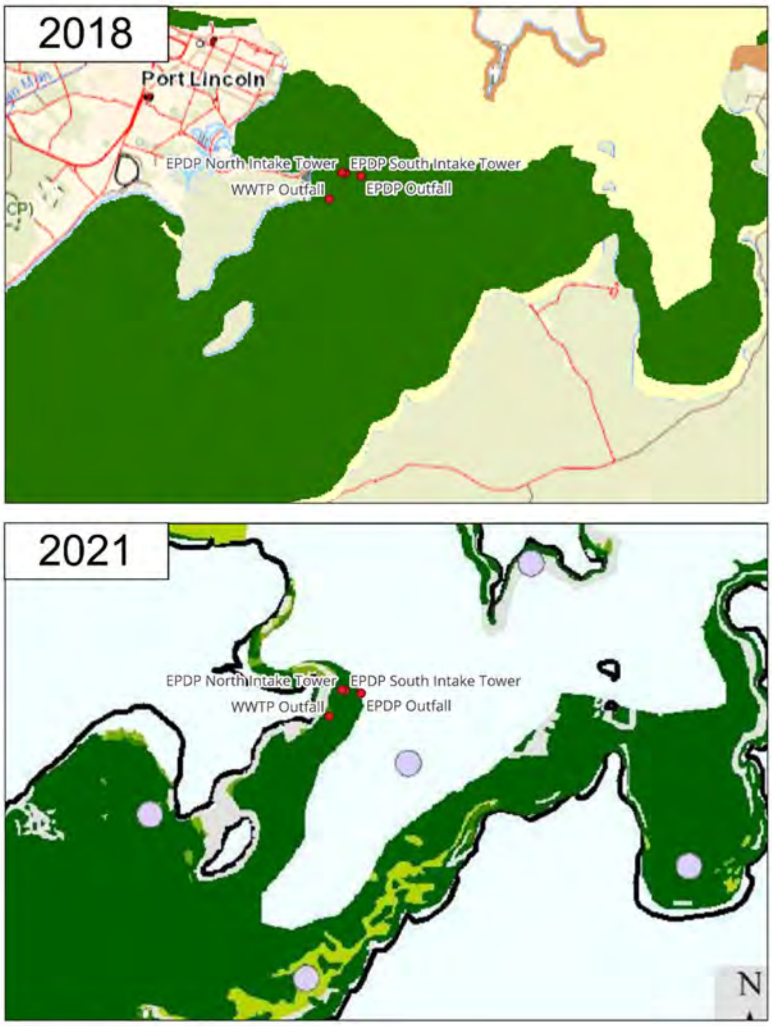

Figure 6.14 Seagrass distribution near Billy Light Point (years 2018 and 2021)

6.4.2 DEA Coastlines

The position of the shoreline around Port Lincoln has been quite stable over the recorded history, which has been analysed back to 1988 where suitable shoreline data is available. For this analysis, shoreline information from Digital Earth Australia (DEA Coastlines https://www.dea.ga.gov.au/) was used. DEA combines satellite data with tidal modelling to map the typical location of the Australian coastline at mean sea level for every year since 1988. Resulting shorelines and detailed rates of change show how beaches, sandspits, river mouths, and tidal flats have grown and eroded over time. Shorelines from DEA were georeferenced to a basemap, allowing the analysis of the shoreline position for a number of years.

The different shoreline positions, from 1988 to 2022, were assessed with reference to the 1988 shoreline along 10 different profiles near Billy Lights Point (Figure 6.15).

Figure 7.16 and Figure 6.17 compare these shoreline positions. There is not a notable trend of shoreline recession (landward movement due to erosion) or progression (seaward movement due to sediment accumulation) over this time. Unfortunately, there are not photogrammetry profiles available along this part of the coastline to extend this analysis into the active beach.

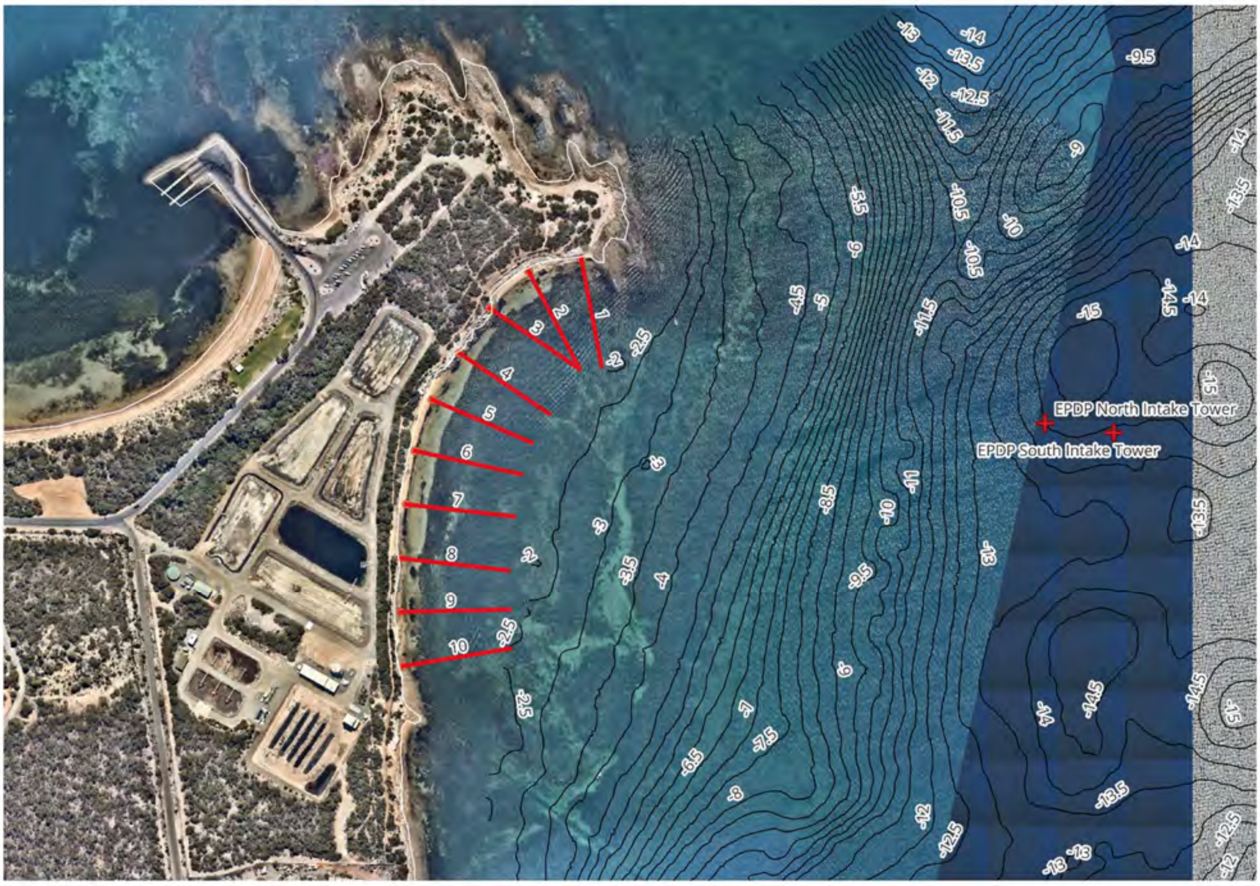

Figure 6.15 Profiles along the beach near Billy Lights Point

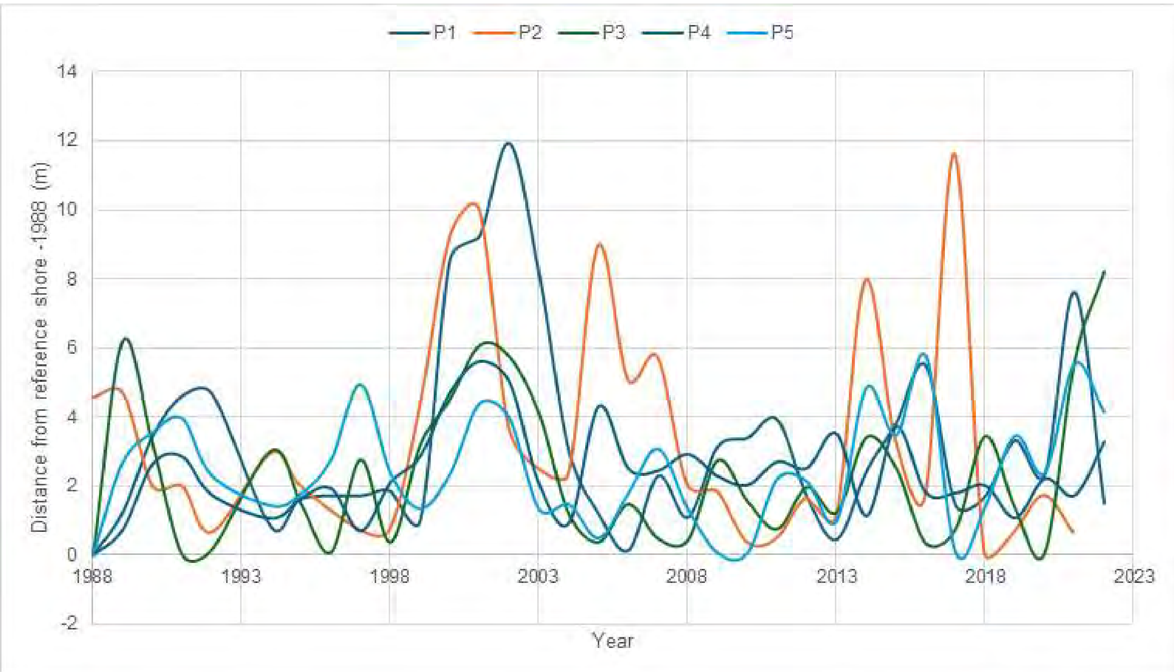

Figure 6.16 Relative shoreline position for profiles 1 to 5

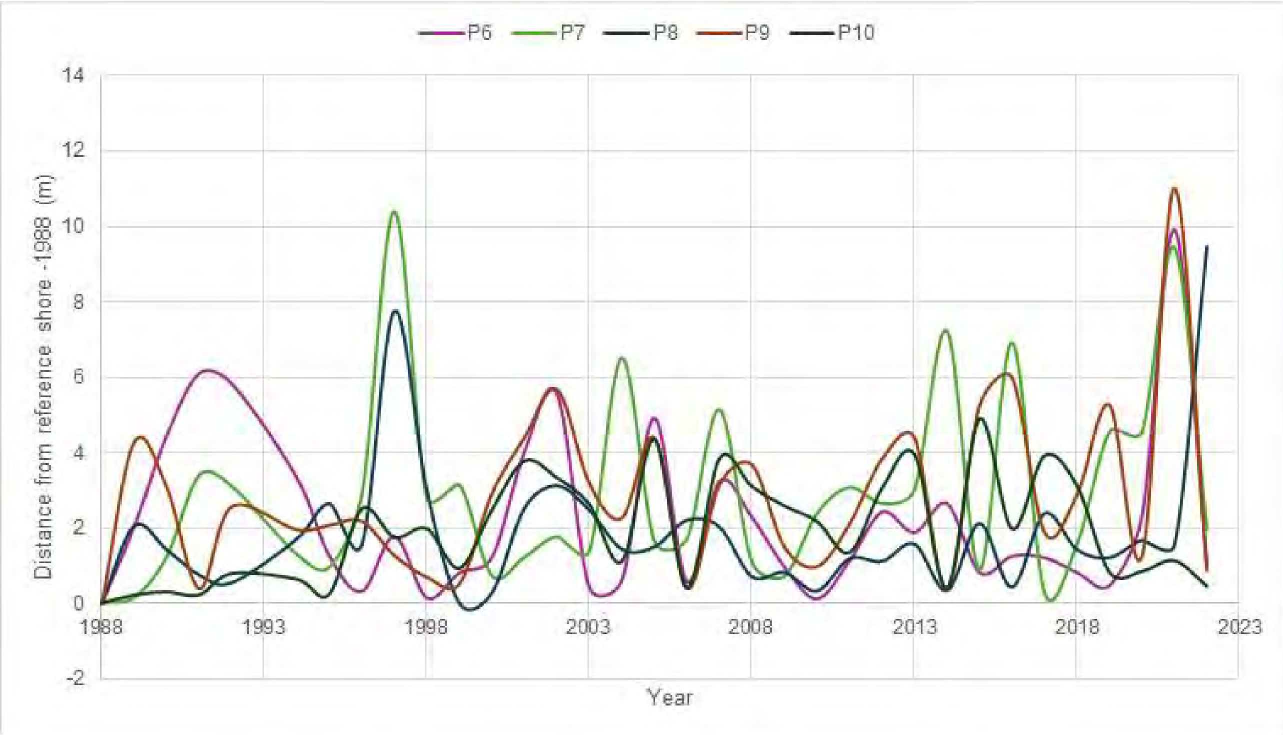

Figure 6.17 Relative shoreline position for profiles 6 to 10

6.5 Shoreline Erosion Risk

6.5.1 Short-term storm erosion

Storm erosion or short-term erosion occurs when increased wave heights erode unconsolidated sediments like sand from the upper beach and dune. The potential for short-term storm erosion at Billys Lights Point due to increased waves and elevated coastal water levels (storm-tide conditions) has been determined using the simple cross-shore equilibrium profile model of Vellinga (1983). This empirical model calculates the dune erosion volume associated with storm-induced water-level and wave conditions. The amount of shoreline recession is based on the wave height, water level, beach sediment parameters and the pre-storm beach profile shape. The model assumes the volume of material eroded from the upper beach/dune system and deposited offshore is a homogenous, unconsolidated sediment which is balanced by a setback of the shoreline.

The pre-storm profile used for the Vellinga assessment derived from the nearshore geophysical survey (MES, 2024), located as shown in Figure 6.18, and selected as representative of a sandy beach profile in the study area.

Figure 6.18 Pre-storm profile location

Wave conditions and water levels are adopted from the accompanying metocean study (BMT, 2024b), and are presented in Table 6.4. This includes 100yr and 500yr ARI weather conditions (extreme still water level and significant wave height) for the present climate at under sea-level rise conditions (+0.98m water level). A median grain size (d50) of 0.9mm was assumed based on limited sediment samples from the active beach profile.

Table 6.4 presents the inputs and results of the short-term erosion assessment, while the pre- and post-storm profiles are presented in Figure 6.19.

Table 6.4 Short-term erosion conditions

	100yr ARI Present Climate	500yr ARI Present Climate	100yr ARI SLR Conditions	500y ARI SLR Conditions
Input Water Level (m AHD)	1.91	1.97	2.71	2.77
Input Significant Wave Height Hs (m)	1.23	1.30	1.23	1.30
Median Grain Size d50 (mm)	0.9	0.9	0.9	0.9
Modelled erosion volume (m^3/m)	13.1	14.1	20.4	21.2
Modelled horizontal landward recession of crest (m)	3	3.5	9.5	10

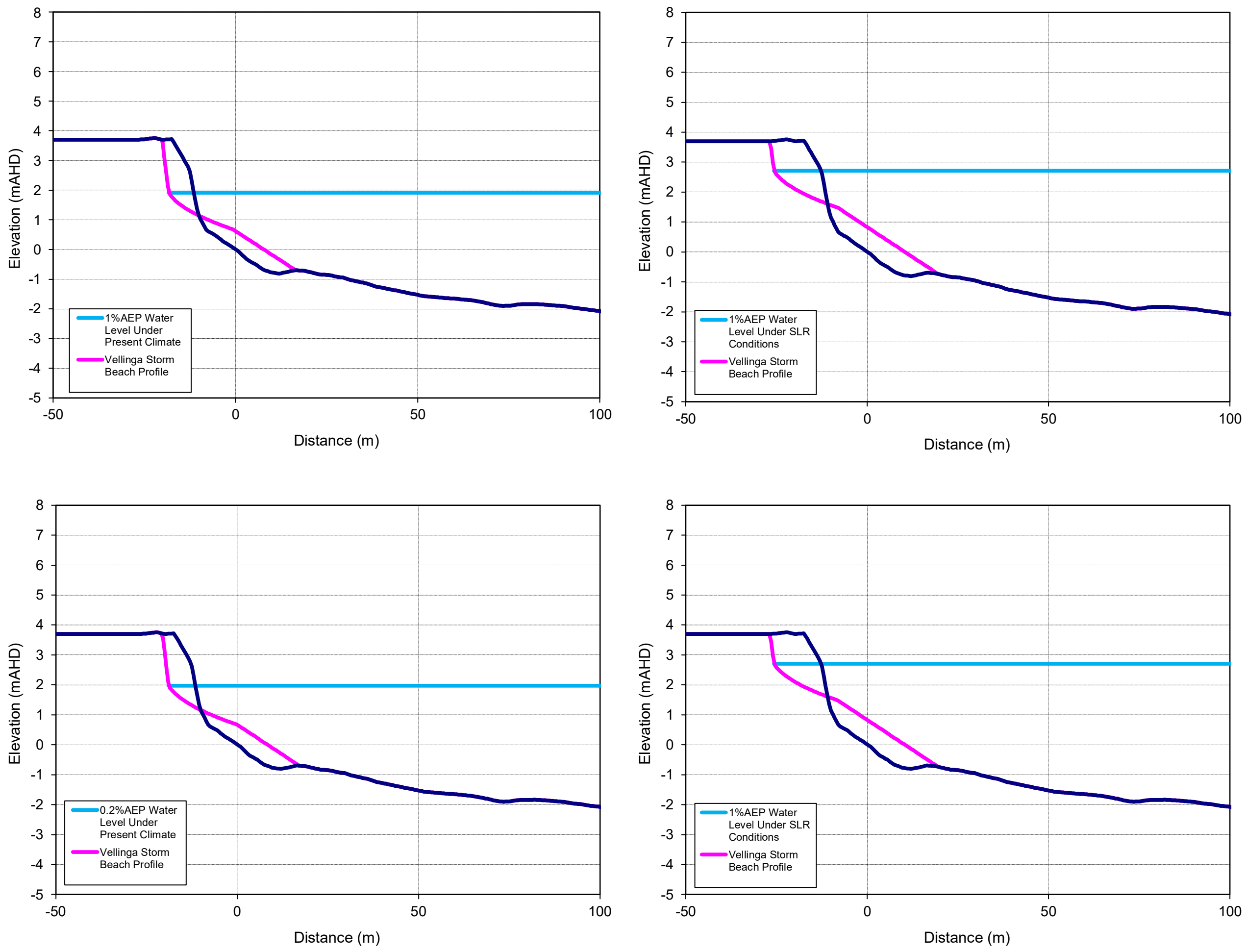

Figure 6.19 Vellinga model pre- and post-storm profiles.100 year ARI (top), 500 year ARI (bottom). Present climate (left), SLR conditions (right).

Landward recession of the crest is the modelled horizontal distance that the top of the dune scarp (or dune face) recedes following the modelled storm event. The values presented in Table 6.4 are particularly conservative estimates of short-term erosion at the site, as the Vellinga model assumes unconsolidated, homogenous material (i.e. sand) comprises the beach and dune. At the location of interest, however, there is a significant amount of rocky substrate and outcrops on the beach, as seen in Figure 6.20 at the site and confirmed in the geophysical survey completed by MES (2023). This survey identified a layer (Unit B, Figure 6.21), interpreted to consist of “bioclastic and aeolian cross-bedded calcarenite, palaeosol, horizons, often capped by calcrete.” (MES, 2023). As such, the calculated erosion volumes and landward recession of the crest is deemed conservative as the material is likely significantly less erodible than modelled.

6.5.2 Shoreline recession due to sea-level rise

Billy Lights Point is situated on a low to moderate wave energy coastline, characterised by a steep, rocky upper beach and a sandy lower beach. In this case, considering the low wave climate, a suggested approach for estimating shoreline recession due to sea-level rise is a modified Bruun approach.

The Bruun Rule (Bruun, 1962) is built on the theory of an equilibrium beach profile which will be maintained as the shoreline moves landward in response to sea-level rise, as a function of the depth of closure (width and height from top of dune), and the rise in sea level.

The modified Bruun Rule, more applicable in low wave-energy and low net sediment transport environments with such as Billys Lights Bay, calculates shoreline recession due to sea-level rise as a function of the upper beach slope and the rise in sea level (+0.98m by 2124). This has been completed for 4 representative profiles along the shoreline of Billys Lights Bay to estimate the shoreline recession due to sea-level rise, and is presented in Table 6.5.

Table 6.5 Shoreline recession due to sea-level rise

Profile	Slope (XH :1V)	Shoreline recession
1	6.3	6.2
2	2.7	2.6
3	3.5	3.4
4	2.0	2.0
MAX		**6.2**

Figure 6.20 Sandy beach at Billys Lights Bay

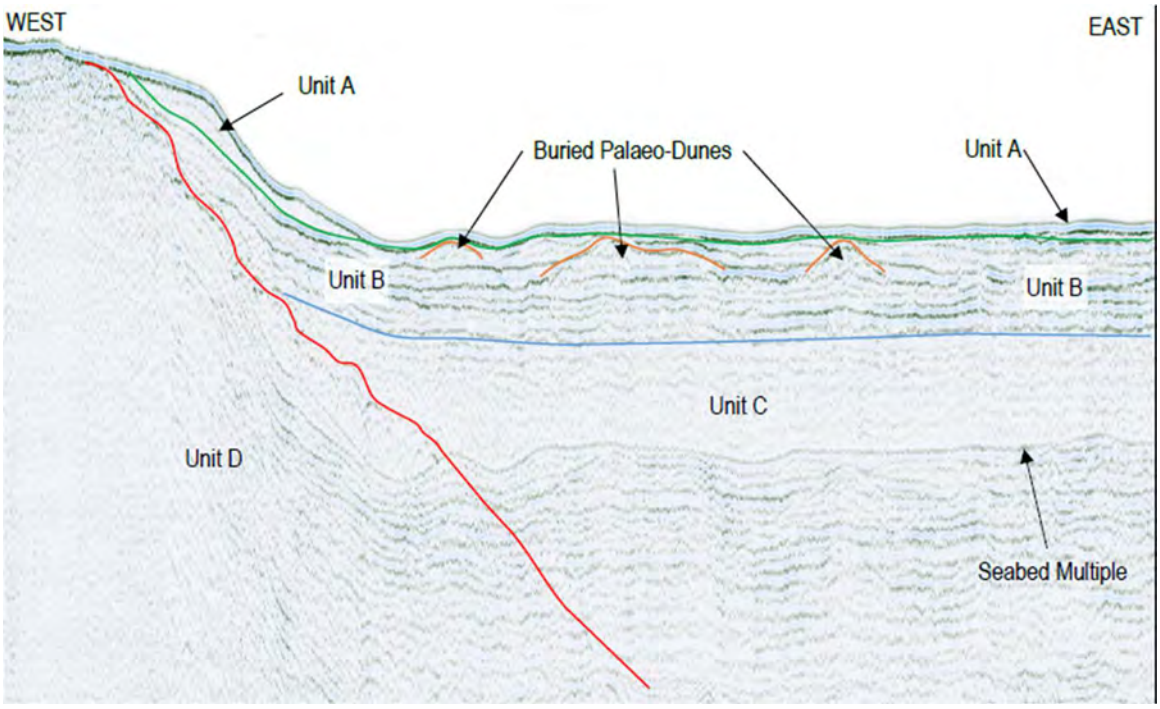

Figure 6.21 Sub-bottom profiled data example and general stratigraphic profile (MES, 2023)

6.6 EPDP Impact Assessment

Impacts from the proposed EPDP on coastal processes in the area may be broken down into either construction phase impacts (temporary impacts associated with the construction activities), and long-term impacts (pertaining to impacts from the establishment of permanent structures).

6.6.1 Construction Phase

The construction phase of the project in the marine environment is envisaged to be relatively low impact due to the construction methodology employing directional drilling to daylight the pipeline beyond the shallow nearshore zone. Directional drilling typically results in negligible sediment release to the water-column and thus suspended sediment impacts are not considered to be an issue during the drilling phase.

Dredging of a temporary pocket approximately 6 m depth below the existing seabed is required by the proposed design where the pipeline transitions from the tunnel to the seabed. The temporary excavation would subsequently be backfilled using stored material from the earlier dredging. This dredging and backfilling activity will have the potential to generate suspended sediment plumes. Assessment of the construction phase sediment plume impacts will require further information about the construction methodology and will be undertaken when this is available.

Further shallow dredging is proposed along the subsea length of the pipeline route and footprint of the intake and outfall infrastructure. This dredging activity and the subsequent placement of foundation material will have the potential to generate suspended sediment plumes. Given the sediment composition at this location (refer section 3.3), majority sand with a small proportion of gravels and very small proportion of silt/clays) combined with mild currents and waves (refer section 6.2), any generated sediment plume is expected to be of low concentration and likely to settle quickly. More detailed assessment of the construction phase sediment plume impacts will be undertaken once the marine construction methodology has been further developed.

6.6.2 Long Term Impacts

Permanent impacts (post construction) to coastal processes, including water levels, currents and sediment transport, resulting from the intake and outfall pipelines and support infrastructure are also considered to be minor.

The pipeline infrastructure itself (refer to Figure 2.3 and Figure 2.4) will cause near-field disturbance to near-seabed currents, with a potentially increased localised current speed over the pipeline itself and decreased current speed at the upstream side (which depends on which way the current is flowing at that stage in the tide). Due to the typically low current speeds (<0.1 m/s) at the proposed deployment site under typical conditions, and the size of the proposed pipeline modules, these impacts on the near bed currents are expected to be minor, with little to no overall impact on sediment transport or larger scale current circulation within Proper Bay. In addition, as noted in Section 6.3, oscillatory currents due to wave action during major storm events may be in the order of 0.3 m/s and have limited capacity to move sediment during such extreme events.

There is currently little evidence of any significant sediment transport occurring at the proposed development site (see 6.3.3). Given that the pipeline infrastructure is not expected to have significant impact on near seabed currents or wave action, it is unlikely that the structure will have any significant impact on sediment transport beyond very localised impacts around the pipeline route (e.g., some sediment could accrete / erode either side of the rubble foundation to a small degree).

It is expected that some marine growth will form around the pipeline infrastructure, potentially creating additional marine habitat for local fauna.

In summary, the proposed development is unlikely to have any significant local or regional impact to coastal processes because the seabed infrastructure is situated in a low-energy area that does not exhibit signs of dynamic morphology.

7 Conclusions

A hydrodynamic modelling study has been conducted to assess the potential impact from the proposed Eyre Peninsula Desalination Plant (EPDP) on the receiving marine environment. Analysis has also been conducted to review the coastal process dynamics and shoreline erosion risk relevant to the EPDP locality off Billy Lights Point.

The EPDP project has undertaken a range of surveys to characterise the baseline coastal environment at Billy Lights Point, including bathymetry, sediment sampling, habitat mapping and a comprehensive metocean monitoring campaign conducted since July 2021.

A suite of coastal numerical models was developed and validated for the purpose of informing the EPDP design development and to additionally meet the Development Approval requirements of the project. A high-resolution, three-dimensional hydrodynamic model was setup for the detailed assessment of brine dispersal at Billy Lights Point. A very high resolution CFD model was developed for the proposed multi-port diffuser design to assess the near-field mixing performance and to provide dynamically coupled boundary conditions of the near-field mixing into the hydrodynamic model.

As part of this study a location assessment has been undertaken to assist with refinement of marine infrastructure siting in the vicinity of Billy Lights Point. This process has supported the selection of a preferred site for seawater intake and brine outlet diffuser to minimise impacts to the receiving marine environment.

The risk of the SWRO brine discharge of the proposed design to the receiving marine environment has been assessed through a detailed assessment of an optimised multi-port diffuser design situated at the preferred outfall location. The proposed diffuser design achieves a worst-case nearfield dilution performance of 1:59, which exceeds the 1:40 performance target.

The coupled nearfield-midfield hydrodynamic modelling of brine dispersion from the proposed diffuser design shows that salinities beyond a 30 m mixing zone remain at all times below 0.978 ppt, which confirms the suitability of the selected location for achieving acceptable levels of brine dilution under a range of seasonal and tidal conditions, including dodge tides. The risk of brine-intake recirculation was also assessed and indicates that the proposed design complies with a performance target of <1% brine recirculation under all conditions.

The potential for visible plumes due to elevated TSS in the brine discharge was found to be a low risk, with the mid-field model indicating no detectable surface plumes and compliance with a threshold of TSS less than 10% above ambient at the seabed.

Permanent impacts to coastal processes from the proposed EPDP design, including changes to water levels, currents and sediment transport are assessed as minor. The proposed design avoids direct impacts to the sensitive nearshore environment at Billy Lights Point through tunnelling the intake and outlet pipelines until approximately 470 m from the shoreline. At this point the intake and outlet pipelines transition to a seabed alignment. In the context of the relatively benign current and wave climate, the seabed pipeline is not expected to significantly impact coastal processes including sediment transport.

Construction of the proposed design will require dredging, backfilling and armour rock placement from the termination of the tunnel to the seaward extent of the outlet diffuser. A detailed construction methodology is not yet available and construction impacts related to potential generation of sediment plumes have not been assessed at this stage.

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Annex A Near-Field Discussion and CFD Model Validation

A.1 Description of Inclined Dense Jets and the Near-Field Mixing Zone

The main flow characteristics for a single dense jet in a stationary environment are shown in Figure A.1. The jet's trajectory and dilution are governed by the interplay of momentum and buoyancy. As the jet rises, the negative buoyancy forces oppose the vertical momentum causing it to reach a terminal rise height and then fall back to the lower boundary where it spreads as a density current.

The flow behaviour in inclined dense jets can be primarily separated into the near- and far-field regions. Near-field transport processes are actively governed by the interplay of source momentum flux and buoyancy forces. The initial momentum flux induces turbulent velocity shear in the ascent phase of the jet, and causes entrainment of the receiving ambient waters. With the descent of the jet, flow has distinctly transitioned into plume behaviour due to the buoyancy forces that result from the density differential between source and ambient fluids. This plume phase is characterised by gravitational instabilities which lead to further entrainment of ambient fluid, thus increasing dilution. After impact, the turbulent radial dispersion leads to further entrainment until the influence of density stratification leads to turbulent collapse, marking the end of the near-field, where beyond which, discharge is passively transported by ambient hydrodynamic forcing (Roberts et al., 1997; Choi et al., 2016).

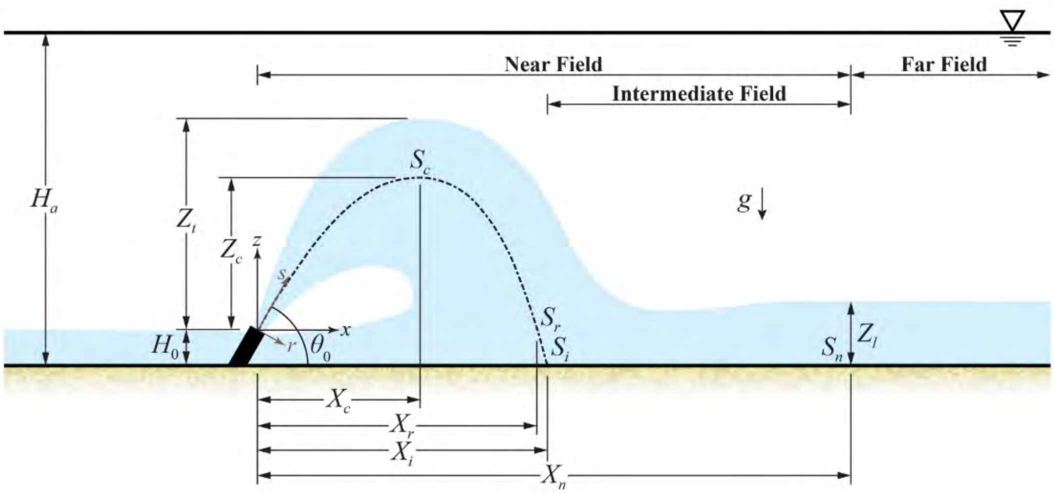


Figure A.1 Side view definition schematic of an inclined dense jet diffuser outfall (Baum, 2019)

The topic of the near-field transport properties of inclined dense jets has been a subject of research since the 1970's. Dimensional analysis and laboratory experiments have demonstrated that the flow properties are characterised by the kinematic momentum and buoyancy fluxes, where trajectory length-scales vary as product of the port diameter (*d*) and the discharge Froude number (*Fr*). Similarly, dilution is proportional to the discharge Froude number (Roberts et al., 1997).

The turbulent mixing processes within the near-field mixing zone are characterised by increasing time- and length-scales along the jet trajectory, with high concentration gradients observed within the dynamic mixing zone. To demonstrate this, time-averaged and instantaneous images are presented from Roberts et al. (1997) in Figure A.2. As seen in the time-averaged image (Figure A.2(a)) the tracer concentrations decrease away from the impact point, while the instantaneous image (Figure A.2(b)) shows decreasing "patchiness" in the spreading layer downstream of the impact point. Relevant to the diffuser configuration applied for the EPDP, video playback of a multiport inclined dense jet diffuser is available via Abessi and Roberts (2014a). While it is noted that the time-averaged conditions never really exist as physical entities, they are universally applied as input to define semi-empirical formulations and more closely resemble mathematical models such as integral entrainment models (e.g., Visual Plumes).

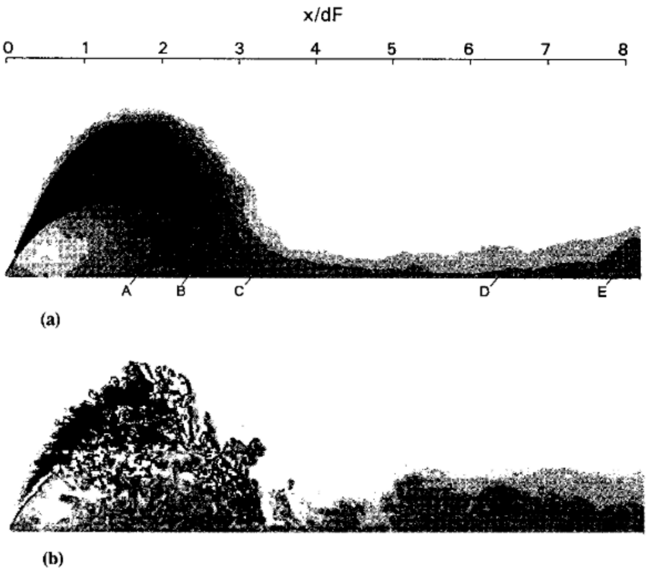


Figure A.2 Side-view experimental images from Roberts et al. (1997). (a) time-average; (b) instantaneous image.

To illustrate the evolution of mixing dynamics with increasing distance away from the diffuser, timeseries' of tracer concentration along the lower boundary are shown in Figure A.3, with corresponding locations indicated on Figure A.2(a). Beyond the impacting jet, at point D, the high frequency fluctuations have decayed, leaving only low-frequency variations. Finally, at point E, the fluctuations have almost completely decayed due to turbulent collapse and re-laminarisation of the flow due to the influence of density stratification.

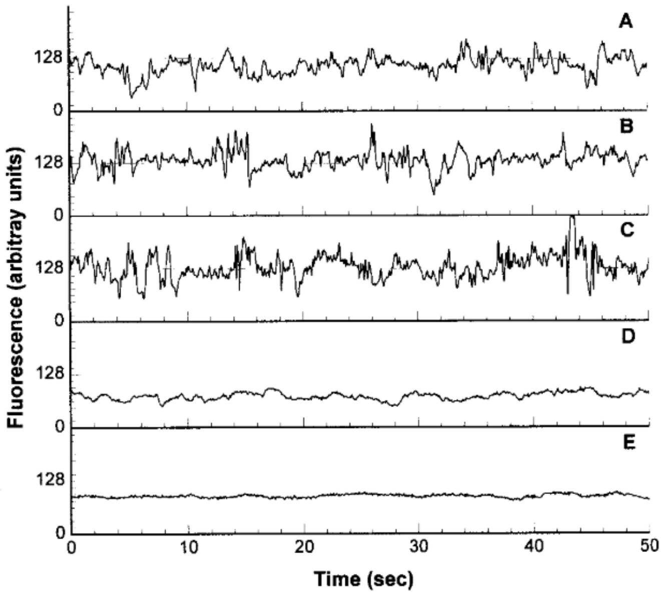


Figure A.3 Evolution of temporal fluctuations in tracer concentration at various points along the bottom boundary (respective locations indicated in Figure A.2(a)) (Roberts et al., 1997).

Demonstrating the spatial evolution of turbulent mixing processes along the lower boundary in a more quantified form, the concentration fluctuation intensities are shown in Figure A.4 (top), with the corresponding normalised dilutions presented in Figure A.4 (bottom).

For the 60° inclined dense jet experiments of Roberts et al. (1997), the turbulent intensity fluctuations asymptote to zero at approximately *x/dF* = 9.0 units. The dilutions also stabilise from this location, marking the end of the dynamic mixing zone and start of the passive mixing zone.

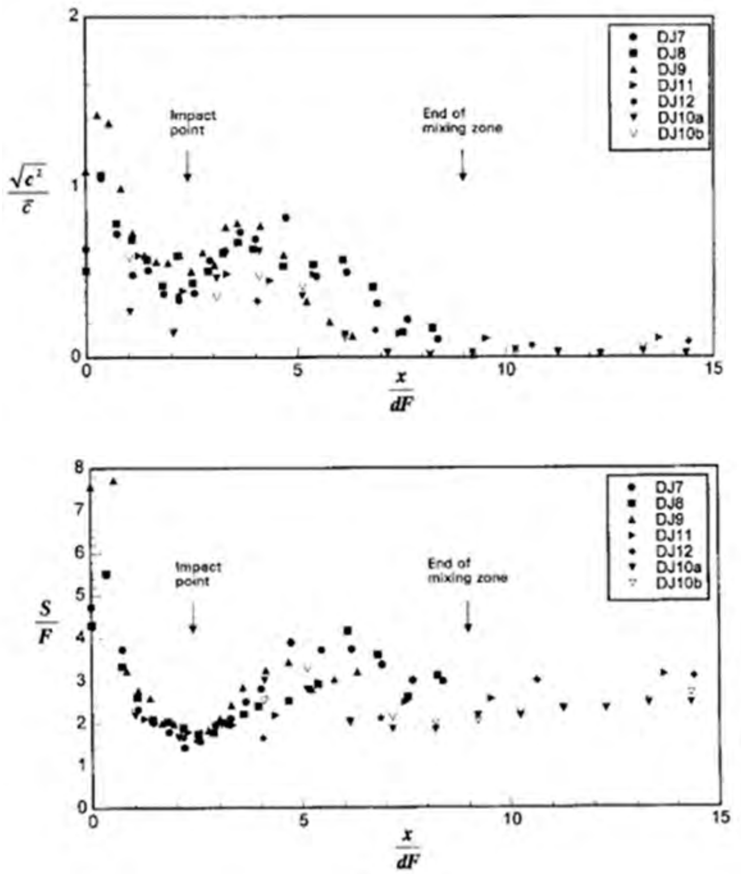


Figure A.4 Decay of intensity fluctuations (top) and variation of dilution (bottom) along the lower boundary (Roberts et al., 1997).

It is important to note that the dense plume lower boundary impact point is located well within the dynamic mixing zone and that dilution at this intermediate point do not fully represent the dynamic mixing potential of the diffuser as measured at the end of the dynamic mixing zone. The turbulent mixing that occurs from the point of plume impact to the end of the mixing zone is substantial. From Roberts et al. (1997), the ultimate minimum dilution at the end of the mixing zone is approximately 63% higher than the impact dilution.

Provided that the turbulence-induced mixing dynamics are governed by the diffuser design (i.e., discharge properties, port inclination, diameter, elevation, spacing, etc.) up until the end of the hydrodynamic mixing zone, this minimum distance is typically used as basis to define the regulatory compliance point for specified threshold limits.

A.2 Existing Regulatory Criteria for Salinity

From Jenkins et al. (2012), there are few actual regulations, standards, or guidelines for brine discharges around the world. A summary of adopted criteria is provided in Table A.1. It is noted that there is substantial variation in the specifics of the regulations, however almost all share two key elements: a salinity limit and a point of compliance expressed as a distance from the discharge. The salinity limit is usually stated as an increment of no more than a specified value above ambient, with typical values of this salinity limit being in the range of 1 to 4 ppt. The point of compliance for the salinity limit is the boundary of the mixing zone, which is usually specified in terms of a fixed distance from the discharge, and in the summary table below typically ranges from 50 to 300 m.

Table A.1. Summary of brine discharge regulations (after Jenkins et al., 2012)

Region/Authority	Salinity Limit	Compliance Point (Relative to Discharge)
Adelaide Desalination Plant, South Australia	Increment ≤ 1.3 ppt	100 m
Perth, Australia/Western Australia EPA	Increment ≤ 1.2 ppt at 50 m and ≤ 0.8 ppt at 1,000 m	50 m and 1,000 m
Sydney, Australia	Increment ≤ 1 ppt	Mixing zone boundary
Gold Coast, Australia	Increment ≤ 2 ppt	60 m
US EPA	Increment ≤ 4 ppt	–
Carlsbad, California, USA	Absolute ≤ 40 ppt	1,000 ft (304.8 m)
Huntington Beach, California, USA	Absolute ≤ 40 ppt salinity (expressed as discharge dilution ratio of 7.5:1)	1,000 ft (304.8 m)
Okinawa, Japan	Increment ≤ 1 ppt	Mixing zone boundary
Abu Dhabi	Increment ≤ 5 %	Mixing zone boundary
Oman	Increment ≤ 2 ppt	300 m

Following from the discussion of the near-field mixing dynamics and the hydrodynamic mixing zone in Annex A.1, an illustration of the point of compliance is shown in Figure A.5. The regulatory mixing zone is typically defined as a region around the discharge that should be equal or larger than the near-field hydrodynamic mixing zone. Due to the physical processes at hand, the actual dimensions of the hydrodynamic mixing zone continuously vary as function of the discharge and environmental characteristics and can be estimated using modelling approaches. As outcome of recommendations issued by the Californian Science Advisory Panel, a fixed 100 m regulatory mixing zone from the discharge point is suggested to define the regulatory mixing zone and thus the distance for compliance monitoring (Jenkins et al., 2012), where it is argued that such a zone will encompass the near-field of well-designed discharges.

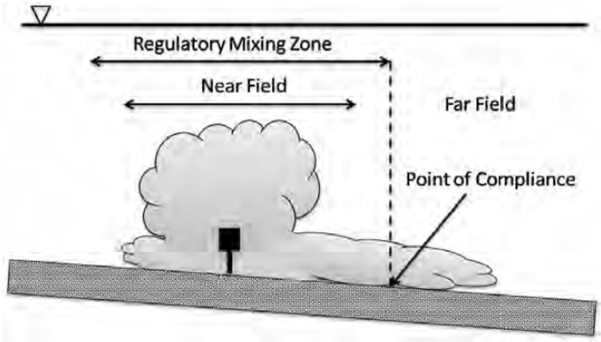


Figure A.5 Relationship of regulatory boundaries to plume features (from Jenkins et al., 2012)

In the context of the EPDP, the project design is required to achieve a 1:40 dilution, which corresponds to a +0.978 salinity increment above ambient (based on an un-diluted brine salinity of +39.1 ppt). This equivalent salinity increment value for EPDP is slightly more stringent than the most conservative compliance values in Table A.1.

As detailed in Annex A.1, the impact location is situated in a zone of significant turbulent fluctuations, with high concentration gradients. The impact dilution is typically defined by time-averaged approaches, however provided the large spatio-temporal gradients, instantaneous concentrations may be notably higher/lower at this location, while the location itself may also exhibit variability in time due to transient current dynamics. Because of this, in practice the point of compliance at the impact location is difficult to evaluate in terms of compliance. For these reasons, it is rationalised that the point of compliance for the dilution requirement stipulated for the EPDP, would be most appropriately defined as at the seabed immediately beyond the end of the hydrodynamic near-field mixing zone. For the provided discharge conditions under the Stage 2 operating capacity the near-field equates to approximately 30 m away from the diffuser. In relation to Figure A.5 an appropriate compliance boundary would be defined at the seabed at a minimum distance of 30 m from the diffuser. This compliance distance is more conservative than the more stringent regulatory conditions defined in Table A.1.

A.3 Near-Field CFD Model Validation

A validation exercise has been conducted to assess the efficacy of the near-field CFD model in terms of its ability to the near-field mixing processes and key trajectory length-scales under both quiescent and dynamic receiving environments. Qualitative assessment has also been conducted to review the response to ambient current dynamics.

Facilitating the model validation, results have been evaluated against applicable laboratory results and their respective semi-empirical formulations. In order to produce fair assessment, a “generic” CFD model has been developed with a flat bed, thus removing the effect of localised bathymetric features inherent with the in-situ diffuser setting. The generic CFD model domain has a length of 352 m in the direction parallel, and 300 m orthonormal to the diffuser. Consistent with the detailed near-field assessment cell sizes range from 0.015 m to 4.0 m. Progressing through the simulation, the internal mesh was iteratively refined to resolve interfaces with high concentration and velocity gradients. Simulations were performed for the brine-only discharge condition, under a range of ambient current scenarios.

To provide comparison against conventional commercial modelling tools, results are also presented for Visual Plumes UM3 (Davis, 1999) simulations.

A.3.1 Comparison of Key Trajectory Length Scales and Dilution

With reference to the trajectory length-scales and dilutions at key near-field locations illustrated in Figure A.1, comparisons between the semi-empirical projections of Abessi and Roberts (2014b; 2015), Visual Plumes and the CFD model utilised in this study are presented for quiescent ambient conditions in Table A.1.

Table A.2. Comparison of Visual Plumes and CFD model results with semi-empirical scaling of Abessi and Roberts (2014b; 2015) for a quiescent ambient discharge condition

Property	Abessi and Roberts (2014b, 2015)[1]	Visual Plumes		CFD	
		Prediction	Error	Prediction	Error
Jet Terminal Rise, Z_t	7.8 m	6.1 m	-21.0%	6.4 m	-18.0%
Impact Distance, X_i	8.4 m	7.5 m	-10.9%	6.3 m	-24.5%
Impact Dilution, S_i	60.1	27.9	-53.7%	43.0	-28.5%
Near-Field Distance, X_n	25.1 m	–[2]	–	–[2]	–
Near-Field Dilution, S_n	78.4	–	–	58.0[3]	-26.1%
		Mean Error	-28.5%		-24.3%

Note 1: Based on a 50° port inclination the semi-empirical formulations of Abessi and Roberts (2015) have been used as input to the spacing-dependent formulations of Abessi and Roberts (2014b)
Note 2: Near-field distance not calculated by either Visual Plumes UM3 or the quasi-steady CFD model.
Note 3: Near-field CFD dilution extracted at semi-empirically derived near-field distance.

Under quiescent ambient conditions the numerical CFD model provides good agreement with the semi-empirical scaling arguments of Abessi and Roberts (2014b, 2015). Similar to the predictions of Visual Plumes, the jet trajectory length-scales including the terminal rise and impact distance are under-predicted by the CFD model by approximately 20%. The predicted impacted dilutions are significantly better represented by the CFD model than the Visual Plumes result, however the projected CFD impact dilutions are conservative by 28.5%. This result is consistent with the findings of Oliver et al. (2008) and Zhang et al. (2016, 2017), where it is rationalised that the CFD model has a tendency to overestimate the stabilising density gradients of the near-field flow dynamics. The dilution at the end of the near-field mixing zone similarly presents approximately 26% conservatism, relative to the semi-empirical estimates.

To consider the model efficacy under ambient current conditions, predictions of the Visual Plumes and CFD models are compared against the semi-empirical scaling arguments of Abessi and Roberts (2017) in Table A.2. Note that the study of Abessi and Roberts (2017) used a jet inclination of 60°, whilst a 50° inclination was used for the Visual Plumes and CFD results in representation of the proposed EPDP diffuser design. For comparison against Abessi and Roberts (2017), the ambient velocity is parameterised in terms of the crossflow-Froude number, which is defined as the product of the ambient-to-jet velocity ratio and the jet densimetric Froude number. For the results presented in Table A.2, the crossflow Froude number conditions constitute ambient velocities ranging 0.15 – 0.25 m/s.

Table A.3. Comparison of Visual Plumes and CFD model results with semi-empirical scaling of Abessi and Roberts (2017) for dynamic co-flowing current conditions

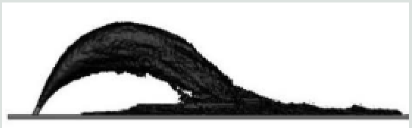
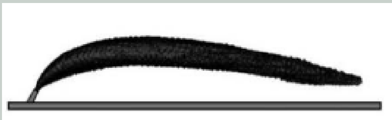
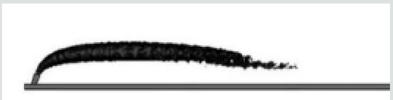
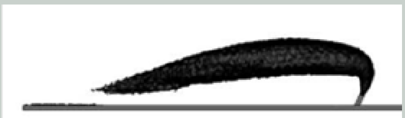
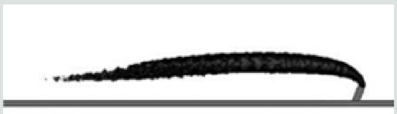
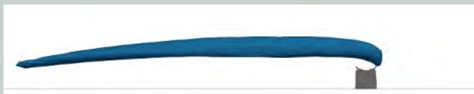
Crossflow Froude No.[2]	Property	Abessi and Roberts (2017)[1]	Visual Plumes		CFD	
			Prediction	Error	Prediction	Error
0.97	Jet Terminal Rise, Z_t	7.4	5.7	-23.4%	6.4	-14.2%
	Impact Distance, X_i	18.4	12.3	-33.4%	19.8	7.6%
	Impact Dilution, S_i	95.3	40.6	-57.4%	79.4	-16.7%
1.29	Jet Terminal Rise, Z_t	7.1	5.5	-22.8%	6.3	-11.9%
	Impact Distance, X_i	22.1	14.2	-35.8%	22.9	3.7%
	Impact Dilution, S_i	118.3	43.6	-63.2%	87.9	-25.7%
1.61	Jet Terminal Rise, Z_t	6.8	5.3	-21.4%	5.8	-15.0%
	Impact Distance, X_i	25.7	16.5	-35.9%	26.2	1.9%
	Impact Dilution, S_i	141.3	47.6	-66.3%	94.4	-33.2%
			Mean Error	-40.0%		-11.5%

Note 1: Abessi and Roberts (2017) laboratory experiments corresponding to a multiport diffuser with 60° port inclination. The EPDP CFD model geometry represents a multiport diffuser with a 50° port inclination.
Note 2: For the discharge conditions implemented for the Visual Plumes and CFD modelling, the ambient crossflow-Froude number constitutes ambient velocities ranging from 0.15 – 0.25 m/s.

Both Visual Plumes and the CFD model demonstrate a tendency to underpredict the jet terminal rise by an average of -22.5% and -13.7%, respectively. Meanwhile, in terms of the horizontal translation of the jet, the CFD model performs significantly better than Visual Plumes with a mean error of +4.4%, relative to the -35.0% discrepancy for the Visual Plumes model. With the much better overall model efficacy of the CFD model with respect to the jet trajectory length scales, the jet impact dilution similarly reflects good model performance. On average, the CFD model yields an error of -25.2%, while the Visual Plumes model returned an impact dilution error of -62.3%. In terms of dilution, both the Visual Plumes and CFD models demonstrate increasing negative bias in the predictive skill with increasing current speed. Notwithstanding, the CFD results still fall within the 90% confidence level of ±40% reported by Abessi and Roberts (2017), where substantial scatter was reported in their laboratory results, which is argued to occur due to experimental artefacts.

Finally, to provide context for the effect of ambient current dynamics on the jet trajectory under both co-flowing and counter-flowing regimes, qualitative comparisons of plume surface iso-contours are shown for various current speeds in Table A.3.

Table A.4. Qualitative comparison of dense jet response to ambient current dynamics for laboratory experiments (Abessi and Roberts, 2017) and the near-field CFD model

Current Direction	Crossflow Froude No.[2]	Abessi and Roberts (2017)[3]	CFD
Co-Flow	0.67		
	1.84		
	2.59		
	3.49		
Counter-Flow	0.67		
	1.84		
	2.59		
	3.49		

Note 1: Since the images from Abessi and Roberts (2017) do not cite the applicable port Froude number or port diameter, the CFD figures have not been scaled to match the laboratory results.
Note 2: For the discharge conditions implemented in the CFD modelling, the ambient crossflow-Froude number constitutes ambient velocities ranging from 0.10 – 0.54 m/s.
Note 3: Abessi and Roberts (2017) laboratory experiments corresponding to a multiport diffuser with 60° port inclination. The EPDP CFD model geometry represents a multiport diffuser with a 50° port inclination.

Results present excellent agreement in the deflection response of the jet trajectory as it is advected in both the co- and counter-flow direction. From Abessi and Roberts (2017) with a 60° inclined jet, for a counter-flowing current a cross-flow Froude number of 0.67 presents the condition where the jet falls back on itself – inducing plume re-entrainment and ultimately having a marked reduction in dilution. While the equivalent counter-flowing jet in the CFD model demonstrates significant shortening of the jet trajectory, the plume is not yet subject to reversal – potentially due to the lower port inclination (50°) and the increased opposing horizontal momentum of the jet. For faster ambient current speeds, the modelled plume demonstrates similar behaviour to the laboratory results, demonstrating a strong transition to the current-governed condition.

In summary, the CFD model demonstrates very good agreement with laboratory-derived semi-empirical arguments, with substantially improved model efficacy over the Visual Plumes integral entrainment model.

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Annex B Additional Near-Field Results

B.1 Dilution Iso-contours

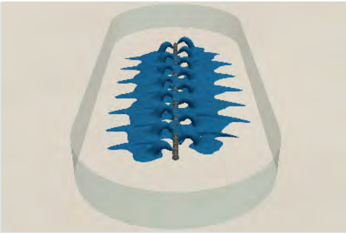
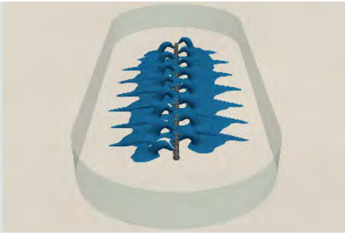
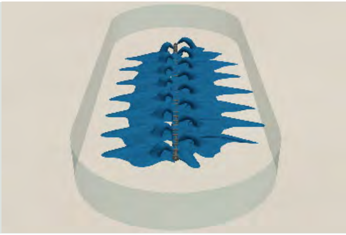
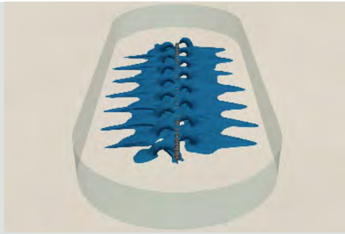
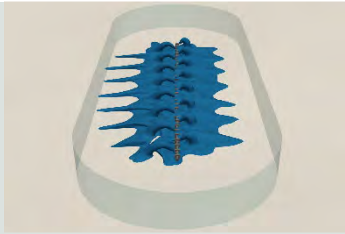
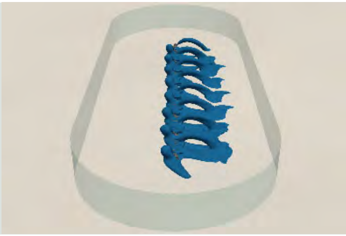
Ambient Velocity	North-North-Easterly Flow	South-South-Westerly Flow
0.010 m/s		
0.025 m/s		
0.050 m/s		
0.100 m/s		
0.150 m/s		
0.200 m/s		
0.250 m/s		

Figure B.1 EPDP brine discharge plume resulting from near-field CFD simulations. Results show the 1:60 iso-surface dilution looking on-shore. Opaque boundary represents 30 m mixing zone

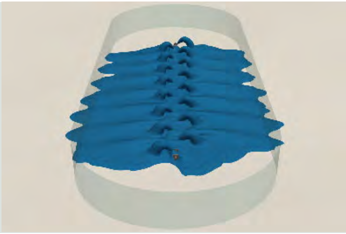
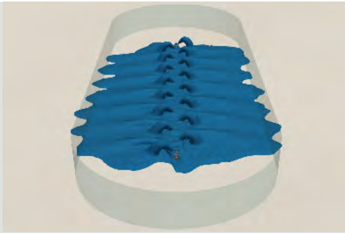
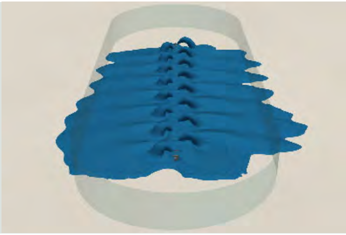
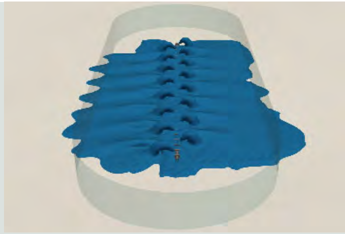
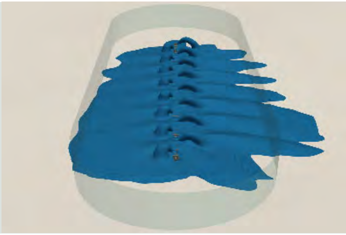
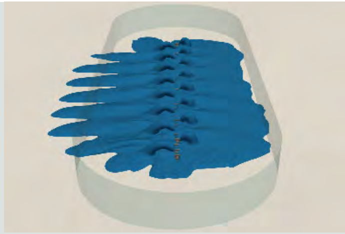
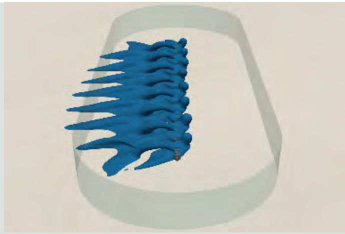
Ambient Velocity	North-North-Easterly Flow	South-South-Westerly Flow
0.010 m/s		
0.025 m/s		
0.050 m/s		
0.100 m/s		
0.150 m/s		
0.200 m/s		
0.250 m/s		

Figure B.2 EPDP brine discharge plume resulting from near-field CFD simulations. Results show the 1:80 iso-surface dilution looking on-shore. Opaque boundary represents 30 m mixing zone

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Appendix M Marine Characterisation of Water Quality

SA Water

Eyre Peninsula Desalination Project

Marine Characterisation of Water Quality at Billy Lights Point, Port Lincoln

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Date: 27/05/24

Status: Final

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Government of South Australia

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Hazel Vandeleur	Senior EIA Officer	0.2	27/05/24

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Table 12. Summary of metal concentrations overserved off site BLP Jetty 2 at Billy Lights Point, Port Lincoln. Guideline values are based on ANZECC (2000) guidelines of 95% species protection.

Table 13. Summary of metal concentrations overserved off site SAW2 at Billy Lights Point, Port Lincoln. Guideline values are based on ANZECC guidelines of 95% species protection.

Table 14. Summary of metal concentrations overserved off site SAW7 at Billy Lights Point, Port Lincoln. Guideline values are based on ANZECC guidelines of 95% species protection.

Table 15. Summary of total recoverable and petroleum hydrocarbons at site BLP Jetty 2 at Billy Lights Point.

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Table 18. Summary of biological water quality properties observed at site BLP Jetty 2 off Billy Lights Point, Port Lincoln. Guideline values for chlorophyll *a* are based on ANZG (2018) guidelines for "slightly to moderately disturbed", and on NHMRC (2008) guidelines for all other parameters.

Table 19. Summary of biological water quality properties observed at site SAW2 off Billy Lights Point, Port Lincoln. Guideline values for chlorophyll *a* are based on ANZG (2018) guidelines for "slightly to moderately disturbed", and on NHMRC (2008) guidelines for all other parameters.

Table 20. Summary of biological water quality properties observed at site SAW7 off Billy Lights Point, Port Lincoln. Guideline values for chlorophyll *a* are based on ANZG (2018) guidelines for "slightly to moderately disturbed", and on NHMRC (2008) guidelines for all other parameters.

Table 21. Sampling dates for all sites including whole of bays profiling since the start of the water quality program. Initial sampling focussed on the BLP Jetty 2 site and was then expanded to include SAW2 and SAW7. The symbol X denotes the date that water samples were collected and/or analysed from a site.

Table 22. Limits of reporting (LOR) for each individual water quality parameter measured at BLP Jetty 2, SAW7 and SAW2 at Billy Lights Point, Port Lincoln. The value represents the minimum concentration that can be accurately measured to determine the quantifiable concentration of the specific test. Note: * represents no specified LOR.

1 Water Quality Sampling off Billy Lights Point, Port Lincoln

A sampling program commenced in July 2021 to inform on the existing physical, chemical and biological water quality of the marine environment at Billy Lights Point, Port Lincoln. This report expands on the data reported previously during 2021-2022 that focussed on sites BLP Jetty 1, 2 and 3 and sites Point Boston South and North (Paterson 2022). Data collection is ongoing, and this report will be updated as required.

The scope of the program changed through time with the project development:

- Initially, *in situ* vertical profiling of the water column was carried out along with the collection of water samples at Billy Lights Point, Port Lincoln, with the aim of establishing background water quality parameters to inform site selection for the proposed Eyre Peninsula desalination plant.
- Vertical profiling of the water column was expanded to the whole of Boston Bay, Proper Bay and Spalding Cove areas encapsulating 106 sites that were sampled at a seasonal scale.
- Multiple sample sites located around Billy Lights Point (BLP Jetty 2, SAW7 and SAW2) were then focussed on at weekly sampling intervals after the selection of Billy Lights Point as the preferred desalination plant location (Figure 1; Table 1).
- Initial works then focussed on the BLP Jetty 2 site, with sampling again expanded to include SAW2 and SAW7 from March 2023 onwards.
- The current program of sampling at sites SAW2 and SAW7 became weekly from March 2023 and was expanded to weekly sampling of BLP Jetty 2 from October 2023 (Table 2).

The sites are surveyed at weekly intervals, with water samples collected approximately two metres above the sea floor. Table 2 provides a summary of the dates that water samples were collected from each of the three sites surrounding Billy Lights Point, since the inception of the water quality sampling program. The table also provides dates that the whole of bays vertical profiling was carried out. The aims of this report are to determine the water quality of the general waters surrounding Billy Lights Point and to categorise the water against the broad criteria of the *Australian and New Zealand Guidelines for Fresh and Marine Waters* (ANZG 2018 and ANZECC 2000) and the National Health and Medical Research Council *Guidelines for Managing Risks in Recreational Water* (NHMRC, 2008).

Table 1. Water quality sampling site latitude and longitude coordinates and depths.

Site	Latitude	Longitude	Depth (m)
BLP Jetty 2	34.7547 °S	135.8894 °E	11.0
SAW2	34.7818 °S	135.8917 °E	10.0
SAW7	34.7463 °S	135.8969 °E	11.0

The water quality sampling design is separated into three separate components. These components are:

1. Weekly *in situ* water quality profiling using water quality instruments that measure changes in ambient concentrations of selected parameters, throughout the water column at sites BLP Jetty 2, SAW2 and SAW7.
2. Seasonal *in situ* water quality profiling at 106 sites covering Boston Bay, Proper Bay and Spalding Cove.
3. Preliminary intake/outfall locations where water quality measurements were compared with the *Australian and New Zealand Guidelines for Fresh and Marine Waters* (ANZG 2018 and ANZECC 2000) to determine guideline values for the classification of water quality. Furthermore, the National Health and Medical Research Council *Guidelines for Managing Risks in Recreational Water* (NHMRC, 2008) are also used for the classification of microbial data for water quality.

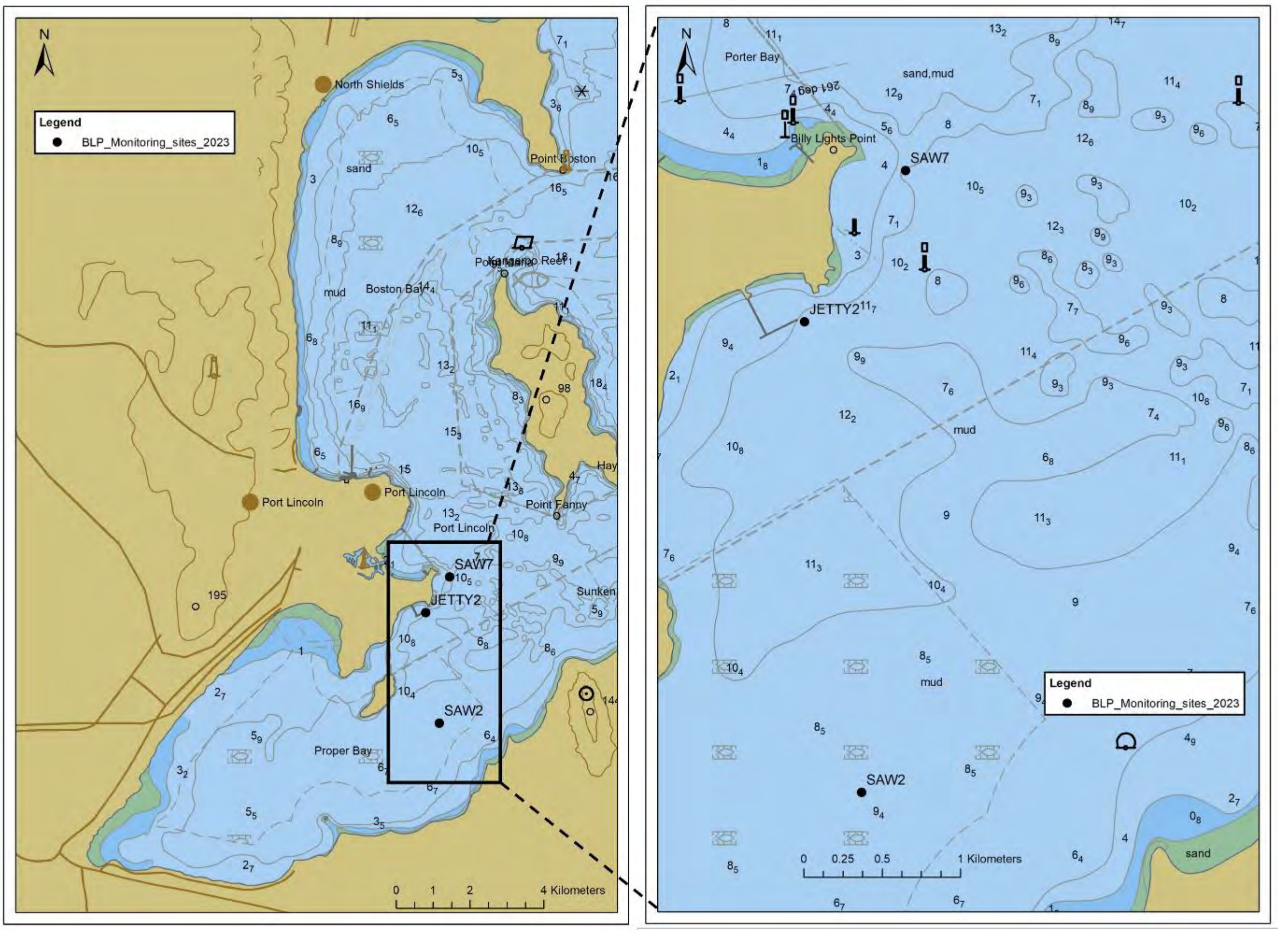


Figure 1. Water quality sampling sites in Port Lincoln, South Australia (left panel) for assessment of the marine waters off Billy Lights Point (right panel) at sites SAW7, BLP Jetty 2 and SAW2 (black dots). See Appendix A, Figure 9 for detailed locations of the whole of bays vertical profiling.

Table 2. Summary of sampling dates for all sites including whole of bays profiling since the start of the water quality program. Initial sampling focussed on the BLP Jetty 2 site and was then expanded to include SAW2 and SAW7. See Appendix A, Table 21 for all individual sampling dates of each site.

Site	Sampling Dates
BLP Jetty 2	26/07/2021 – 25/03/2024
SAW2	16/03/2023 – 25/03/2024
SAW7	16/03/2023 – 25/03/2024
Whole of Bays Profiling	30/09/2021 – 15/01/2024

1.1 *In situ* water column profiling

Water column profiling was carried out concurrently to the water quality sampling at each core site (SAW 2, SAW7 and BLP Jetty 2). Furthermore, water column profiling was also carried out at 106 sites covering Boston Bay, Proper Bay and Spalding Cove (Appendix A, Figure 9). For each site, an average of the entire water column was calculated and used for each parameter measured. The profiling works measure a variety of water quality parameters from surface waters to the maximum depth at each site. The following parameters were measured using a YSI EXO2 series sonde:

- Salinity (specific conductivity)
- Dissolved Oxygen (DO)
- Chlorophyll *a*
- Turbidity
- Temperature

1.2 Water quality in the region of the preliminary intake and outfall locations

A range of water quality parameters were measured at all sample sites. Water samples were collected at approximately 2-montly then weekly intervals from two (2) metres above the benthic substrate. The following parameters are measured:

Physical parameters:

- Total Dissolved Solids (TDS) (by evaporation) and Total Suspended Solids (TSS)
- Turbidity, measured in NTU (Nephelometric Turbidity Units)
- pH

Chemical parameters:

- Metals (Sb, As, Cd, Cr, Cu, Pb, Hg, Ni, Se, Ag, Th, Zn, Fe, Mn, Al, Ba, Sr)
- Nutrients (TN, NOx, TKN, FRP, TP)
- Total alkalinity (carbonate and bicarbonate) and hardness as CaCO3
- Total and dissolved organic carbon
- Silica
- Major Cations (Na, K, Mg, Ca) and Anions (Cl, SO4, HCO3, F)
- Boron
- Bromide
- Total recoverable and petroleum hydrocarbons, volatile organic compounds

Biological parameters:

- Chlorophyll *a,* algae and plankton species and abundance
- *Escherichia coli* and total coliforms

1.3 Water quality analysis

Water samples were collected using National Association of Testing Authorities (NATA) accredited protocols. All samples were stored within eskies between sampling and analysis to preserve their chemical properties and returned to the laboratory within 24 hours. Seawater samples collected for NO*x* and ammonia are filtered in the field using 0.45 µm syringe filters, to prevent biological activity altering the nutrient concentrations before laboratory analysis. Analyte concentrations are determined by Australian Water Quality Centre laboratories, South Australia, which is an accredited NATA laboratory. Limits of reporting for each of the water quality parameters are provided in Appendix A, Table 22.

1.4 Data analysis

Descriptive statistics are used to summarise the data, based on the method utilised by Gaylard (2009). Where a water quality parameter was recorded as below the limit of reporting (LOR; see Appendix A), the LOR was applied for calculating the statistical parameters used for water quality classification. The following statistics were calculated for each of the water quality parameters.

1.4.1 Mean (or average)

The mean, often called the average, is the most common measure of central tendency. The sample mean is a good estimate when the data are normally distributed, but if the distribution is skewed the mean should be used with caution.

1.4.2 Median

The median is the middle point of a distribution, where an equal number of measurements fall below and above it. For this reason, it is also known as the 50th percentile. The median is a more robust estimate of central tendency (particularly when the distribution is not normal) than the mean as it is not influenced so strongly by skewed distributions or outliers.

1.4.3 95th percentile

The 95th percentile is a measure that excludes the outer most 5% of the data. This gives a result that is more robust to extreme events which can skew the mean.

2 Classifying the water quality at Billy Lights Point, Port Lincoln

The water quality parameters investigated at Billy Lights Point, Port Lincoln were based on those used by the Environment Protection Authority to define environmental health as described by Gaylard, (2009).

The water quality parameters used to characterise water quality at all sites are defined into three categories: physical, chemical and biological. The physical parameters that have been reported are salinity, dissolved oxygen, pH, turbidity, temperature, dissolved solids and suspended solids. The chemical parameters consist of nutrients, metals, hydrocarbons and volatile organic compounds (VOC), and the biological parameters are an estimation of algal biomass using chlorophyll *a*, the identification and abundance of algal and plankton species, and the microbiological parameters faecal coliforms and *Escherichia coli*.

The properties of the three categories from the ambient seawater collected at sites BLP Jetty 2, SAW7 and SAW2 have been assessed under the *Australian and New Zealand Guidelines for Fresh and Marine Waters* (ANZG 2018 and ANZECC 2000), based on guideline values that have been defined for ecosystem protection, and aquaculture protection for microbial data. The mesoscale bioregion of "Eyre" has been used for the determination of default guideline values (DGV) within ANZG 2018. The physical and chemical parameters for this report have been classified from the ANZG 2018 guidelines as "slightly to moderately disturbed", however if a parameter is not included within ANZG 2018 then the ANZECC 2000 guidelines are used. Toxicant parameters, such as metals and petroleum hydrocarbons, have been classified from the ANZECC 2000 guidelines and a water quality guideline value is set at a level that will protect 95% of species (ANZECC, 2000; Gaylard, 2009). The water quality is then graded based on the following definitions:

Good – If the 95th percentile is less than or equal to the guideline value.

Moderate - If the 95th percentile is greater than, but the 50th percentile is less than or equal to, the guideline value.

Poor – If the 50th percentile is greater than the guideline value.

For this report, Billy Lights Point, Port Lincoln has been classified as three individual sampling sites (BLP Jetty 2, SAW2 and SAW7) with properties categorised based on data collected from each site. Section three summarises the water quality off Billy Lights Point at each individual sample site.

3 Results

3.1 Physical properties

The physical characteristics of the water quality parameters measured at all three sites off Billy Lights Point, Port Lincoln were within the normal range observed for coastal waters (Gaylard, 2009). All parameters, averaged across the entire 2021-2024 sampling period, were classified as "Good" (Table 3-5), which was based on the EPA's grading for water quality within a healthy aquatic ecosystem. Conductivity, dissolved oxygen, temperature, and turbidity parameters in Tables 3-8 were measured from water column profiling. An average of the entire water column was calculated and used for each sampling date.

Table 3. Summary of the physical water quality properties observed at BLP Jetty 2 during 2021-2024. All parameters, unless noted, were measured via vertical profiling of the water column on each sampling date. Guideline values are based on ANZG (2018) guidelines for "slightly to moderately disturbed". Where values are not are not present in ANZG, the ANZECC (2000) guidelines are used.

Water quality parameter	Units	Mean	Median	95th Percentile	Maximum	Sample number	Guideline values	Quality classification
Conductivity	µS/cm	55638	55403	56713	56978	37		-
Salinity	PSU	36.93	36.77	37.76	37.98	37		
pH*	-	7.99	8.00	8.10	8.10	42	8.0 – 8.5	-
Dissolved oxygen	mg/L	7.77	7.78	8.50	8.52	38	5.37 – 5.73	Good
Temperature	°C	17.45	16.94	22.92	23.97	38	16.8 – 20.0	Good
Suspended solids*	mg/L	0.541	0.516	0.895	1.200	38	10	Good
Dissolved solids*	mg/L	40512	40000	43600	44400	41		-
Turbidity	NTU	0.27	0.22	0.51	1.94	36	0.5 – 10.0	Good

Notes: *Measured from water samples collected on each sampling date.

Table 4. Summary of the physical water quality properties observed at SAW7 during 2023-2024. All parameters, unless noted, were measured via vertical profiling of the water column on each sampling date. Guideline values are based on ANZG (2018) guidelines for "slightly to moderately disturbed". Where values are not are not present in ANZG, the ANZECC (2000) guidelines are used.

Water quality parameter	Units	Mean	Median	95th Percentile	Maximum	Sample number	Guideline values	Quality classification
Conductivity	µS/cm	55726	55853	56485	57264	33		-
Salinity	PSU	37.01	37.14	37.59	38.18	33		
pH*	-	7.93	8.0	8.10	8.10	51	8.0 – 8.5	-
Dissolved oxygen	mg/L	7.57	7.56	8.34	8.50	35	5.37 – 5.73	Good
Temperature	°C	18.36	18.65	22.80	23.65	35	16.8 – 20.0	Good
Suspended solids*	mg/L	0.543	0.530	0.802	1.110	51	10	Good
Dissolved solids*	mg/L	40541	40300	43800	44300	51		-
Turbidity	NTU	0.25	0.25	0.42	3.38	31	0.5 – 10.0	Good

Notes: *Measured from water samples collected on each sampling date.

Table 5. Summary of the physical water quality properties observed at SAW2 during 2023-2024. All parameters, unless noted, were measured via vertical profiling of the water column on each sampling date. Guideline values are based on ANZG (2018) guidelines for "slightly to moderately disturbed". Where values are not are not present in ANZG, the ANZECC (2000) guidelines are used.

Water quality parameter	Units	Mean	Median	95th Percentile	Maximum	Sample number	Guideline values	Quality classification
Conductivity	µS/cm	55920	56106	56762	57327	33		-
Salinity	PSU	37.16	37.33	37.81	38.22	33		
pH*	-	7.94	8.0	8.10	8.10	51	8.0 – 8.5	Good
Dissolved oxygen	mg/L	7.51	7.48	8.25	8.34	34	5.37 – 5.73	Good
Temperature	°C	18.54	18.79	22.72	23.81	34	16.8 – 20.0	Good
Suspended solids*	mg/L	0.519	0.480	0.891	1.395	51	10	Good
Dissolved solids*	mg/L	39914	39200	43250	43900	51		-
Turbidity	NTU	0.23	0.22	0.40	0.93	31	0.5 – 10.0	Good

Notes: *Measured from water samples collected on each sampling date.

3.1.1 Weekly water column vertical profiling

Seasonal changes in temperature, salinity and dissolved oxygen were observed at all sites over the 2021-2024 monitoring period (Figure 2-4). Vertical profiles of temperature were uniform through the water column at all three sites, with no clear thermal stratification present (Figure 2). Average water column temperature ranged from 22.66°C in late summer to 12.43°C in winter, both observed at BLP Jetty 2 (Table 6). Changes in salinity through the water column was observed at all three sites, with more saline water at the bottom of the water column present in January 2022 and 2023 at BLP Jetty 2, and in May of 2023 at SAW2 and SAW7 (Figure 3). Measures of salinity were highest in summer with a value of 38.22 PSU at SAW2 and lowest in winter with a value of 36.2 PSU (Figure 3). Dissolved oxygen concentrations through the water column were generally uniform, however profiles in February 2022 at BLP Jetty 2 and in April 2023 at SAW2 exhibited stratification with lower concentrations at the bottom (Figure 4). Average dissolved oxygen concentration of the water column ranged from 8.50 mg/L in July 2021 at BLP Jetty 2 and 6.81 mg/L in summer at SAW7 (Table 6-7, Figure 4). This is consistent with temperature and salinity values having an inverse relationship with dissolved oxygen, where an increase in these parameters will see a reduction dissolved oxygen concentration.

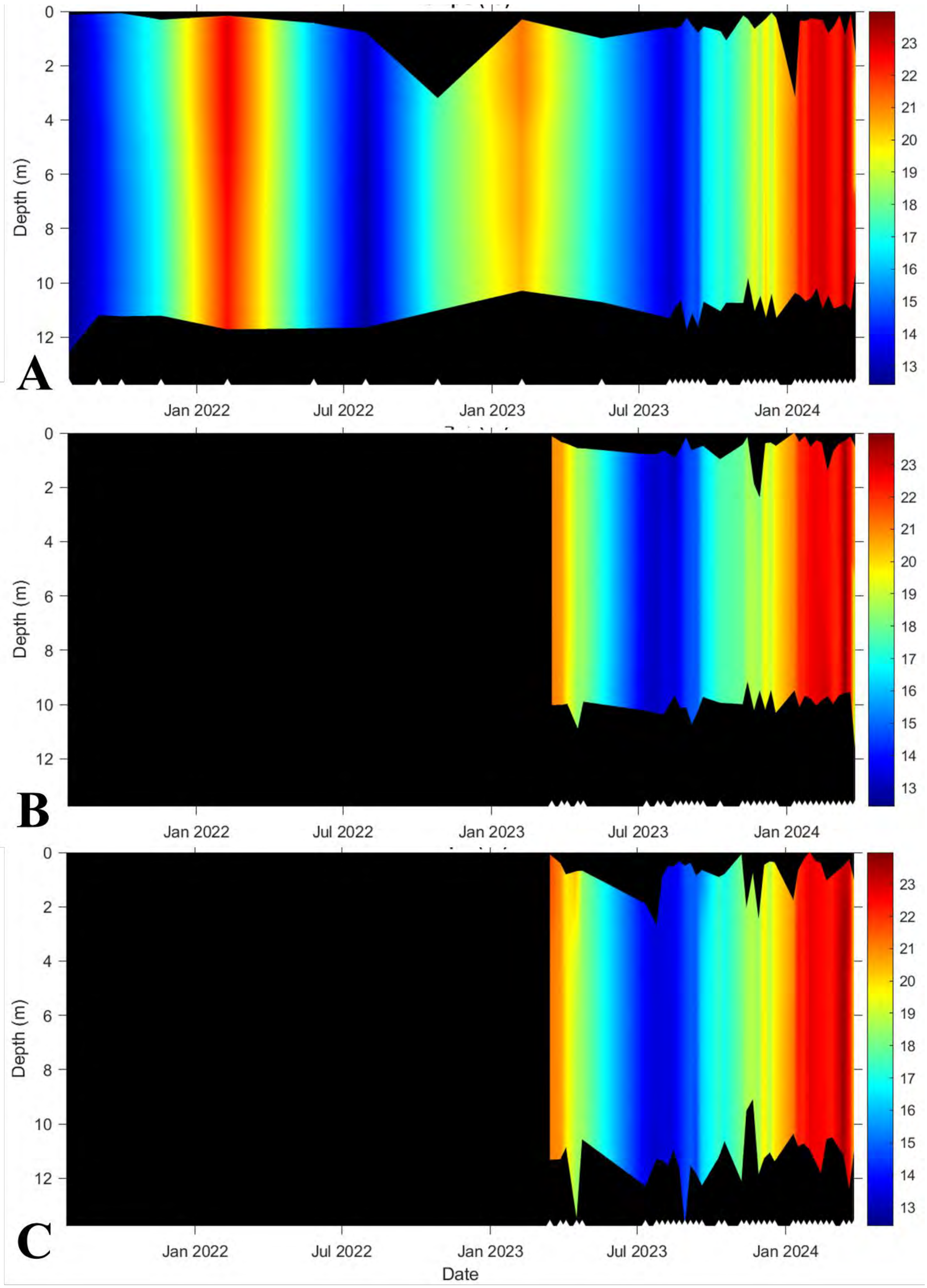


Figure 2. Vertical profiles of temperature (°C) across seasons during 2021-2024 at the three sample sites off (A) BLP Jetty 2, (B) SAW2 and (C) SAW7. White triangles on the x-axis represent sample dates.

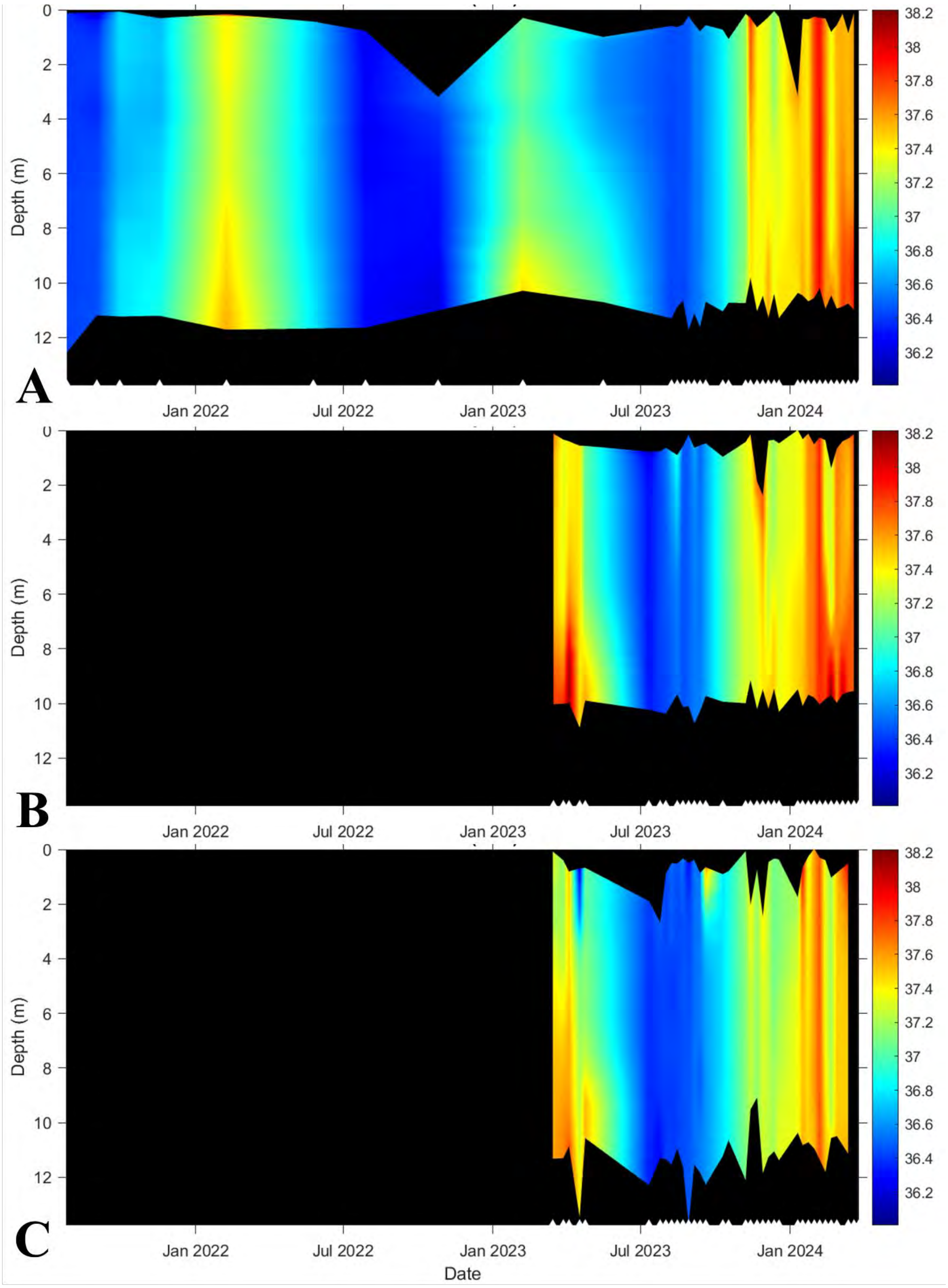


Figure 3. Vertical profiles of salinity (PSU) across seasons during 2021-2024 at the three sample sites off (A) BLP Jetty 2, (B) SAW2 and (C) SAW7. White triangles on the x-axis represent sample dates.

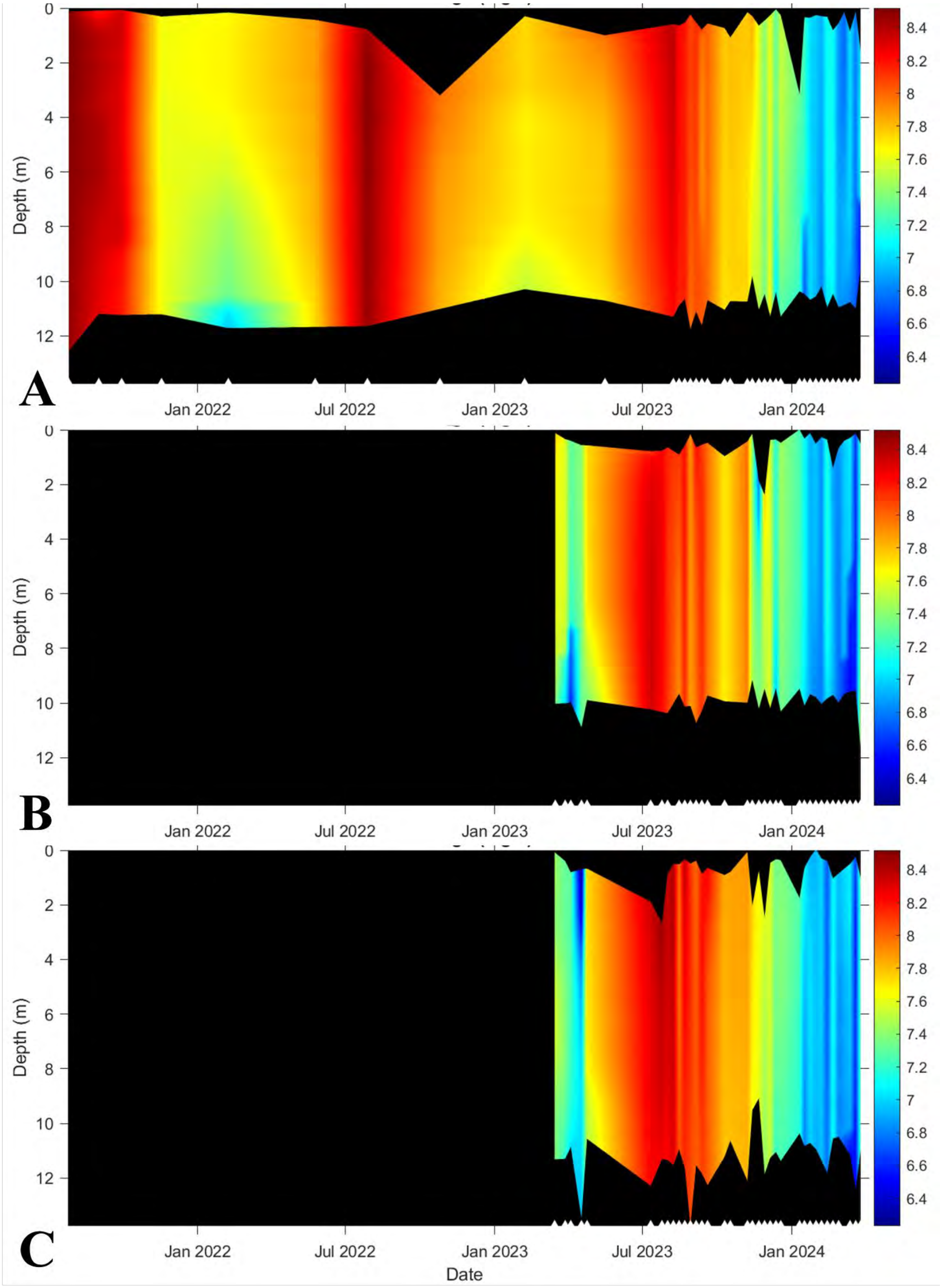


Figure 4. Vertical profiles of dissolved oxygen (mg/L) across seasons during 2021-2024 at the three sample sites of (A) BLP Jetty 2, (B) SAW2 and (C) SAW7. White triangles on the x-axis represent sample dates.

3.1.2 Suspended solids and turbidity

The concentration of suspended solids was low for the entire monitoring period at all three locations, with the highest measurement across all sites of 1.395 mg/L at SAW2 (Table 5) and an average of 0.543 mg/L at SAW7 (Table 4). When suspended solids concentrations are greater than 10 mg/L it can be detrimental to the marine environment and effect the growth of sponges and reduce recruitment of macroalgae onto reef substrates. Average turbidity of the water column was highest in summer with a maximum of 1.00 NTU recorded at BLP Jetty 2 in February 2021, while lowest values of 0.01 NTU were observed in November 2021 at BLP Jetty 2. Generally, turbidity was below 1.0 NTU for most of the monitoring period at all three sites (Table 6-8).

Table 6. Mean values for salinity, water temperature, dissolved oxygen (concentration and percentage saturation) and turbidity for each sampling month at site BLP Jetty 2, Port Lincoln during 2021-2024. Values were obtained by averaging the entire water column profile of each sampling date. Note: values for February, May, July and October 2022 were extracted from Boston Bay monitoring site BB067.

Month	Conductivity (µS/cm)	Salinity (PSU)	Temperature (°C)	Dissolved oxygen (mg/L)	Percentage oxygen saturation (%)	Turbidity (NTU)
July 2021	55085	36.40	12.43	8.50	100.03	0.19
September 2021	55129	36.52	14.50	8.32	102.21	0.14
November 2021	55338	36.74	17.20	7.62	98.85	0.01
February 2022	56341	37.49	22.59	7.54	108.42	1.00
May 2022	55349	36.73	15.89	7.83	98.98	0.22
July 2022	54840	36.25	12.93	8.47	100.59	0.18
October 2022	54743	36.31	17.66	7.89	102.96	0.19
February 2023	55864	37.15	20.85	7.69	106.89	-
May 2023	55383	36.77	16.46	7.83	100.06	0.18
August 2023	55056	36.45	13.83	8.18	99.09	0.35
September 2023	55174	36.58	15.25	8.02	99.99	0.34
October 2023	55508	36.87	17.07	7.77	100.54	0.25
November 2023	56119	37.34	18.67	7.60	101.71	0.33
December 2023	56096	37.33	19.54	7.43	100.98	0.27
January 2024	56424	37.56	22.14	7.07	100.88	0.31
February 2024	56504	37.61	22.66	6.99	100.66	0.24
March 2024	56552	37.64	22.34	6.87	98.59	0.33

Table 7. Mean values for salinity, water temperature, dissolved oxygen (concentration and percentage saturation) and turbidity for each sampling month at site SAW7, Port Lincoln during 2023-2024. Values were obtained by averaging the entire water column profile of each sampling date.

Month	Conductivity (µS/cm)	Salinity (PSU)	Temperature (°C)	Dissolved oxygen (mg/L)	Percentage oxygen saturation (%)	Turbidity (NTU)
March 2023	56184	37.39	21.08	7.39	103.34	-
April 2023	55966	37.23	19.09	7.23	97.35	0.13
July 2023	55031	36.42	13.55	8.33	100.30	0.27
August 2023	55039	36.43	13.86	8.22	99.64	0.28
September 2023	55217	36.61	15.29	8.09	101.05	0.30
October 2023	55447	36.82	17.11	7.83	101.40	0.25
November 2023	55960	37.22	18.41	7.70	102.46	0.36
December 2023	55906	37.18	19.41	7.39	100.14	0.22
January 2024	56323	37.48	22.08	7.02	99.95	0.40
February 2024	56310	37.47	22.43	6.91	98.92	0.26
March 2024	56533	37.62	22.60	6.81	98.86	0.21

Table 8. Mean values for salinity, water temperature, dissolved oxygen (concentration and percentage saturation) and turbidity for each sampling month at site SAW2, Port Lincoln during 2023-2024. Values were obtained by averaging the entire water column profile of each sampling date.

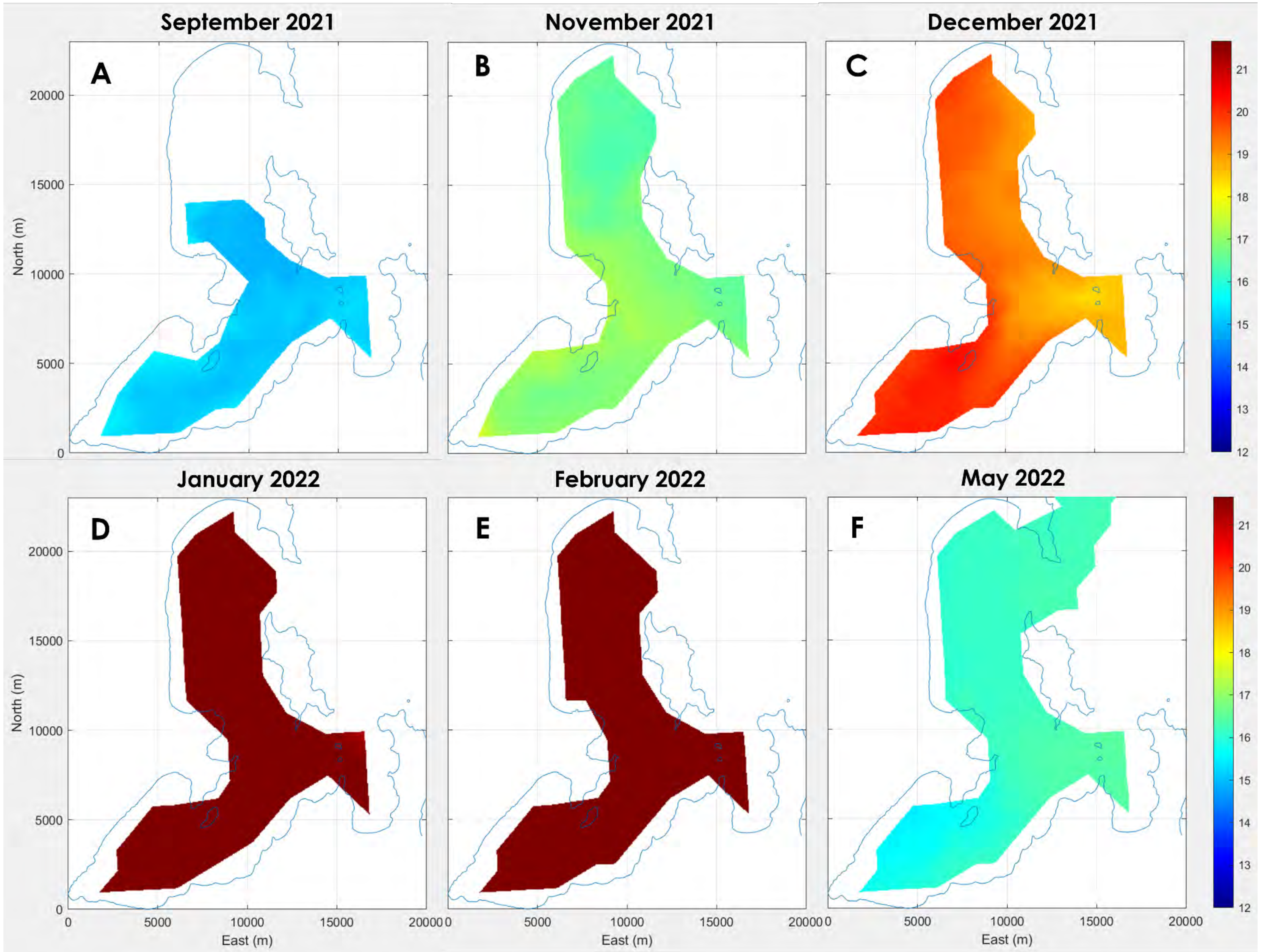
Month	Conductivity (µS/cm)	Salinity (PSU)	Temperature (°C)	Dissolved oxygen (mg/L)	Percentage oxygen saturation (%)	Turbidity (NTU)
March 2023	56358	37.52	20.85	7.56	105.33	-
April 2023	56270	37.46	19.11	7.34	99.00	0.14
July 2023	54942	36.34	13.30	8.28	99.19	0.32
August 2023	55136	36.51	13.87	8.04	97.53	0.29
September 2023	55164	36.57	15.28	8.06	100.57	0.28
October 2023	55617	36.96	17.53	7.69	100.51	0.14
November 2023	56253	37.44	18.33	7.51	99.85	0.16
December 2023	56077	37.31	19.49	7.37	100.05	0.18
January 2024	56396	37.54	21.99	7.03	99.99	0.22
February 2024	56518	37.62	22.52	6.92	99.34	0.25
March 2024	56625	37.70	22.01	6.90	98.67	0.24

3.1.3 Whole of bays water column profiling

Vertical profiles of temperature, salinity and dissolved oxygen mapped throughout Boston, Proper Bay and Spalding Cove exhibited seasonal and temporal changes (Figure 5-7). Water temperature during summer of each year was warmest in the southern area of Proper Bay and the north-western shore of Boston Bay, while in autumn and winter water temperature was warmest on the eastern edges of Boston Bay and Spalding Cove (Figure 5). Water temperature was observed to be warmer in the south of Proper Bay in spring of each year.

Concentrations of salinity were more consistent between seasons with highest levels in Proper Bay during spring, summer and autumn, while in winter highest concentrations were observed in the north-west of Boston Bay (Figure 6). During the transition from spring to summer, salinity increases throughout the bays starting from the south of Proper Bay with Spalding Cove the final location to equilibrate with the other bays in late Summer (Figure 6). During winter, the concentration of salinity is shown to be consistent across the whole of bays, then begins to increase in Proper Bay during early spring of each year (Figure 6).

Dissolved oxygen concentrations exhibited both temporal and seasonal variability, with highest concentrations during winter (Figure 7). Lowest dissolved oxygen concentrations were recorded during summer, primarily in the south of Proper Bay and the north-west of Boston Bay (Figure 7). Dissolved oxygen remained elevated in the north of Proper Bay in November 2021 (Figure 7B), while an area of high dissolved oxygen was observed on the western side of Boston Island in January 2024 (Figure 7L). Spalding Cove remained higher in dissolved oxygen concentrations compared to the other bays in the summer months of each year (Figure 7).


September 2021
November 2021
December 2021
January 2022
February 2022
May 2022
A
B
C
D
E
F
North (m)
East (m)
0
5000
10000
15000
20000
12
13
14
15
16
17
18
19
20
21

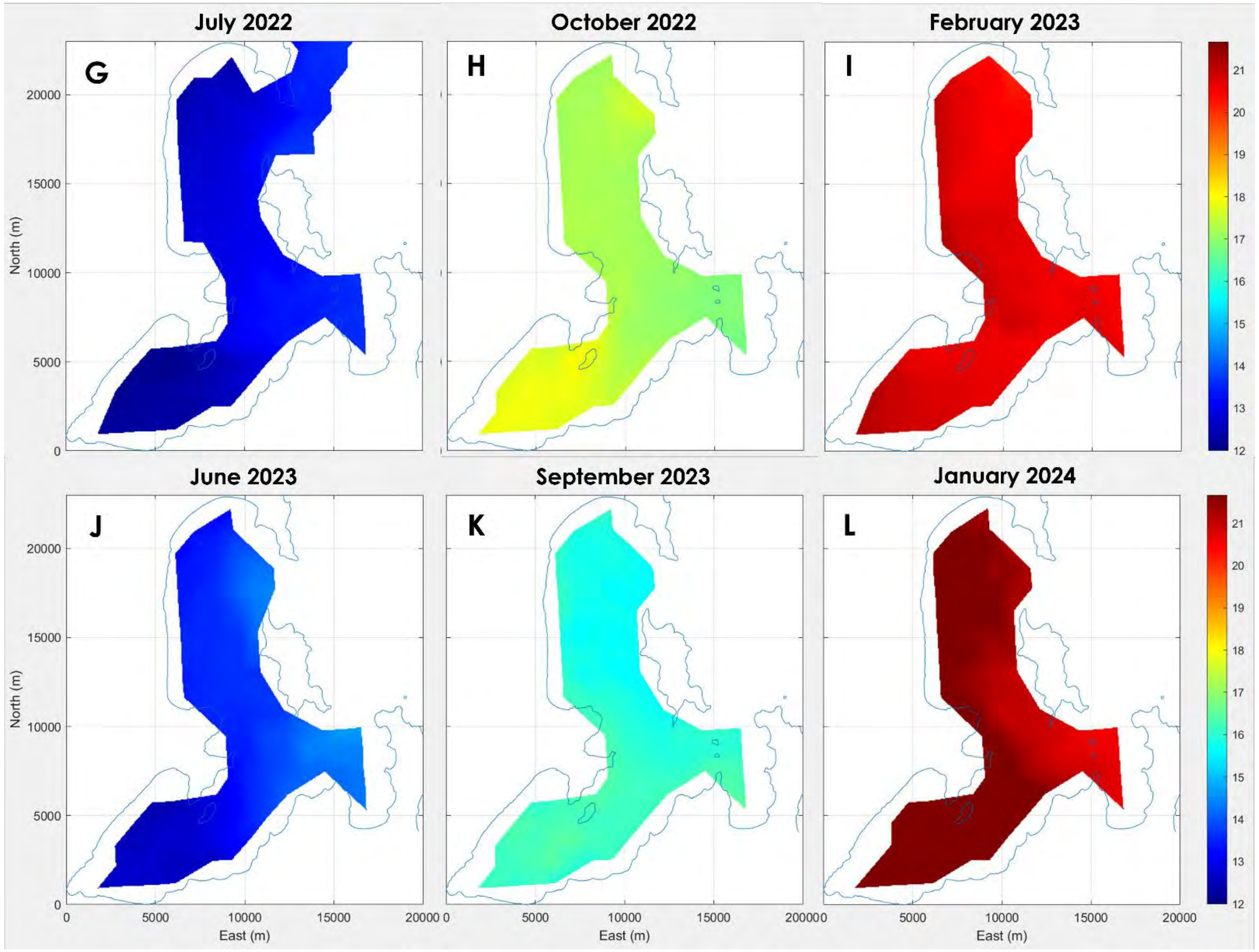
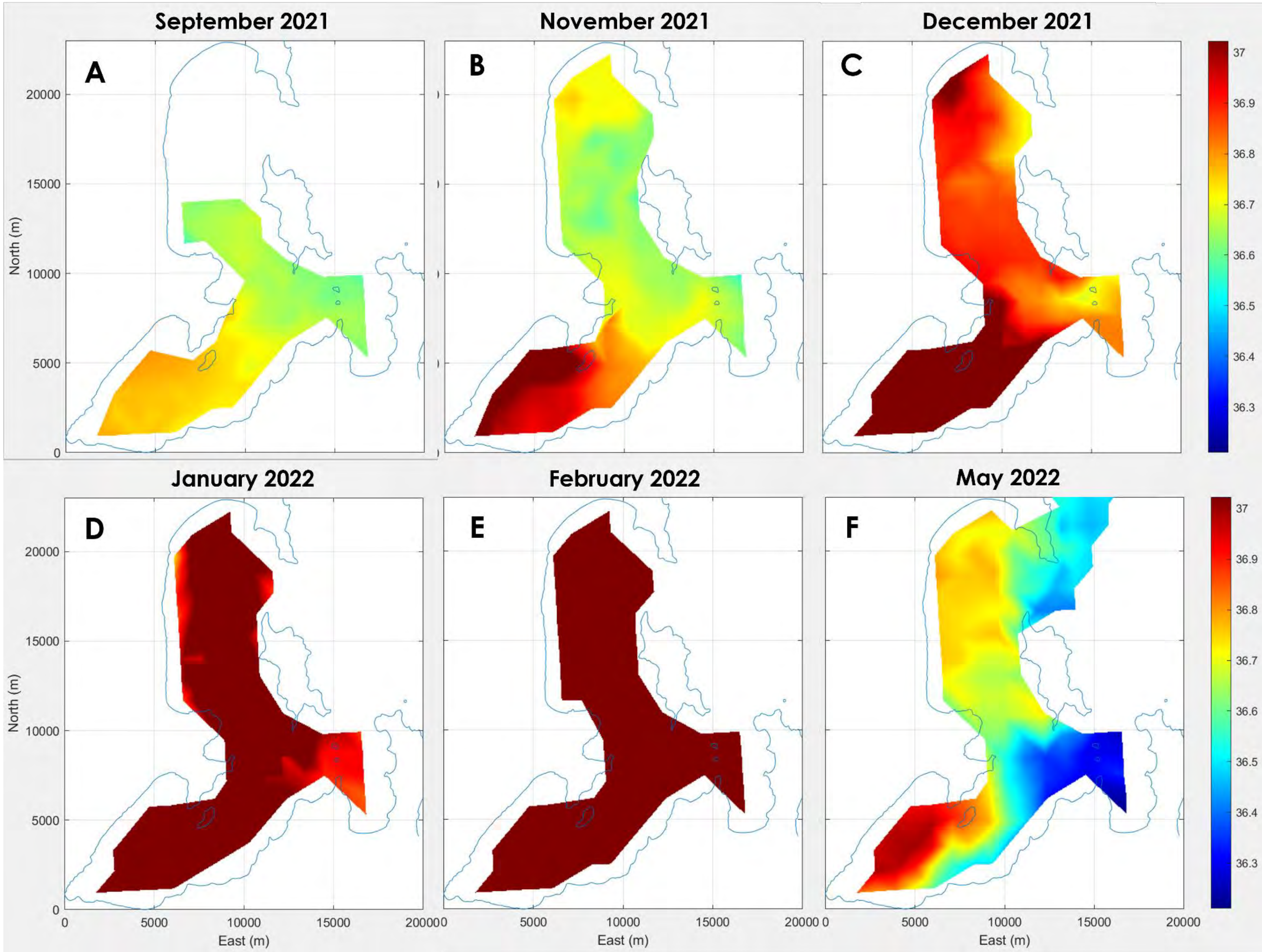


Figure 5. Mean sea temperature (°C) of the Boston Bay, Proper Bay and Spalding Cove regions across (A) September 2021, (B) November 2021, (C) December 2021, (D) January 2022, (E) February 2022. (F) May 2022. (G) July 2022, (H) October 2022, (I) February 2023, (J) July 2023, (K) September 2023 and (L) January 2024. Values of temperature plotted were calculated as a mean of each vertical profile recorded in Boston and Proper Bays (n = 106). Note: mean values were used due to the range of time in which sites were profiled.


September 2021
November 2021
December 2021
A
B
C
January 2022
February 2022
May 2022
D
E
F
North (m)
East (m)
0
5000
10000
15000
20000
37
36.9
36.8
36.7
36.6
36.5
36.4
36.3

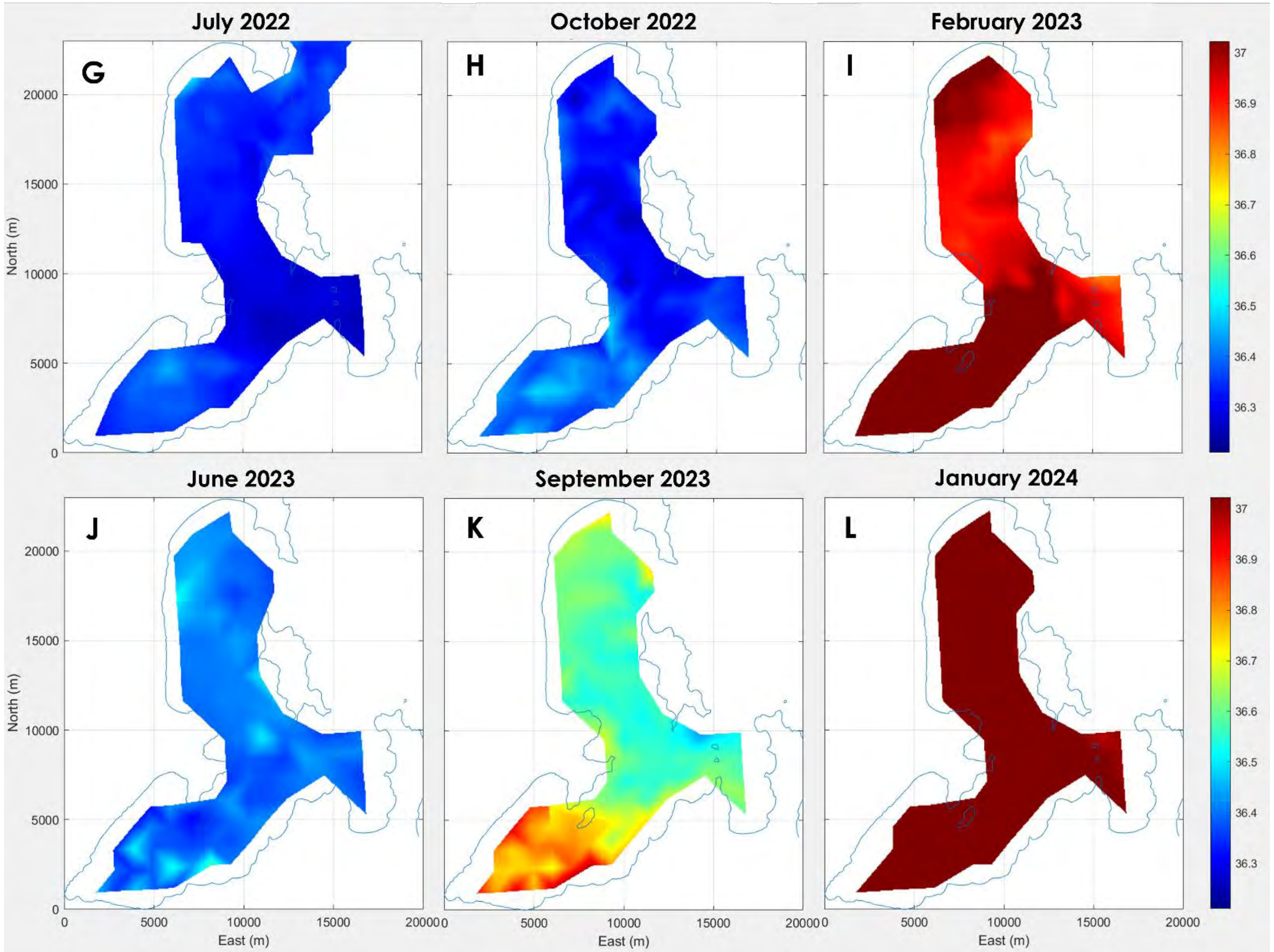
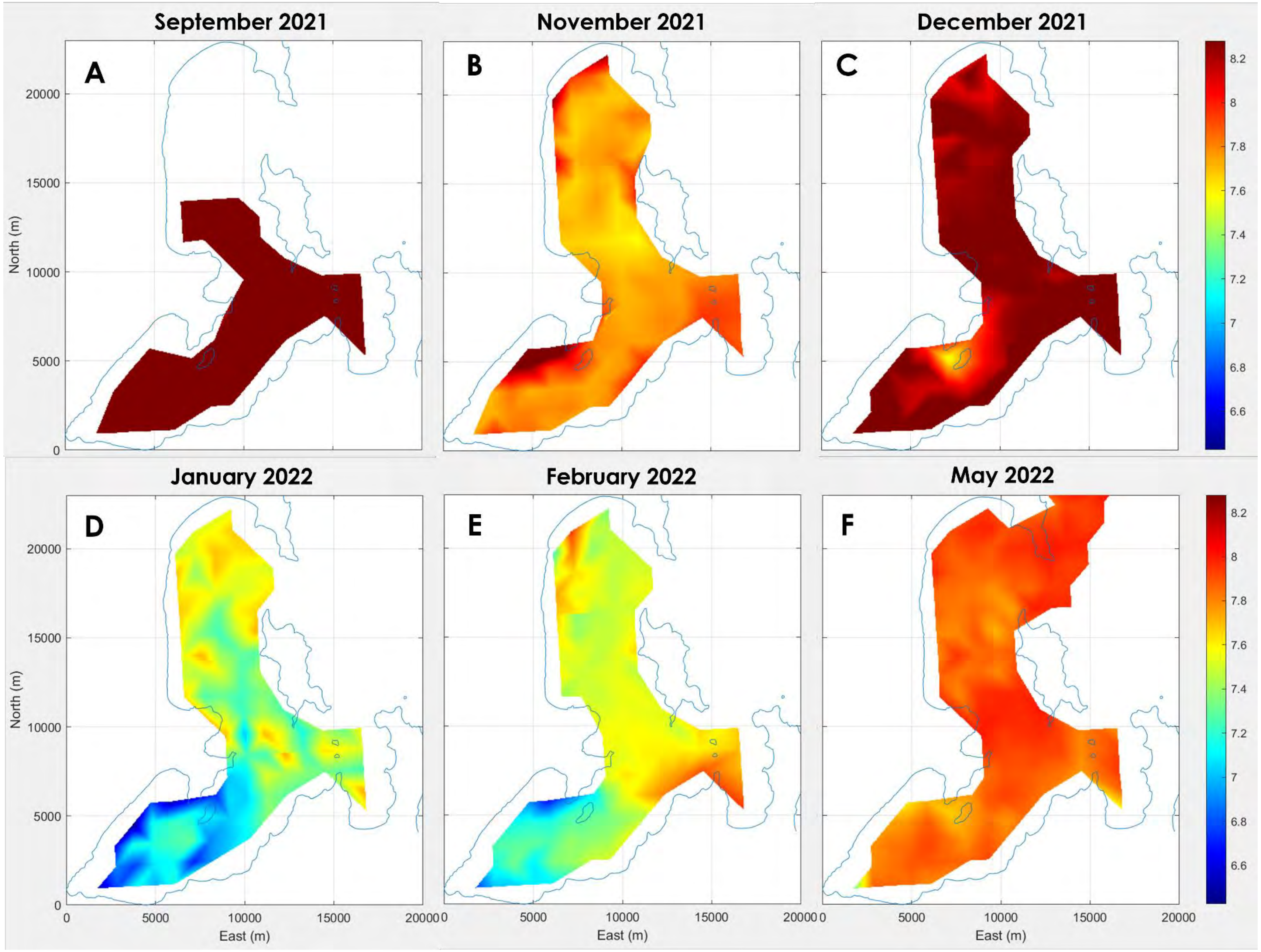


Figure 6. Mean salinity (PSU) of the Boston Bay Proper Bay and Spalding Cove regions across (A) September 2021, (B) November 2021, (C) December 2021, (D) January 2022, (E) February 2022. (F) May 2022. (G) July 2022, (H) October 2022, (I) February 2023, (J) July 2023, (K) September 2023 and (L) January 2024. Values of salinity plotted were calculated as a mean of each vertical profile recorded in Boston and Proper Bays (n = 106). Note: mean values were used due to the range of time in which sites were profiled.


September 2021
November 2021
December 2021
January 2022
February 2022
May 2022
A
B
C
D
E
F
North (m)
East (m)
0
5000
10000
15000
20000
6.6
6.8
7
7.2
7.4
7.6
7.8
8
8.2

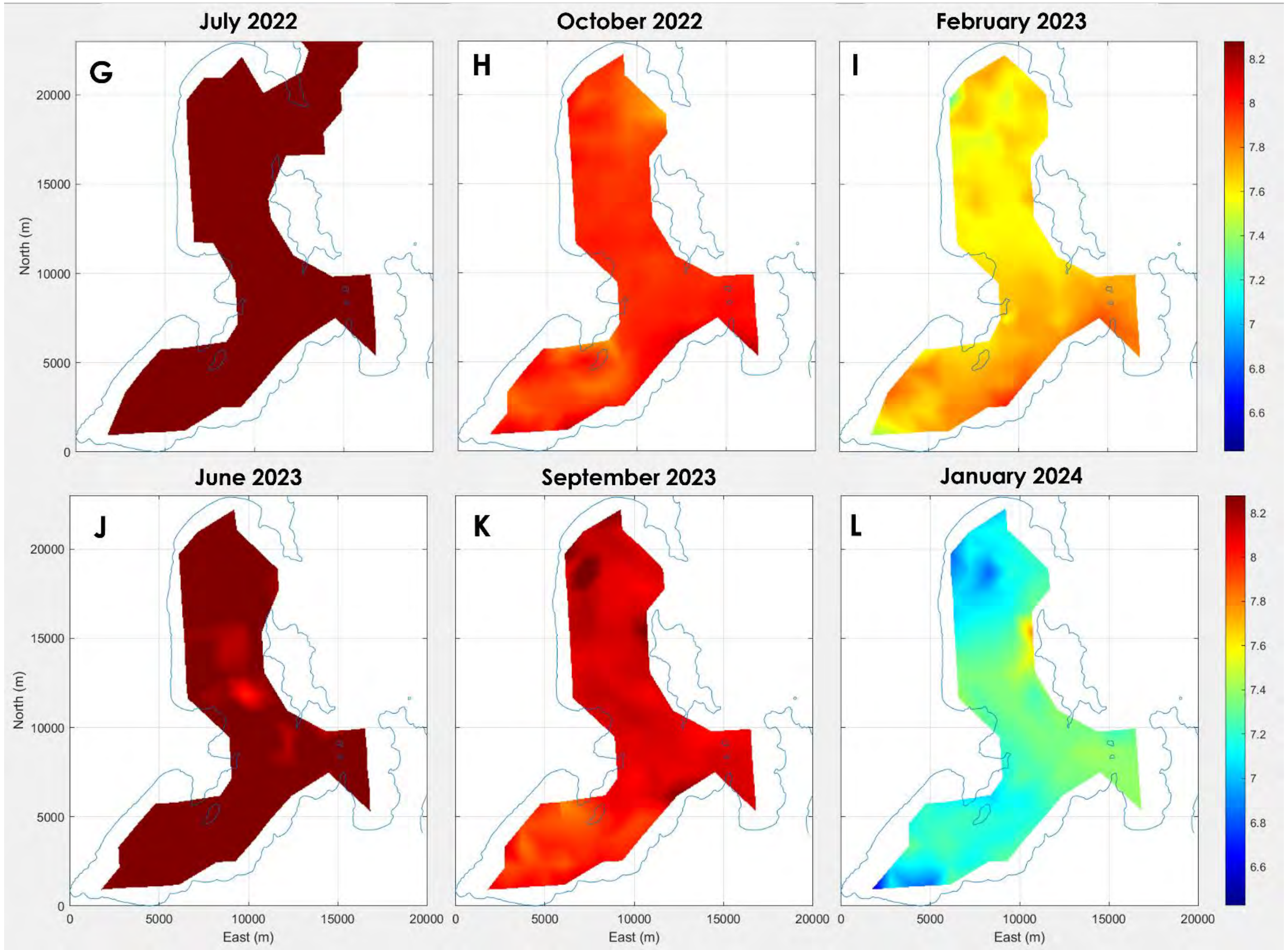


Figure 7. Mean dissolved oxygen (mg/L) of the Boston Bay Proper Bay and Spalding Cove regions across (A) September 2021, (B) November 2021, (C) December 2021, (D) January 2022, (E) February 2022. (F) May 2022. (G) July 2022, (H) October 2022, (I) February 2023, (J) July 2023, (K) Septemb er 2023 and (L) January 2024. Values of dissolved oxygen plotted were calculated as a mean of each vertical profile recorded in Boston and Proper Bays (n = 106). Note: mean values were used due to the range of time in which sites were profiled.

3.2 Chemical properties

Nutrient and metal concentrations measured at Billy Lights Point, Port Lincoln during the 2021-2024 monitoring period were all within the normal range observed for coastal waters across all three sites (Gaylard, 2009). All parameters expect one were below the guideline values stated by ANZECC and classified as "Good" (Table 9-14) based on the EPA's water quality grading for a healthy aquatic ecosystem. Only copper was classified as "Moderate" at all three sites (Table 9).

3.2.1 Nutrients

Concentrations of nutrients across all three sites at Billy Lights Point, Port Lincoln over the 2021-2024 monitoring period were low, with all parameters recording a "Good" classification. All nutrient parameters were approximately 5 to 10-fold lower in concentration at the 95th percentile compared to the "Good" guideline value (Table 9-11).

Table 9. Summary of nutrient concentrations observed off BLP Jetty 2 at Billy Lights Point, Port Lincoln. Guideline values are based on ANZG (2018) guidelines for "slightly to moderately disturbed". Where values are not are not present in ANZG, the ANZECC (2000) guidelines are used.

Water quality parameter	Units	Mean	Median	95th percentile	Maximum	Sample number	Guideline values	Quality classification
TKN as N	mg/L	0.135	0.130	0.190	0.430	42		-
Filterable reactive phosphorous	mg/L	0.0036	0.0030	0.0070	0.010	42	0.01	Good
Nitrate + Nitrite as N	mg/L	0.0037	0.0030	0.0049	0.0210	42	0.05	Good
Ammonia as N	mg/L	0.009	0.008	0.019	0.032	37	0.91	Good
Nitrogen – total	mg/L	0.136	0.140	0.200	0.430	42	1.000	Good
Silica – reactive	mg/L	0.123	0.070	0.360	0.730	41		-
Total organic carbon	mg/L	1.093	1.000	1.600	1.700	41	10	Good
Total phosphorous	mg/L	0.0132	0.0080	0.0239	0.0810	42	0.1	Good

Table 10. Summary of nutrient concentrations observed off SAW2 at Billy Lights Point, Port Lincoln. Guideline values are based on ANZG (2018) guidelines for "slightly to moderately disturbed". Where values are not are not present in ANZG, the ANZECC (2000) guidelines are used.

Water quality parameter	Units	Mean	Median	95th percentile	Maximum	Sample number	Guideline values	Quality classification
TKN as N	mg/L	0.149	0.150	0.220	0.290	51		-
Filterable reactive phosphorous	mg/L	0.004	0.003	0.006	0.230	51	0.01	Good
Nitrate + Nitrite as N	mg/L	0.004	0.003	0.010	0.016	51	0.05	Good
Ammonia as N	mg/L	0.013	0.007	0.039	0.132	50	0.91	Good
Nitrogen – total	mg/L	0.151	0.150	0.225	0.290	51	1.00	Good
Silica – reactive	mg/L	0.224	0.090	0.230	6.330	51		-
Total organic carbon	mg/L	1.077	1.000	1.350	1.500	51	10	Good
Total phosphorous	mg/L	0.013	0.010	0.028	0.077	51	0.1	Good

Table 11. Summary of nutrient concentrations observed off SAW7 at Billy Lights Point, Port Lincoln. Guideline values are based on ANZG (2018) guidelines for "slightly to moderately disturbed". Where values are not are not present in ANZG, the ANZECC (2000) guidelines are used.

Water quality parameter	Units	Mean	Median	95th percentile	Maximum	Sample number	Guideline values	Quality classification
TKN as N	mg/L	0.138	0.130	0.215	0.280	51		-
Filterable reactive phosphorous	mg/L	0.003	0.003	0.006	0.007	51	0.1	Good
Nitrate + Nitrite as N	mg/L	0.004	0.003	0.011	0.018	51	0.05	Good
Ammonia as N	mg/L	0.012	0.006	0.034	0.159	51	0.91	Good
Nitrogen – total	mg/L	0.139	0.130	0.220	0.280	51	1.00	Good
Silica – reactive	mg/L	0.131	0.090	0.361	1.270	50		-
Total organic carbon	mg/L	1.039	1.000	1.250	1.300	51	10	Good
Total phosphorous	mg/L	0.013	0.009	0.026	0.085	51	0.1	Good

3.2.2 Metals

Metal concentrations measured across all three sites at Billy Lights Point, Port Lincoln were all generally low (Table 12-14) and mostly below the guideline values stated by ANZECC (2000), being recorded a "Good" classification. One metal recorded during the monitoring period, copper at all sites, had 95th percentile values above the guideline values for water quality and therefore recorded a "Moderate" classification (Table 12-14). Some ANZECC guidelines for metal concentrations are very low and in cases (e.g. cadmium) are below the analytical detection limit. In these cases, the analytical detection limit is used as the guideline to classify sites.

Table 12. Summary of metal concentrations overserved off site BLP Jetty 2 at Billy Lights Point, Port Lincoln. Guideline values are based on ANZECC (2000) guidelines of 95% species protection.

Water quality parameter	Units	Mean	Median	95th percentile	Maximum	Sample number	Guideline values	Quality classification
Aluminium – total	mg/L	0.0052	0.0040	0.0100	0.0100	40	-	-
Antimony – total	mg/L	0.0010	0.0003	0.0050	0.0050	40	-	-
Arsenic – inorganic	mg/L	0.0020	0.0018	0.0030	0.0030	40	-	-
Cadmium – total	mg/L	*	*	*	*	40	0.002	Good
Copper – total	mg/L	0.0008	0.0007	0.0021	0.0036	40	0.0013	Moderate
Iron – total	mg/L	0.0066	0.0066	0.0101	0.0114	40	-	-
Lead – total	mg/L	0.0005	0.0002	0.0020	0.0040	40	0.0044	Good
Mercury – total	mg/L	0.0001	0.00003	0.0003	0.0003	40	0.0004	Good
Nickel – total	mg/L	0.0006	0.0005	0.0010	0.0020	40	0.07	Good
Selenium – total	mg/L	0.0005	0.0004	0.0010	0.0010	40	-	-
Silver – total	mg/L	*	*	*	*	40	0.0014	Good
Zinc- total	mg/L	0.0013	0.0009	0.0031	0.0076	40	0.015	Good

Notes: * represents all measurements below limit of reporting (LOR). See Appendix A for all LOR values.

Table 13. Summary of metal concentrations overserved off site SAW2 at Billy Lights Point, Port Lincoln. Guideline values are based on ANZECC guidelines of 95% species protection.

Water quality parameter	Units	Mean	Median	95th percentile	Max	Sample number	Guideline values	Quality classification
Aluminium – total	mg/L	0.0040	0.0030	0.0075	0.0150	51	-	-
Antimony – total	mg/L	0.0003	0.0003	0.0003	0.0003	51	-	-
Arsenic – total	mg/L	0.0018	0.0018	0.0021	0.0022	51	-	-
Cadmium – total	mg/L	*	*	*	*	51	0.002	Good
Copper – total	mg/L	0.0006	0.0003	0.0015	0.0028	51	0.0013	Moderate
Iron – total	mg/L	0.0046	0.0043	0.0078	0.0104	51	-	-
Lead – total	mg/L	0.0002	0.0002	0.0003	0.0009	51	0.0044	Good
Mercury – total	mg/L	0.00003	0.00003	0.00004	0.0001	51	0.0004	Good
Nickel – total	mg/L	0.0005	0.0005	0.0008	0.0018	51	0.07	Good
Selenium – total	mg/L	0.0004	0.0004	0.0004	0.0005	51	-	-
Silver – total	mg/L	*	*	*	*	51	0.0014	Good
Zinc- total	mg/L	0.0008	0.0004	0.0020	0.0024	51	0.015	Good

Notes: * represents all measurements below limit of reporting (LOR). See Appendix A for all LOR values.

Table 14. Summary of metal concentrations overserved off site SAW7 at Billy Lights Point, Port Lincoln. Guideline values are based on ANZECC guidelines of 95% species protection.

Water quality parameter	Units	Mean	Median	95th percentile	Max	Sample number	Guideline values	Quality classification
Aluminium – total	mg/L	0.0041	0.0030	0.0090	0.0170	51	-	-
Antimony – total	mg/L	0.0003	0.0003	0.0003	0.0003	51	-	-
Arsenic – total	mg/L	0.0018	0.0018	0.0020	0.0021	51	-	-
Cadmium – total	mg/L	*	*	*	*	51	0.002	Good
Copper – total	mg/L	0.0006	0.0003	0.0017	0.0031	51	0.0013	Moderate
Iron – total	mg/L	0.0053	0.0054	0.0087	0.0120	51	-	-
Lead – total	mg/L	0.0002	0.0002	0.0003	0.0007	51	0.0044	Good
Mercury – total	mg/L	0.00003	0.00003	0.00004	0.00020	51	0.0004	Good
Nickel – total	mg/L	0.0006	0.0005	0.0006	0.0029	51	0.07	Good
Selenium – total	mg/L	0.0004	0.0004	0.0004	0.0007	51	-	-
Silver – total	mg/L	*	*	*	*	51	0.0014	Good
Zinc- total	mg/L	0.0008	0.0005	0.0019	0.0037	51	0.015	Good

Notes: * represents all measurements below limit of reporting (LOR). See Appendix A for all LOR values.

3.2.3 Hydrocarbons

Total recoverable and total petroleum hydrocarbons were observed across all three sites at Billy Lights Point, Port Lincoln during the 2021-2024 monitoring period (Table 15-17). The highest value of petroleum hydrocarbons was 200 µg/L for the C15-C28 fraction at BLP Jetty 2 (Table 15), while highest values of recoverable hydrocarbons was 200 µg/L for the C15-C28 fraction at BLP Jetty 2 (Table 15). Sixty-six volatile organic compounds (VOC) were also measured throughout the monitoring period (see Appendix B), with only toluene being present at 1.0 µg/L at BLP Jetty 2 in November 2021. All other VOCs were below limit of reporting (LOR) (Appendix B).

Table 15. Summary of total recoverable and petroleum hydrocarbons at site BLP Jetty 2 at Billy Lights Point.

Water quality parameter	Units	Mean	Median	95th percentile	Maximum	Sample number	Guideline values	Quality classification
TPH C06-C09	µg/L	19.34	10.00	41.10	50.00	35		-
TPH C10-C14	µg/L	*	*	*	*	38		-
TPH C15-C28	µg/L	27.47	10.00	200.00	200.00	38		-
TPH C29-C36	µg/L	*	*	*	*	38		-
TRH C06-C09	µg/L	35.39	18.50	83.35	100.00	38		-
TRH C10-C14	µg/L	13.16	10.00	50.00	50.00	38		-
TRH C15-C28	µg/L	36.89	13.00	200.00	200.00	38		-
TRH C29-C36	µg/L	*	*	*	*	38		-

Note: * represents all measurements below limit of reporting (LOR). See Appendix A for all LOR values.

Table 16. Summary of total recoverable and petroleum hydrocarbons at site SAW2 at Billy Lights Point, Port Lincoln.

Water quality parameter	Units	Mean	Median	95th percentile	Maximum	Sample number	Guideline values	Quality classification
TPH C06-C09	µg/L	26.23	25.00	52.40	57.00	47		-
TPH C10-C14	µg/L	*	*	*	*	47		-
TPH C15-C28	µg/L	16.13	12.00	29.00	45.00	47		-
TPH C29-C36	µg/L	*	*	*	*	47		-
TRH C06-C09	µg/L	44.87	53.00	83.70	90.00	47		-
TRH C10-C14	µg/L	10.02	10.00	10.00	11.00	47		-
TRH C15-C28	µg/L	28.85	27.00	56.50	111.00	47		-
TRH C29-C36	µg/L	*	*	*	*	47		-

Note: * represents all measurements below limit of reporting (LOR). See Appendix A for all LOR values.

Table 17. Summary of total recoverable and petroleum hydrocarbons at site SAW7 at Billy Lights Point, Port Lincoln.

Water quality parameter	Units	Mean	Median	95th percentile	Maximum	Sample number	Guideline values	Quality classification
TPH C06-C09	µg/L	23.23	19.00	55.70	68.00	47		
TPH C10-C14	µg/L	*	*	*	*	47		-
TPH C15-C28	µg/L	15.40	10.00	37.20	44.00	47		-
TPH C29-C36	µg/L	*	*	*	*	47		-
TRH C06-C09	µg/L	39.87	46.00	94.00	104.00	47		-
TRH C10-C14	µg/L	10.09	10.00	10.70	12.00	47		-
TRH C15-C28	µg/L	25.85	23.00	63.50	94.00	47		-
TRH C29-C36	µg/L	*	*	*	*	47		-

Note: * represents all measurements below limit of reporting (LOR). See Appendix A for all LOR values.

3.3 Biological properties

The biological characteristics of samples collected across BLP Jetty 2, SAW7 and SAW 2 at Billy Lights Point, Port Lincoln were within the normal range observed for coastal waters (Gaylard, 2009). All parameters, except chlorophyll *a*, were given a "Good" classification (Table 18-20), based on the ANZG (2018) and NHMRC (2008) guidelines and the EPAs water quality classification of a healthy ecosystem.

Table 18. Summary of biological water quality properties observed at site BLP Jetty 2 off Billy Lights Point, Port Lincoln. Guideline values for chlorophyll *a* are based on ANZG (2018) guidelines for "slightly to moderately disturbed", and on NHMRC (2008) guidelines for all other parameters.

Water quality parameter	Units	Mean	Median	95th percentile	Maximum	Sample number	Guideline values	Quality classification
E. coli	/100ml	8.29	2.00	27.75	64.00	42	150	Good
Total coliforms	/100ml	9.60	4.50	27.95	66.00	42	150	Good
Chlorophyll *a*	µg/L	0.77	0.61	1.82	3.14	42	0.29-0.63	Moderate
Green algae-phytoflagellates	cells/ml	234	138	894	965	42	-	-
Cryptomonads	cells/ml	61	21	208	500	42	-	-
Nitzschia	cells/ml	18	5	52	58	42	-	-

Table 19. Summary of biological water quality properties observed at site SAW2 off Billy Lights Point, Port Lincoln. Guideline values for chlorophyll *a* are based on ANZG (2018) guidelines for "slightly to moderately disturbed", and on NHMRC (2008) guidelines for all other parameters.

Water quality parameter	Units	Mean	Median	95th percentile	Maximum	Sample number	Guideline values	Quality classification
E. coli	/100ml	0.36	0.00	2.55	7.00	50	150	Good
Total coliforms	/100ml	0.68	0.00	3.55	8.00	50	150	Good
Chlorophyll *a*	µg/L	1.29	0.79	3.22	7.16	51	0.29-0.63	Poor
Green algae-phytoflagellates	cells/ml	133	50	485	500	51	-	-
Cryptomonads	cells/ml	31	35	50	50	51	-	-
Nitzschia	cells/ml	16	5	50	50	51	-	-

Table 20. Summary of biological water quality properties observed at site SAW7 off Billy Lights Point, Port Lincoln. Guideline values for chlorophyll *a* are based on ANZG (2018) guidelines for "slightly to moderately disturbed", and on NHMRC (2008) guidelines for all other parameters.

Water quality parameter	Units	Mean	Median	95th percentile	Maximum	Sample number	Guideline values	Quality classification
E. coli	/100ml	5.12	2.00	16.55	49.00	50	150	Good
Total coliforms	/100ml	12.86	4.50	56.20	100.0	50	150	Good
Chlorophyll *a*	µg/L	1.34	0.77	3.40	6.71	51	0.29-0.63	Poor
Green algae-phytoflagellates	cells/ml	179	55	554	860	51	-	-
Cryptomonads	cells/ml	87	36	500	500	51	-	-
Nitzschia	cells/ml	21	5	50	50	51	-	-

3.3.1 Chlorophyll *a* and Phytoplankton

Chlorophyll *a* concentration across all three sites at Billy Lights Point, Port Lincoln changed temporally across the 2021-2024 monitoring period (Table 18-20; Figure 8). Maximum values recorded were 7.16 µg/L at SAW2 during June 2023, which was at the same period as a *Gymnodinoids* bloom of up to 1100 cells/mL (Appendix B). Chlorophyll *a* concentration at SAW7 and SAW2 were classified as "Poor" due to the 50th percentile values, 0.77 µg/L and 0.79 µg/L respectively, being greater than the ANZG (2018) guideline range of 0.29 – 0.63 µg/L (Table 19 and 20). Chlorophyll a concentration across all three sites exhibited consistent temporal patterns, with SAW2 and SAW7 showing the most similar trends (Figure 8). Over the entire 2021-2024 sampling period, only *Gymnodinoids* showed a positive significant correlation to chlorophyll *a* concentration at sites SAW2 and SAW7, while all other algal groups showed no significant correlation (Appendix B).

Phytoflagellates, Cryptomonads and *Nitzschia* were the most common algal groups across the 2021-2024 sampling period across all three sites, with a maximum Phytoflagellates abundance of 965 cells/mL in September 2021 at BLP Jetty 2 (Table 18). Unicellular green algae were detected at high abundances at SAW2 and SAW7 in March 2024, with the highest abundance of 4850 cells/ml recorded at site SAW2 (Appendix B). Other organisms identified during the monitoring period but in infrequent abundances were *Karenia mikimotoi, Gymnodinoids, Leptocylindrus*, *Dinophysis*, *Guinardia*, Chroomonas and *Gyrodinium* (Appendix B). Only one sample across the 2021-2024 period detected a geosmin producing algal species, the identification of *Phormidium* at BLP Jetty 2 at an abundance of 2 cells/ml (Appendix B). No other toxin or MIB producing algal species were recorded across any of the three sites at Billy Lights Point during the monitoring period.

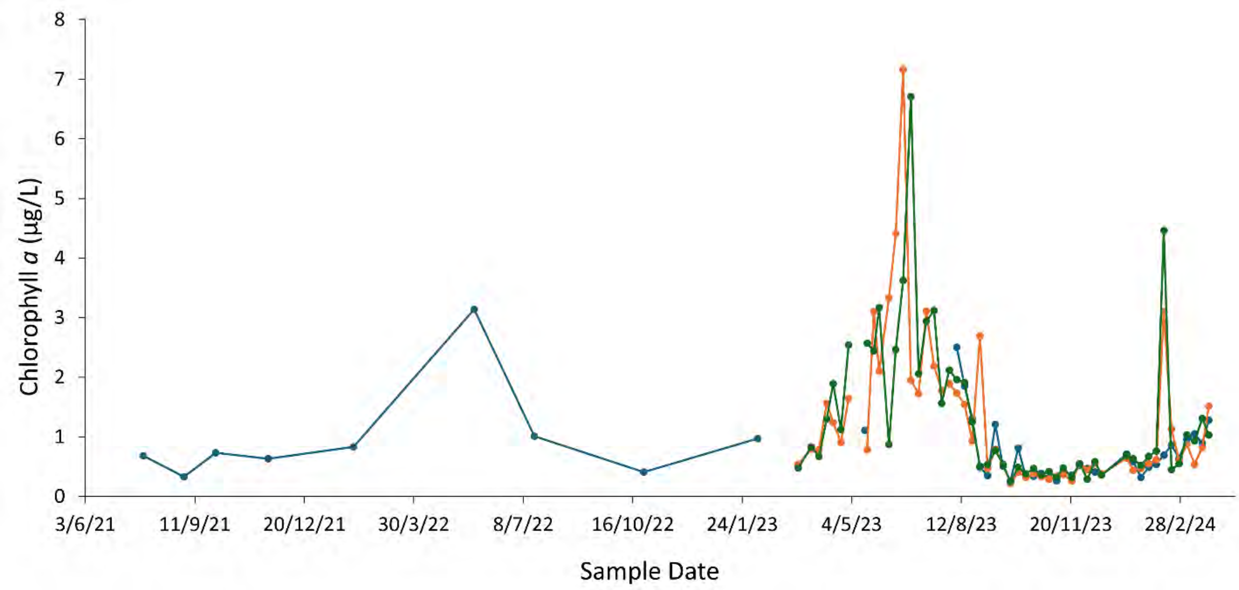


Figure 8. Chlorophyll *a* concentration (µg/L) across seasons during 2021-2024 at sites BLP Jetty 2 (blue line), SAW2 (orange line) and SAW7 (green line).

3.3.2 Microbiology

Indicator microbes were chosen to assess microbiological water quality across all three sites at Billy Lights Point, Port Lincoln, including *Escherichia coli* (*E. coli*) and total coliforms. Both *E. coli* and total coliform counts were highest at site SAW7 at 49 CFU/100mL and 100 CFU/100mL respectively, in June 2023 (Table 20). These values are well below the NHMRC (2008) guideline value of 150 CFU/100mL and therefore are both classified as "Good" based on the EPAs water quality classification of a healthy ecosystem.

4 Discussion

The analysis of water quality data from the three individual sites (BLP Jetty 2, SAW7 and SAW2) highlighted similar trends in physical properties of vertical profiling at Billy Lights Point (Figures 2-4). A stratification of the water column was observed in May 2023 at both SAW7 and SAW2 (Figure 3), where saline water was present on the sea floor. Profiles at BLP Jetty 2 exhibited relatively uniform profiles across the sampling period, apart from November and December 2023 where the presence of higher saline water observed in surface waters, while in February 2022 and 2023 higher saline water was observed at the sea floor (Figure 3). Furthermore, dissolved oxygen stratification was observed at BLP Jetty 2 (February 2022) and SAW2 (April 2023) where lower dissolved oxygen values were present on the sea floor (Figure 4). This occurred at the same profiles that higher saline waters were present at these sites (Figure 3).

The vertical profiling of 106 sites within Boston and Proper Bays allowed for the identification of temporal and spatial changes in physical parameters (Figure 5 – 7). Notably, there is a presence of warm saline water within Proper Bay that establishes during spring (Figure 6). Water temperatures drop into autumn, however the salinity levels in Proper Bay remain elevated and low in Spalding Cove (Figure 6F). Dissolved oxygen is shown to increase in Proper Bay in winter, while levels in spring and summer are higher along the western edge of Boston Bay and the entrance to Spalding Cove (Figure 7).

Most chemical parameters showed consistency between individual sites at Billy Lights Point. However, the maximum lead concentrations were observed to be higher at sites BLP Jetty 2 and SAW7, sites closest to land than at SAW2 (Table 12-14). Copper concentrations were classified as "Moderate" at all three sites, where the 95th percentile values were slightly greater than the guideline values. However, maximum values of copper observed at all three sites were between 2 and 3 times greater than the guideline value (Table 12-14). Total nitrogen and TKN as N concentrations were highest at the BLP Jetty 2 site, almost double the maximum observed at SAW7 and SAW2 (Table 9-11; Appendix B). Concentrations of ammonia were greater at SAW7 and SAW2 compared to BLP Jetty 2 site, where the maximum concentrations were up to 5 times greater (Table 9-11). However, all other sampling periods showed consistency between sites, suggesting further seasonal sampling is required to gain further understanding of seasonal cycles of metal and nutrient concentrations in this area.

The concentration of chlorophyll *a* was classified as "Poor" at sites SAW2 and SAW7, and "Moderate" at BLP Jetty 2 (Table 15-17). Peaks in chlorophyll *a* were observed in June 2023, up to 7.16 µg/L, and in February 2024, up to 4.46 µg/L, both at SAW2 and SAW7 (Figure 8; Appendix B). These observed values were likely a result of elevated levels of the dinoflagellate *Gymnodinoids*, which was recorded at up to 1100 cells/mL in June 2023, showing strong positive correlation with chlorophyll *a* concentration at SAW2 (Appendix B). The highest concentration of chlorophyll *a* at BLP Jetty 2 was 3.14 µg/L on 25th May 2022

(Figure 8), most likely due to high abundances of the diatom *Guinardia* and the dinoflagellate *Gymnodinium* (Appendix B). Furthermore, elevated levels of *Karenia mikimotoi*, *Nitzschia* and phytoflagellates were also observed across the sampling period, some at consistently high levels for months at a time (Appendix B). However, there was no correlation between chlorophyll *a* concentration and any other algal species across 2021-2024 (Appendix B), highlighting the importance of carrying out algal identification and counts in combination with chlorophyll *a* analysis. Concentrations of *E. coli* were consistently higher at sites SAW7 and BLP Jetty 2 due to their closer proximity to the Port Lincoln wastewater treatment plant outfall. All recorded concentrations were below the NHMRC's guideline value of 150 CFU/100mL (Table 15-17), however concentrations at SAW7 exhibited high levels during June 2023 and January 2024, while high levels were observed at BLP Jetty 2 during December 2023 and January 2024.

This report provides the foundations of understanding the temporal and seasonal changes in physical, chemical and biological properties of Billy Lights Point and the wider Boston and Proper Bay regions. Further water quality sampling of the three sites at Billy Lights Point will continue at weekly intervals and this report will be updated accordingly to provide a more detailed understanding of these systems.

5 References

Australian and New Zealand Environment and Conservation Council, ANZECC. 2000. Australian and New Zealand guidelines for fresh and marine water quality. ANZECC and Agriculture and Resource Management Council of Australia and New Zealand, Canberra.

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Gaylard, S. (2009). Ambient water quality of Boston and Proper Bays, Port Lincoln 1997-2008. Environmental Protection Authority, pp 1-49.

National Health and Medical Research Council, NHMRC. 2008. *Guidelines for Managing Risks in Recreational Water*. Australian Government.

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A Appendix A

Figure 9. Vertical water column profiling sampling sites for the whole of bays profiling. A total of 106 sites (green dots) were selected throughout Boston Bay, Proper Bay and Spalding Cove. Sites were sampled at the seasonal scale, see Appendix A, Table 21 for dates.

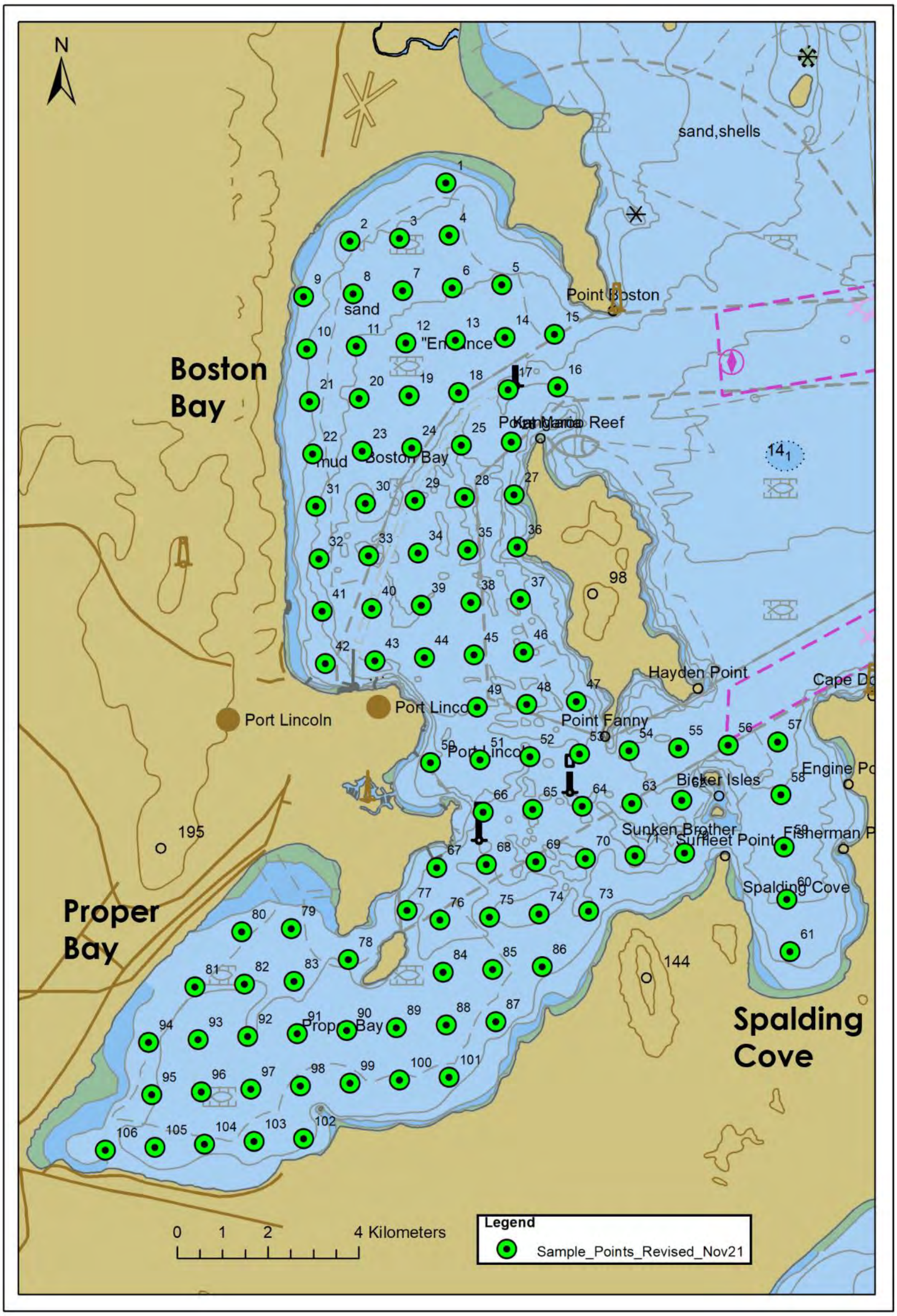

Table 21. Sampling dates for all sites including whole of bays profiling since the start of the water quality program. Initial sampling focussed on the BLP Jetty 2 site and was then expanded to include SAW2 and SAW7. The symbol X denotes the date that water samples were collected and/or analysed from a site.

Sample Date	BLP Jetty 2	SAW2	SAW7	Whole of Bays Profiling
26/07/2021	X			
01/09/2021	X			
30/09/2021	X			X
17/11/2021	X			X
05/12/2021				X
24/01/2022				X
03/02/2022	X			
07/02/2022				X
24/05/2022	X			
25/05/2022				X
18/07/2022	X			
29/07/2022				X
25/10/2022				X
26/10/2022	X			
07/02/2023	X			X
16/03/2023		X	X	
28/03/2023		X	X	
04/04/2023		X	X	
11/04/2023		X	X	
17/04/2023		X	X	
24/04/2023		X	X	
01/05/2023		X	X	
16/05/2023	X			
18/05/2023		X	X	
24/05/2023		X	X	
29/05/2023		X	X	
07/06/2023		X	X	
13/06/2023		X	X	
20/06/2023		X	X	
27/06/2023		X	X	
30/06/2023				X
04/07/2023		X	X	
11/07/2023		X	X	

18/07/2023		X	X	
25/07/2023		X	X	
01/08/2023		X	X	
08/08/2023	X	X	X	
15/08/2023	X	X	X	
22/08/2023	X	X	X	
29/08/2023	X	X	X	
05/09/2023	X	X	X	
12/09/2023	X	X	X	
19/09/2023	X	X	X	X
26/09/2023	X	X	X	
03/10/2023	X	X	X	
10/10/2023	X	X	X	
17/10/2023	X	X	X	
24/10/2023	X	X	X	
31/10/2023	X	X	X	
07/11/2023	X	X	X	
13/11/2023	X	X	X	
21/11/2023	X	X	X	
28/11/2023	X	X	X	
05/12/2023	X	X	X	
12/12/2023	X	X	X	
18/12/2023	X	X	X	
10/01/2024	X	X	X	
15/01/2024				X
16/01/2024	X	X	X	
23/01/2024	X	X	X	
30/01/2024	X	X	X	
06/02/2024	X	X	X	
13/02/2024	X	X	X	
20/02/2024	X	X	X	
27/02/2024	X	X	X	
05/03/2024	X	X	X	
12/03/2024	X	X	X	
19/03/2024	X	X	X	
25/03/2024	X	X	X	

Table 22. Limits of reporting (LOR) for each individual water quality parameter measured at BLP Jetty 2, SAW7 and SAW2 at Billy Lights Point, Port Lincoln. The value represents the minimum concentration that can be accurately measured to determine the quantifiable concentration of the specific test. Note: * represents no specified LOR.

Analyte	LOR
Alkalinity as Calcium Carbonate	*
Bicarbonate	*
Carbonate	*
Hydroxide	*
Aluminium – Total	0.010 mg/L
Ammonia as N	0.005 mg/L
Antimony – Total	0.005 mg/L
Arsenic – Total	0.0003 mg/L
Barium – Total	0.005 mg/L
Beryllium - Total	0.003 mg/L
Boron – Soluble	0.2 mg/L
Bromide	0.025 mg/L
Cadmium – Total	0.001 mg/L
Calcium	0.4 mg/L
Chloride	4.0 mg/L
Chlorophyll *a*	0.1 µg/L
Chromium – Total	0.001 mg/L
Cobalt – Total	0.001 mg/L
Coliforms	*
Conductivity	2.00 µS/cm
Copper – Total	0.001 mg/L
Dissolved Organic Carbon	1.00 mg/L
E. coli	*
Fluoride	0.10 mg/L
Green algae- phytoflagellates	*
Iodide	0.01 mg/L
TRH and TPH C06-C09	10 µg/L
TRH and TPH C10-C14	10 µg/L
TRH and TPH C15-C28	10 µg/L
TRH and TPH C29-C36	80 µg/L

Iron – Total	0.005 mg/L
Lead – Total	0.001 mg/L
Lithium – Total	0.003 mg/L
Magnesium	0.4 mg/L
Manganese – Total	0.001 mg/L
Mercury – Total	0.0003 mg/L
Molybdenum - Total	0.001 mg/L
Nickel – Total	0.001 mg/L
Nitrite + Nitrate as N	0.003 mg/L
Nitrogen – Total	*
pH	*
Phosphorous – Filterable Reactive P	0.003 mg/L
Phosphorous – Total	0.005 mg/L
Potassium	0.4 mg/L
Selenium – Total	0.001 mg/L
Silica – Total	0.05 mg/L
Silver – Total	0.0003 mg/L
Sodium – Total	0.4 mg/L
Strontium – Total	0.001 mg/L
Suspended Solids – Total	1.00 mg/L
Thallium – Total	0.001 mg/L
Tin – Total	0.005 mg/L
Titanium – Total	0.003 mg/L
TKN as Nitrogen	0.05 mg/L
Total Dissolved Solids	1 mg/L
Total Hardness as CaCO3	2.00 mg/L
Total Organic Carbon	1.00 mg/L
Turbidity	0.10 NTU
Uranium – Total	0.001 mg/L
Vanadium – Total	0.001 mg/L
Zinc - Total	0.003 mg/L
1 1 1 2-Tetrachloroethane	1 µg/L
1 1 1-Trichloroethane	1 µg/L
1 1 2 2-Tetrachloroethane	1 µg/L
1 1 2-Trichloroethane	1 µg/L
1 1-Dichloroethane	1 µg/L
1 1-Dichloroethene	1 µg/L

1 1-Dichloropropene	1 µg/L
1 2 3-Trichlorobenzene	1 µg/L
1 2 3-Trichloropropane	1 µg/L
1 2 4-Trichlorobenzene	1 µg/L
1 2 4-Trimethylbenzene	1 µg/L
1 2-Dibromo-3-chloropropane	1 µg/L
1 2-Dibromoethane (EDB)	1 µg/L
1 2-Dichlorobenzene	1 µg/L
1 2-Dichloroethane	1 µg/L
1 2-Dichloropropane	1 µg/L
1 3 5-Trimethylbenzene	1 µg/L
1 3-Dichlorobenzene	1 µg/L
1 3-Dichloropropane	1 µg/L
1 4-Dichlorobenzene	1 µg/L
2 2-Dichloropropane	1 µg/L
2-Butanone (MEK)	1 µg/L
2-Chlorotoluene	1 µg/L
4-Chlorotoluene	1 µg/L
4-Isopropyltoluene	1 µg/L
Benzene	1 µg/L
Bromobenzene	1 µg/L
Bromochloromethane	1 µg/L
Bromodichloromethane	1 µg/L
Bromoform	1 µg/L
Bromomethane	4 µg/L
Carbon Tetrachloride	1 µg/L
Chlorobenzene	1 µg/L
Chloroethane	4 µg/L
Chloroform	1 µg/L
Chloromethane	4 µg/L
cis-1 2-Dichloroethene	1 µg/L
cis-1 3-Dichloropropene	1 µg/L
Dibromochloromethane	1 µg/L
Dibromomethane	1 µg/L
Dichlorodifluoromethane	1 µg/L
Dichloromethane	4 µg/L
Ethylbenzene	1 µg/L
Hexachlorobutadiene	0.7 µg/L

Isopropylbenzene	1 µg/L
m+p Xylene	2 µg/L
Naphthalene	1 µg/L
n-Butylbenzene	1 µg/L
n-Propylbenzene	1 µg/L
o-Xylene	1 µg/L
p-Isopropyltoluene	1 µg/L
Sec-butylbenzene	1 µg/L
Styrene	1 µg/L
Tert-butylbenzene	1 µg/L
Tetrachloroethene	1 µg/L
Toluene	1 µg/L
Total 1 2-dichloroethene	2 µg/L
Total 1 3-dichloropropene	2 µg/L
Trans-1 2-dichloroethene	1 µg/L
Trans-1 3-dichloropropene	1 µg/L
Total Trichlorobenzene	2 µg/L
Total Xylene	3 µg/L
Trichloroethene	1 µg/L
Trichlorofluoromethane	1 µg/L
Trihalomethanes - Total	4 µg/L
Vinyl Chloride	0.3 µg/L

B Appendix B

See attached file "Appendix B – Raw Data.xlsx" for individual data points for all sampling dates and sites.

Appendix N Sediment Sampling and Analysis Report

Eyre Peninsula Sediment Sampling and Analysis Plan Implementation Report

Customer	Acciona
Project	003039
Deliverable	002
Version	00
	22 January 2024

Document Control

Document Identification

Title	Eyre Peninsula Sediment Sampling and Analysis Plan Implementation Report
Project No	003039.000
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Customer	Acciona
Classification	{None}

Author	Jessica Priess, Dr Kathryn Wheatley
Checked By	Dr Darren Richardson
Certified By	
Approved By	
Project Manager	Dr Kathryn Wheatley

Amendment Record

The Amendment Record below records the history and issue status of this document.

Version	Version Date	Distribution	Record
00	22 January 2024	Acciona	Draft Report for Review

Acknowledgement of Country

The project team would like to acknowledge the traditional custodians of the land upon which we operate. We pay our respects to their Elders past, present and emerging.

We acknowledge Aboriginal people as Australia's First Peoples and as the Traditional Owners and custodians of the land and water on which we rely.

We recognise and value the ongoing contribution of Aboriginal people and communities to Australian life and how this enriches us. We embrace the spirit of reconciliation, working towards the equality of outcomes and ensuring an equal voice.

Executive Summary

South Australia Water is proposing to build a desalination plant at Billy Lights Point on the Eyre Peninsula. A sediment sampling and analysis program was conducted to characterise the physical and chemical properties of the sediment in the proposed location, to better understand contaminant status, to support the risk assessment and inform appropriate management measures.

Sediment sampling and analysis of sediment was undertaken following the Sediment Sampling and Analysis Plan (SAP; BMT 2023). Samples were collected using a vibrocorer at 12 locations. Sediment was carbon dated and analysed for contaminants. The results were compared to screening levels in the National Assessment Guidelines for Dredging (NAGD 2009) and the National Environment Protection (Assessment of Site Contamination) Amendment Measure (NEPM) 2013.

The physical properties of sediments were dominated by sand. Most contaminants were not detected at levels above the laboratory limits of reporting, with the exception of most metals and metalloids, tributyltin and two synthetic pyrethroids. The upper 95% confidence limits (95% UCL) of the mean concentration of all analysed metals and metalloids were less than respective NAGD screening levels and investigation values in the NEPM. The tributyltin detected in samples was also below than the NAGD screening level.

The evaluation of laboratory and field QA/QC procedures and assessments indicated that all sampling, sample handling and storage and laboratory analysis was undertaken to a standard providing scientific confidence that the presented results are valid to allow an assessment of sediment quality against the NAGD and NEPM.

Contents

Tables

Figures

1 Introduction

1.1 Background

South Australia Water (SAW) is proposing to build a desalination plant at Billy Lights Point on the Eyre Peninsula. Technical investigations and assessments are required to inform the detailed design of the plant, including the location of the intake and outfall pipes. The data from these investigations and assessments, along with community input, will inform the development application for the project, which will be lodged with the State Planning Commission.

The construction and/or operational phases of the Eyre Peninsula Seawater Desalination Plant (EPDP) Project (Figure 1.1) may involve disturbance and impacts to the seabed (e.g. pipeline placement). Given nearby boatyard and aquaculture uses on land, there may be some contamination in nearby sediments. However, there is no contemporary good quality data to characterise these sediments. Therefore, there is a necessity to characterise the baseline physical and chemical properties of sediments to better understand contaminant status, to support the risk assessment and inform appropriate management measures. As such, Acciona, on behalf of SAW, engaged BMT to undertake an assessment of sediment quality near the proposed location of the Project to address this gap.

A sediment Sampling and Analysis Plan (SAP) was prepared based on requirements and input stipulated by SAW, to facilitate the collection of sediment for the analysis of potential contamination from past and/or current site uses and whether it will significantly impact the proposed use of the site or represent potential public health or environmental risks.

1.2 Aim and Objectives

This report documents the findings of the implementation of the sediment SAP, undertaken in October 2023. The aims of this study are to: (i) characterise the physical and chemical properties of sediments at the proposed desalination plant site and (ii) with reference to relevant guidelines, determine the contaminant status of sediments.

The assessment of physico-chemical sediment properties was undertaken in accordance with the SAP design document (Annex A), which was based on:

- National Assessment Guidelines for Dredging (NAGD; CoA 2009). The methodologies for determining sampling effort, survey design, sampling and analysis set out in NAGD represent best practice for the characterisation of marine sediments.
- National Environment Protection (Assessment of Site Contamination) Amendment Measure (NEPM) 2013. NEPM provides contaminant guideline values for land-based disposal/placement of sediments.
- Australian and New Zealand Government Guidelines for Fresh and Marine Water (ANZG 2018), which provide default sediment guideline values for assessing potential risks to the marine environment. The screening levels set out in NAGD are superseded by the most recent default sediment quality guideline values published in ANZG (2018).

The specific objectives of the study were to:

- Describe and quantify the physical properties of sediments sampled.
- Quantify concentrations of potential contaminants in sediments sampled.

- Compare contaminant concentrations to relevant guidelines to determine whether there is a need for further assessment.

Figure 1.1 Proposed site location for the EPDP at Billy Lights Point, Port Lincoln

2 Methodology

2.1 Compliance with SAP and Guidelines

Sampling and analysis procedures were consistent with NAGD.

Sampling and analysis was undertaken in the approved SAP design document (refer Annex A), except for the following departures:

- Sites 8 and 10 were relocated to avoid interferences with aquaculture cages/nets. The closest suitable site was chosen.
- Site 12 was added to fill a knowledge gap on sediments in this area.
- For other sites, the position for sampling varied from original positions due to ground surface composition and/or interferences which were unknown until the sampling was being undertaken.

2.2 Sampling Timing

Sediment sampling was conducted on the 31st of October 2023, during daylight hours.

2.3 Sampling Locations

A global positioning system (GPS) was used to locate the proposed sediment sampling sites, and the 'actual' location of each site was recorded on the GPS to mark and confirm the sampled location.

Twelve (12) sediment core samples were collected from the proposed Project area (see Figure 2.1), including Quality Assurance/ Quality Control (QA/QC) samples, in accordance with the SAP design document (see Annex A). The site identification, coordinates, and QA/QC samples are provided in Table 2.1.

Title:
Locations of sediment sampling sites

Figure: 2.1

Rev: A

BMT endeavours to ensure that the information provided in this map is correct at the time of publication. BMT does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

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Figure 2.1 Locations of sediment sampling sites

Table 2.1 Sediment sampling locations

Site ID	Latitude	Longitude	Field QA/QC
EPW1	34.75548° S	135.88727° E	
EPW2	34.74728° S	135.89772° E	
EPW3	34.74601° S	135.89585° E	
EPW4	34.74581° S	135.89996° E	
EPW5	34.74917° S	135.89445° E	Rinsate (sampling equipment)
EPW6	34.74929° S	135.89674° E	
EPW7	34.75236° S	135.89271° E	Field split
EPW8	34.75419° S	135.88710° E	
EPW9	34.75316° S	135.88710° E	Carbon Dating
EPW10	34.75404° S	135.89021° E	
EPW11	34.75362° S	135.88851° E	
EPW12	34.74314° S	135.88564° E	Rinsate (coring equipment)

2.4 Sample Collection and Handling

2.4.1 Survey Vessel, Equipment and Personnel

Sediment samples were collected using a vibrocorer. The core tubes were aluminium with an outer diameter of 76.2 mm, a tube thickness of 2.09 mm, and were 3.66 m long. Each core tube was used once and then recycled for other uses. Each sample was taken to core refusal, which varied between sites (see Section 3.1.1). All sediment sampling was undertaken by the Aquatic Biosecurity Pty Ltd team, and then transferred to the BMT team onshore for processing at SAW facilities.

2.4.2 Sample Collection, Handling and Storage

Photographs of the samples were taken, and samples were logged for their physical characteristics and variation in sediment type and texture (Annex B), including the following information:

- Sediment colour
- Odour (e.g. marine, sulphurous)
- Field texture
- Qualitative description of particle size (fine, fine silt, sand, clay, clayey sand, soil clay, loamy clay)
- Plasticity/consistency
- Estimated % stones
- Presence of shell/shell grit

Each sample was homogenised in a clean container, except for samples to be analysed for volatile organic compounds, prior to filling laboratory supplied jars. Powder free nitrile gloves were worn by all field personnel handling samples, and gloves were disposed after processing each sample.

Sample jars were labelled with a waterproof marker pen on the jar label and lid. Sample jars for organic analyses were filled with zero headspace to minimise volatilisation. All jars were chilled on ice bricks immediately following sample collection. Samples were sent away for analysis on the 1st November 2023. All samples were submitted to the primary (Envirolab) and secondary (ALS) analytical laboratories, including Chain of Custody (CoC) documentation.

During the processing of samples, there were difficulties extracting the core sample obtained from Site 8. Partial extraction occurred on the day of sampling (labelled EPW8). Additional methods (angle grinder to cut core tube) were required to extract the remainder of the sample the following day (~12 hrs later). The top ~2 cm of sediment was removed and disposed of to minimise potential contamination of the sample. The second part of the core (labelled EP8WA) was potentially compromised by sediment compression and cross contamination (e.g. aluminium fragments).

2.4.3 Sample Collection, Handling and Storage (Carbon Dating)

As per guidance from SAW on sub-sampling methods for carbon dating, the core (EPW9) was sub-sampled by slicing ~1 cm thick horizons for the top 20 cm and then 4 cm slices below 20 cm with testing of every 4th layer after 20 cm.

Powder free nitrile gloves were worn by all field personnel handling the samples, and gloves were disposed of after processing the sample. Sample jars were labelled with a waterproof marker pen on the jar label and lid.

Samples were sent to ANSTO for radiocarbon dating.

2.5 Laboratory Analysis

2.5.1 Analytical Tests

Samples were analysed for the following contaminants, as listed in the SAP (Annex A):

- Particle size distribution
- Total organic carbon (TOC)
- Recoverable metal and metalloids (aluminium, antimony, arsenic, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, nickel, selenium, silver, vanadium and zinc)
- Tributyltin (TBT)
- Cyanide (total, low level)
- Nutrient suite
- Volatile and semi-volatile organic compounds
- Total recoverable hydrocarbons (TRHs)
- Benzene, Toluene and Ethylbenzene (BTEX)
- Polycyclic aromatic hydrocarbons (PAHs)
- Pesticides, Herbicides and Chlorinated Organics
- Phenoxy Acid Herbicides
- Praziquantel

For further information on the justification for testing for each analyte and laboratory methods, refer to the SAP (Annex A).

The bulk organics of the sediments were also carbon dated (% modern carbon).

2.5.2 Laboratory QA/QC

The laboratory services used for analysis were Envirolab and ALS, which are National Association of Testing Authorities (NATA) accredited and experienced in the chemical analysis of marine sediments.

As part of the NATA requirements and in accordance with the NAGD (CoA 2009), the laboratories incorporate a range of QA/QC methods to ensure accuracy of data. This includes the analysis of internal QA/QC samples and described in Table 2.2.

Table 2.2 Laboratory QA/QC details

Laboratory QA/QC Sample	Details
Laboratory/Method Blank	Laboratory blanks are samples submitted by the laboratory during sample analysis to assist in identifying any cross contamination during laboratory preparation, extraction or analysis. Analysis of laboratory blank samples should result in concentrations not exceeding the detection limit for a particular contaminant.
Laboratory Standard (Control)	Standard samples are sediments of known composition that are included in each batch as a check on analysis accuracy.
Laboratory Duplicates	The precision of analysis performed by the laboratory is determined by the calculation of the relative percent difference (RPD). The RPD is calculated based on a comparison of an intra-laboratory split of the sample material with results representing the percent difference between the two sample concentrations for a specific contaminant.
Laboratory Spike	Surrogate spikes are known additions to each sample compounds similar in composition to the target analyte but are not likely to be present within the environment. Samples are spiked with the surrogate material and a calculation of the per cent recovery of the spiked amount against the returned concentration is performed. The percent recovery result provides an indication of the ability of the laboratory to extract a specified contaminant type from the sample matrix. Typically, surrogate spikes are performed only on organic compounds. Matrix spikes are undertaken by the laboratory to identify the amount of interference from the sample matrix on contaminant recovery. Samples collected from the field are split from the base sample and spiked with a known contaminant concentration. The percent recovery of the contaminant is then calculated.

2.6 Field QA/QC

2.6.1 QA/QC Samples

In accordance with NAGD requirements and based on the number of sample locations, the following field and laboratory quality control samples were taken:

- Two rinsate samples (one during collection and one during processing) to assess whether the decontamination process has been adequately undertaken and there are no residual contaminants from previous sampling.
- One trip blank sample, laboratory prepared to provide an indication of cross contamination from volatile substances during field sampling.
- One trip spike sample, laboratory prepared to provide an indication of potential loss of volatile compounds during transport.
- One field split sample (sample from 5% of locations thoroughly mixed and split into two sample container sets) to assess laboratory variation, with one of the samples sent to a second (reference) laboratory for analysis. Split samples were obtained at one location EC7 (see Table 2.1).

There were a couple of variations from standard field QA/QC procedures:

- Trip blank and trip spike samples did not arrive until the day after sampling was complete, so were not included in the field QA/QC assessment.
- For field split samples, typically sediments are split into three sample containers set to assess laboratory variation (two to primary laboratory and one to secondary laboratory), but there was insufficient volume in the core sample; therefore, only one sample was sent to the primary laboratory for analysis.

2.6.2 QA/QC Assessment

For each of the analytes of the split sample, the relative percentage difference (RPD) of the sample from the primary lab and the secondary laboratory sample (i.e. inter-laboratory variation) was calculated as:

$$RPD = \frac{Primary\ Sample - Duplicate\ Sample}{Average\ of\ Primary\ and\ Duplicate\ Samples}$$

Generally, if RPDs are less than 35% then field, inter-laboratory procedures are considered of acceptable quality and meaningful conclusions can be drawn from the data. If the RPD for a measured analyte fell outside this limit, the value of the measured analyte was flagged as an estimate rather than a precise value (CoA 2009).

2.7 Data Analysis

2.7.1 Normalisation of Organics

Organic contaminant results were normalised to 1% TOC where the measured value is within the range of 0.2-10%. If TOC values were outside of this range, the highest (10%) or lowest (0.2%) value was adopted as appropriate. Organic parameters with concentrations below the Limit of Reporting (LOR) were not normalised to 1% TOC but were included at half their LOR.

2.7.2 NAGD Phase II - Comparison to NAGD Screening Levels

Concentrations of contaminants measured in sediment samples were compared to screening levels listed in Table 2 of the NAGD, or ANZG (2018) where updated sediment quality guidelines were available (i.e. total PCBs, DDD, DDE, Total DDT, dieldrin, endrin, lindane, chlordane, Total TPHs).

The assessment against NAGD criteria involves the comparison of mean concentrations at the upper 95% confidence level (95% UCL) of the mean to the NAGD screening levels. ProUCL Version 5.2.0 was used to calculate the 95% UCL. LORs used by the primary laboratory (ALS) were below relevant Practical Quantitation Limits (PQLs) for all parameters (as per NAGD). Analytical values below the laboratory LOR were set to one-half of the LOR as per NAGD recommendation to facilitate 95% UCL calculation. This was only undertaken where there was greater than 25% detections of the chemical parameter in the proposed dredge area i.e. the 95% UCL was not calculated for areas where the required minimum number of detections were not met. This was because bias can be introduced if a large proportion of data are below the LOR, leading to underestimation of contamination at certain sites. Where there were not enough samples (with detections) to complete the calculations, the individual site concentrations were compared to the relevant screening levels.

One assumption in the calculation of the 95% UCL is that the samples are statistically independent. Therefore, field split samples were averaged in the 95% UCL calculation.

2.7.3 National Environmental Protection Measures (NEPM)

In the event sediment may be disposed to land, bulk sediment results were compared to relevant investigation levels provided in Schedule B2 of the NEPM (2014).

3 Results

3.1 Core Details

3.1.1 Sample Retention

Table 3.1 shows the estimated length of each core sample upon collection, compared to the length of the sample upon processing and the strata collected for each sample.

Table 3.1 Sample Retention

Site	Estimated Length (cm)	Length Sampled (cm)	Strata Collected
EPW1	99	100	0.0-0.5, 0.5-1.0
EPW2	83	50	0.0-0.5
EPW3	93	90	0.0-0.5, 0.5-1.0
EPW4	43	50	0.0-0.5
EPW5	60	50	0.0-0.5
EPW6	97	90	0.0-0.5, 0.5-1.0
EPW7	163	150	0.0-0.5, 0.5-1.0, 1.0-1.5
EPW8	221	0.65	0.0-0.5, 0.5-1.0
EPW8A*		0.8	1.0-1.5, 1.5-2.0
EPW9^	105	124	-
EPW10	80	90	0.0-0.5, 0.5-1.0
EPW11	153	163	0.0-0.5, 0.5-1.0, 1.0-1.5
EPW12	63	70	0.0-0.5

***Site EPW8 refer to Section 2.4.2.**
^Site EPW9 was used for carbon dating analysis, therefore no strata were sampled for other analyses.

3.1.2 Description of samples

Samples were processed on land at the SA Water facility. Each sample was assessed for colour, odour, texture, composition, and the percentage of stones, organic matter, or shell. The findings are outlined in Table B.1. (Annex B). Many of the samples consisted of green/grey sand with shell fragments.

3.1.3 Particle size distribution

The sediment gain particle size distribution (PSD) results for each sub-sample are presented in Figure 3.1. Sand fractions generally dominated, ranging from 47% to 100%, with a mean of 75.9% ± 16.8% standard deviation. Fines (clay and silt) made up a smaller percentage of the PSD ranging from 0 – 27% (mean = 5.8% ± 7.2% standard deviation). Coarse fractions (>2 mm) were present in all but one sample, comprising 0 – 43% of sample mass (mean = 12.5% ± 9.9% standard deviation).

The 0.0-0.5 m stratum typically had a higher proportion of sand than deeper layers at most sites (Figure 3.1).

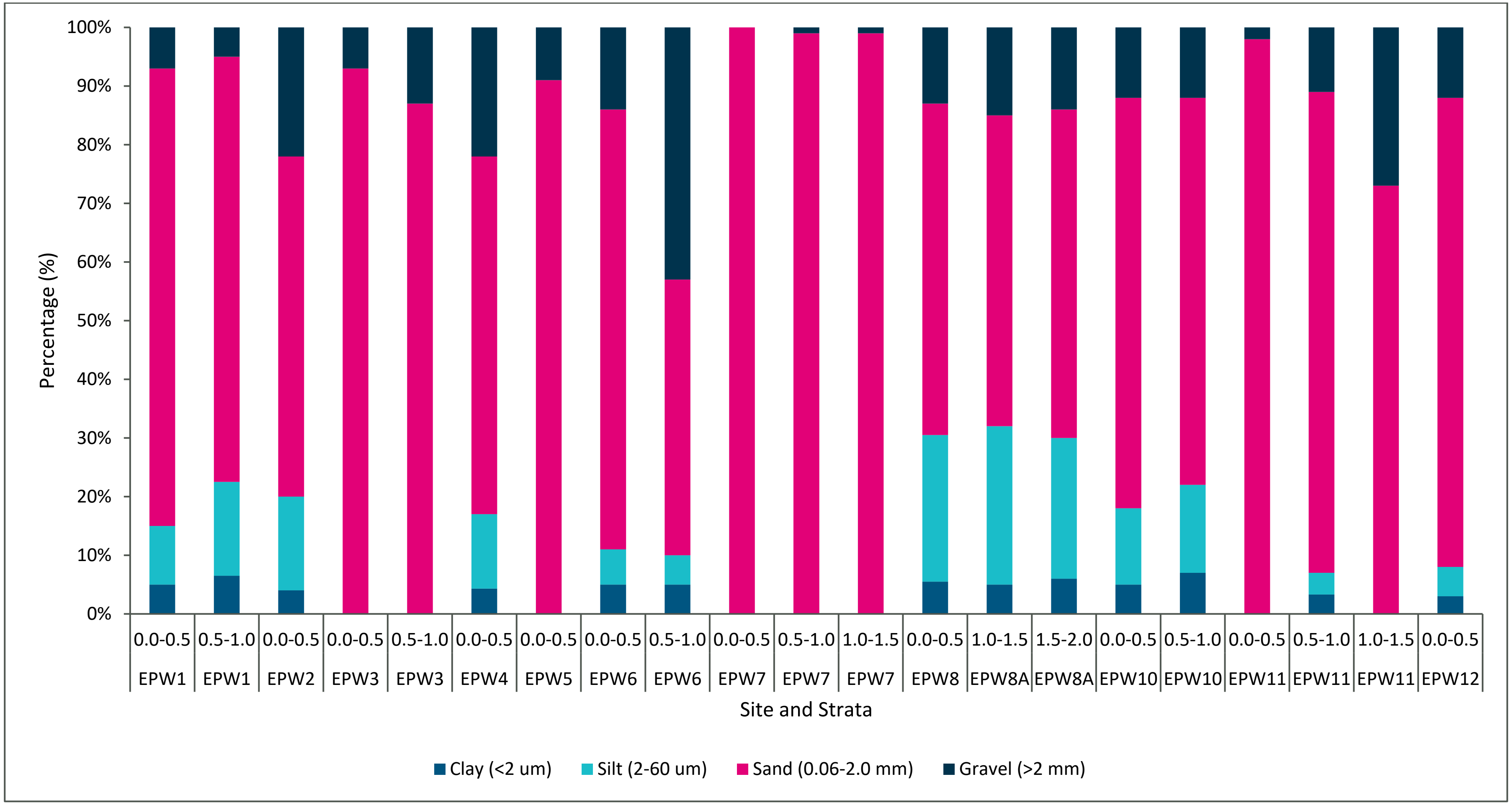

Figure 3.1 Particle size distribution of sediments sampled at each site and sub-sample

***Note: strata EPW8 (0.5-1.0) did not have sufficient sample size for PSD analysis**

3.2 Metal and Metalloids

Metal and metalloid concentrations from the sample sites were compared to ANZG (2018) default sediment quality guideline values and NEPM investigation levels (health-based investigation levels for commercial and industrial areas (HIL-D)), and results are provided in Table 3.2. Most metals and metalloids were detected in all samples. Silver was the only metal not detected in any sample. For many sites the concentration of metals/metalloids were below the limit of reporting (LOR).

All metals/metalloids except arsenic had concentrations less than NAGD screening levels. Arsenic exceeded the NAGD screening level (20 mg/kg) in only one sample (Site EPW12 at 38 mg/kg). The 95% UCL for arsenic in all samples was 13.2 mg/kg, which was below the NAGD screening level of 20 mg/kg. On this basis, no further assessment of arsenic is required with respect to NAGD requirements. All metals/metalloids were below NEPM screening levels.

3.3 Nutrient Content

No screening levels exist for nutrients in the NAGD or NEPM.

- TKN concentrations ranged from 450 mg/kg to 2900 mg/kg, with a mean concentration of 1269 mg/kg. The highest concentrations were recorded in the lower strata of EPW8 (i.e. EPW8A; see Section 2.4 for details).
- Ammonia concentrations were above the laboratory LOR in all but four samples, with the concentrations ranging between 0.52 mg/kg to 5.6 mg/kg and the average concentration of 2.08 mg/kg.
- The nitrite and nitrate concentrations (NOx) were below the laboratory LOR in all samples.

Table 3.2 Metal and metalloid concentrations in sediments from sampling sites

Metal		Aluminium	Antimony	Arsenic	Cadmium	Chromium	Cobalt	Copper	Iron	Lead	Manganese	Mercury	Nickel	Selenium	Silver	Vanadium	Zinc
Unit		mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
LOR		1.0	0.5	1.0	0.1	1.0	0.5	1.0	1.0	1.0	1.0	0.01	1.0	0.1	0.1	0.5	1.0
NAGD Screening***		-	2	20	1.5	80	-	65	-	50	-	0.15	21	-	1	-	200
NAGD High		-	25	-	10	370	-	270	-	220	-	1	52	-	3.7	-	410
NEPM**		-	-	3,000	900	3,600	4,000	240,000	-	1,500	60,000	730	6,000	10,000	-	-	400,000
Site	Depth (m)																
EPW1	0.0-0.5	170	<0.50	9.9	0.10	33	<0.50	1.9	270	1.6	14	0.012	4.9	0.65	<0.10	23	3.4
EPW1	0.5-1.0	190	0.58	12	0.10	35	<0.50	1.6	280	1.6	14	<0.010	5.5	0.74	<0.10	27	2.3
EPW2	0.0-0.5	120	<0.50	5.5	<0.10	22	<0.50	4.0	210	2.9	9.6	0.022	3.1	0.36	<0.10	13	9.9
EPW3	0.0-0.5	27	<0.50	6.5	<0.10	20	<0.50	0.63	100	0.95	12	<0.010	0.59	0.13	<0.10	15	1.8
EPW3	0.5-1.0	20	<0.50	6.3	<0.10	17	<0.50	<0.50	77	0.59	12	<0.010	0.71	0.26	<0.10	13	0.77
EPW4	0.0-0.5	130	<0.50	8.7	<0.10	22	<0.50	1.6	230	1.5	8.4	<0.010	3.7	0.55	<0.10	18	22
EPW5	0.0-0.5	49	<0.50	15	<0.10	33	<0.50	2.2	230	1.5	14	<0.010	1.1	0.25	<0.10	30	4.3
EPW6	0.0-0.5	86	<0.50	9.8	<0.10	21	<0.50	1.8	210	1.9	8.9	0.014	2.6	0.42	<0.10	16	4.6
EPW6	0.5-1.0	64	0.67	9.5	<0.10	15	<0.50	0.79	170	0.92	8.3	<0.010	2.3	0.49	<0.10	15	1.4
EPW7	0.0-0.5	51	<0.50	5.3	<0.10	15	<0.50	4.3	100	1.3	11	<0.010	0.95	0.14	<0.10	7.7	6.3
EPW7	0.5-1.0	45	<0.50	6.0	<0.10	15	<0.50	1.1	110	1.0	10	<0.010	1.0	0.18	<0.10	9.1	3.2
EPW7	1.0-1.5	42	<0.50	7.5	<0.10	15	<0.50	<0.50	100	0.70	11	<0.010	0.86	0.17	<0.10	7.3	0.73
EPW8	0.0-0.5	250	0.53	12	<0.10	29	0.61	2.1	350	2.0	16	<0.010	6.6	0.84	<0.10	29	3.9
EPW8	0.5-1.0	220	0.57	11	<0.10	30	0.55	2.0	330	1.8	12	<0.010	6.5	0.87	<0.10	29	2.7
EP8WA*	1.0-1.5	180	0.51	11	<0.10	30	<0.50	2.2	300	1.8	9.8	<0.010	5.3	0.78	<0.10	26	3.5
EP8WA*	1.5-2.0	230	0.54	11	0.10	36	0.57	2.0	350	1.9	11	<0.010	6.5	0.89	<0.10	30	2.7
EPW10	0.0-0.5	170	<0.50	9.7	<0.10	30	0.53	4.2	290	2.5	12	0.014	4.8	0.70	<0.10	22	9.0
EPW10	0.5-1.0	240	<0.50	13	0.12	43	0.65	2.4	400	2.2	13	<0.010	7.4	0.94	<0.10	35	3.2
EPW11	0.0-0.5	55	<0.50	9.6	<0.10	24	<0.50	1.2	170	1.4	14	<0.010	1.3	0.22	<0.10	14	3.8
EPW11	0.5-1.0	49	<0.50	9.3	<0.10	24	<0.50	0.50	180	1.1	14	<0.010	1.1	0.19	<0.10	14	1.4
EPW11	1.0-1.5	39	<0.50	11	<0.10	19	<0.50	<0.50	140	0.85	12	<0.010	1.0	0.23	<0.10	12	1.0
EPW12	0.0-0.5	81	0.70	38	<0.10	52	<0.50	1.4	700	2.4	9.3	0.026	1.4	0.26	<0.10	69	5.1
Mean		114	0.59	10.8	0.11	26.36	0.58	1.9	240.7	1.56	11.65	0.018	3.15	0.46	-	21.55	4.4
95% UCL		142.6	NC	13.21	NC	29.96	NC	2.44	291.8	1.79	12.43	NC	4.01	0.57	NC	26.46	6.24

*Site EPW8 was separated into two sampling batches (see Section 2.4).
**Investigation values taken from National Environment Protection Measures (NEPM)
Yellow shading = concentration > screening level; NC = not calculated due to <25% detections
***equivalent to ANZG (2018)

3.4 Total Petroleum and Total Recoverable Hydrocarbons (TPH and TRH)

Total Recoverable Hydrocarbons (TRHs) measures the amount of hydrocarbons that can be recovered from a sample. These provide context on potential petroleum sources (AST 2019). Significant contributions can also come from non-petroleum sources such as fatty acids and cholesterols from sewage, or humic substances from plant material. All samples were analysed for TPH and TRH.

There were no detectable concentrations of TPH/TRHs withing any of the carbon fractions (semi-volatile/volatile). On this basis, no further assessment of TRHs is required with respect to NAGD requirements.

3.5 Volatile and Semi-volatile Organic Compounds

All volatile and semi-volatile organic compound concentrations were below the LOR in all samples.

3.6 Benzene, Toluene, Ethylbenzene and Xylenes (BTEX)

Concentrations of BTEX compounds were below the LOR in all samples. On this basis, no further assessment of BTEX is required with respect to NAGD requirements.

3.7 Polyaromatic Hydrocarbons (PAHs)

Concentrations of PAHs were below the LOR in all samples. On this basis, not further assessment of PAHs is required with respect to NAGD requirements.

3.8 Tributyltin (TBT)

Concentrations of Tributyltin (TBT) were detected in only five samples, but the concentrations (normalised to 1% TOC) were below the screening level of 9 µg Sn/kg in all samples (Table 3.3). On this basis, no further assessment of organotins is required with respect to NAGD requirements. Other organotins (e.g. monobutyltin (MBT) and dibutyltin (DBT)) were not assessed.

Table 3.3 Summary of organic carbon and TBT (normalised to 1% TOC) for all sample sites and sub-samples

Site	Strata	TOC (%)	TBT (µg Sn/kg)*
LOR		0.010	0.5
NAGD		-	9
EPW1	0.0-0.5	1.1	<4.0^
EPW1	0.5-1.0	1.2	<0.5
EPW2	0.0-0.5	0.99	1.71
EPW3	0.0-0.5	0.15	<0.5
EPW3	0.5-1.0	0.13	<0.5
EPW4	0.0-0.5	0.86	<0.5
EPW5	0.0-0.5	0.43	2.30
EPW6	0.0-0.5	0.67	<2.5^
EPW6	0.5-1.0	0.74	<0.5
EPW7	0.0-0.5	0.97	4.12

Site	Strata	TOC (%)	TBT (µg Sn/kg)*
EPW7	0.5-1.0	0.41	<2.5^
EPW7	1.0-1.5	0.23	<0.5
EPW8	0.0-0.5	1.7	<0.5
EPW8	0.5-1.0	0.32	<0.5
EPW8A	1.0-1.5	1.6	<4.0^
EPW8A	1.5-2.0	1.6	<0.5
EPW10	0.0-0.5	1.3	1.92
EPW10	0.5-1.0	1.7	<0.5
EPW11	0.0-0.5	0.34	<0.5
EPW11	0.5-1.0	0.26	<0.5
EPW11	1.0-1.5	0.24	3.04
EPW12	0.0-0.5	0.6	<0.5
Mean	-	-	NC
95% UCL	-	-	NC

^ LOR has been raised due to matrix interference

NC = not calculated due to <25% detections

*concentration normalised to 1% TOC as per NAGD

3.9 Organochlorine Pesticides (OCPs)

Concentrations of all OCPs were below the LOR in all samples. Therefore, no further assessment of OCPs is required with respect to NAGD requirements.

3.10 Organophosphorus Pesticides (OPPs)

Concentrations of all OPPs were below the LOR in all samples. Therefore, no further assessment of OCPs is required with respect to NAGD requirements.

3.11 Carbamates

Concentrations of all carbamates were below the LOR in all samples.

3.12 Polychlorinated Biphenyls (PCBs)

Total PCB concentrations were below the LOR in all samples. Therefore, no further assessment of OCPs is required with respect to NAGD requirements.

3.13 Phenols

All phenols were below the LOR in all samples.

3.14 Synthetic Pyrethroids

Synthetic pyrethroid concentrations were below the LOR in all samples except EPW4 which had a concentration of 15 µg/kg of bifenthrin and 14 µg/kg of lamda-cyhalothrin. There are no default sediment quality guideline values/screening levels for these parameters.

3.15 Phenoxy Acid Herbicides

Phenoxy acid herbicide concentrations were below the LOR in all samples.

3.16 Triazine Herbicides

Triazine herbicide concentrations were below the LOR in all samples.

3.17 Cyanide

Total cyanide concentrations were below the LOR in all samples.

3.18 Praziquantel

Praziquantel concentrations were below the LOR in all samples indicating there was no praziquantel accumulation in the sediment near the proposed EPDP site.

3.19 Carbon Dating

Awaiting results of carbon dating.

4 Data Validation

4.1 Laboratory QA/QC

Details of the laboratory QA/QC for the primary and secondary laboratories are provided in Annex C. A summary of this assessment is provided in the following sections. Refer to Section 2.5.2 for a description of laboratory QA/QC procedures.

4.1.1 Limits of Reporting (LOR)

LORs used by the primary laboratory (Envirolab) were below relevant PQLs for all parameters (as per NAGD).

4.1.2 Sample Holding Times and Storage Conditions

All samples were received by the laboratories in appropriately pre-treated and preserved containers. Samples were chilled with icepacks whilst in the field and during delivery (ice packs and refrigerated transport). All analyses were undertaken by the laboratories within recommended holding times.

For the analysis of praziquantel, the sub-contracting laboratory did not provide analysis and/or preparation and/or sample receipt dates. The date the samples were received at the sub-contracting laboratory have been used to assess holding times.

4.1.3 Laboratory Blanks

No laboratory blank outliers occurred. Measurements of laboratory blanks for the chemical analyses were always below the LOR of the specific analysis method in the primary and secondary laboratories. This indicates that samples were not contaminated during laboratory analysis.

4.1.4 Laboratory Duplicates

Results indicate that the laboratory duplicate assessment was generally within the acceptable criteria with the exception of:

- BEK0531-DUP1 & DUP3 - copper and selenium in sediment. The laboratory duplicate RPD acceptance criteria was exceeded with sample heterogeneity suspected.
- EPW11 (0.0-0.5) - zinc in sediment. The laboratory duplicate RPD acceptance criteria was exceeded with sample heterogeneity suspected.
- BEK0511-DUP2 - nickel in water (rinsate). Duplicate %RPD may be flagged as an outlier to routine laboratory acceptance.

The laboratory duplicate RPD acceptance criteria was exceeded with sample heterogeneity suspected. Although exceeding RPD criteria, the primary concentration for this parameter is below the respective NAGD screening criteria therefore this result is not considered to impact data quality.

4.1.5 Surrogate and Matrix Spikes

The assessment of surrogate and matrix spike recoveries was satisfactory for most samples. The exceptions were:

- EPW8A (1.5-2.0) - total cyanide: spike recovery is outside routine acceptance criteria (70-130%).
- EPW5 (0.0-0.5) - ammonia as N: spike recovery is outside routine acceptance criteria (70-130%).
- BEK0531-MS1 - aluminium and iron: spike recovery is not applicable due to the relatively high analyte background in the sample.
- EPW2 (0.0-0.5) – iron: spike recovery is not applicable due to the relatively high analyte background in the sample.
- BEK0495-MS1, PEK0250-02, PEK0250-24 - o-Terphenyl: Surrogate recovery is outside routine acceptance criteria (60-140%) as a result of the high concentration of analyte(s) in the sample.
- EPW5 (0.0-0.5) - 2-Chlorophenol-D4; aldrin; 2,4-D; MCPA. Spike and surrogate recovery is outside routine acceptance criteria (60-140%).
- EPW8A (1.5-2.0) – 2,4,5-T; 2,4-D; MCPA. Spike recovery is outside routine acceptance criteria (60-140%).

Recoveries less than the lower data quality objectives indicated there may be matrix interferences that may be attributed to sample heterogeneity. However, as method blanks were less than the laboratory LORs for the respective parameters these exceedances do not impact data quality.

4.2 Field QA/QC

4.2.1 Field Trip Blank and Trip Spike

Due to issues with delivery times this was not achieved, see Section 2.6.1for further information.

4.2.2 Field Rinsate Samples

Rinsate samples were collected in the field to assess the effectiveness of decontamination procedures. All analytes were below the LOR for both rinsate samples with the exception of zinc, which was present at 5.7 µg/L for Site EPW5 only (Table 4.1). Given the very low levels of contaminants found throughout the sampling area, this is not considered to have affected the validity of the results.

Table 4.1 Rinsate results

Analyte	Unit	LOR	Rinsate 1 (EPW5)	Rinsate 2 (EPW12)
Silver	µg/L	1.0	<1.0	<1.0
Aluminium	µg/L	10	<10	<10
Arsenic	µg/L	1.0	<1.0	<1.0
Cadmium	µg/L	0.10	<0.10	<0.10
Cobalt	µg/L	1.0	<1.0	<1.0
Chromium	µg/L	1.0	<1.0	<1.0
Copper	µg/L	1.0	<1.0	<1.0
Iron	µg/L	10	<10	<10

Analyte	Unit	LOR	Rinsate 1 (EPW5)	Rinsate 2 (EPW12)
Mercury	µg/L	0.050	<0.050	<0.050
Manganese	µg/L	1.0	<1.0	<1.0
Nickel	µg/L	1.0	<1.0	<1.0
Lead	µg/L	1.0	<1.0	<1.0
Antimony	µg/L	1.0	<1.0	<1.0
Selenium	µg/L	1.0	<1.0	<1.0
Vanadium	µg/L	1.0	<1.0	<1.0
Zinc	µg/L	1.0	5.7	<1.0
TBT	µg/L	0.0020	<0.0020	<0.0020

Legend

Value exceeds LOR

4.2.3 Field Split Samples

Analyses of field split was generally within the 35% NAGD criterion for RPDs for most analytes, the exceptions are outlined in Table 4.2. Differences may reflect a problem with laboratory performance, especially with aluminium and iron. However, given the relatively low levels of these analytes in all sediment samples, results indicate that the analysis provides a suitable basis for assessment of sediment quality against the NAGD and NEPM guidelines.

Table 4.2 Comparison of analytes in the field split sample. Only analytes that exceeded the acceptable range are presented

Analyte	EPW7 (0.0-0.5) (Envirolab)	EPW7 (0.0-0.5) (ALS)	RPD (%)
TOC	0.5	0.97	63.9
Aluminium	51	980	180.2
Iron	100	1870	179.7
Selenium	0.14	0.2	35.3
TKN	620	420	38.4

5 Discussion

Key findings of the study are as follows:

- Sediments were dominated by sand and gravel fractions.
- Most metals and metalloids were detected in all samples. Silver was the only metal not detected in any sample. Mean concentrations and 95% UCL of the mean for detected metals and metalloids across all sites and sub-samples were below their respective NAGD screening levels.
- There were detections of the organotin TBT in five samples. All were below the NAGD screening level.
- All other analytes analysed were below LOR for all samples except EPW4 (0.0-0.5) which had low level concentrations of two synthetic pyrethroids (bifenthrin and lamda-cyhalothri).

6 References

[AST] Analytical Services Tasmania (2019). Analytical Services Tasmania gains NATA Accreditation for TRH analysis (INFO19V1.2 AST - TRH TPH and NEPM.docx).

[CoA] Commonwealth of Australia (2009). National Assessment Guidelines for Dredging (NAGD): Department of the Environmental, Water, Heritage and the Arts, Canberra.

[NEPM] National Environment Protection (Assessment of Site Contamination) Measure 1999 (April 2013). Schedule B1 Guidelines on Investigation levels for Soil and Groundwater, NEPC 2013, Canberra.

Annex A Eyre Peninsula Sediment Sampling and Analysis Plan Design Report

Eyre Peninsula Sediment Sampling and Analysis Plan Design Report

Customer	Acciona
Project	003039
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Amendment Record

The Amendment Record below records the history and issue status of this document.

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Contents

Tables

Figures

1 Introduction

1.1 Background

South Australia Water (SAW) is proposing to build a desalination plant at Billy Lights Point on the Eyre Peninsula. Billy Lights Point is the preferred location because it offers the quickest solution to ensuring long-term water security for the region. Further scientific investigations and assessments will inform the detailed design of the plant, including the location of the intake and outfall pipes. The data from these investigations and assessments, along with community input, will inform the development application for the project, which will be lodged with the State Planning Commission.

Acciona on behalf of SAW has engaged BMT to undertake an assessment of sediment quality near the location for the proposed Erye Peninsula Seawater Desalination Plant (EPDP) Project (Figure 1.1).

Figure 1.1 Proposed location for the EPDP Project

1.2 Sediment Sampling and Analysis Plan (SAP) Objectives

The aim of this Sediment Sampling and Analysis Plan (SAP) is to provide a set of procedures that will allow a statistically valid evaluation of the baseline physical and chemical properties of sediments in relation to the proposed location of the EPDP Project. The results of this assessment will provide important information on the baseline conditions that will support development applications and approvals from relevant agencies (e.g. Environment Protection Authority).

The assessment of physico-chemical sediment properties will be undertaken based on the approaches set out in the:

- National Assessment Guidelines for Dredging 2009 (NAGD) (CoA 2009)
- National Environment Protection (Assessment of Site Contamination) Measure 1999 (NEPM) (including Amendment measure 2013).
- EPA Standard for the Production and use of Waste Derived Fill 2013 (WDF Standard)

The specific objectives of this SAP are to:

- Identify a list of contaminants based on a review of existing data and potential contaminant sources.
- Develop procedures for adequate field collection and handling of sediment samples.
- Outline adequate quality assurance and quality control (QA/QC) procedures for field sampling and laboratory analysis.
- Provide a description of statistical procedures used to determine the contaminant status of the dredged material.
- Describe procedures for validating the analytical data to assess whether the sample collection, handling and laboratory analysis was undertaken to a standard allowing assessment of sediment quality against relevant guidelines.
- Outline the proposed reporting framework for the sediment quality results that will address the requirements of the Determining Authority.

2 Review of Existing Information

The proposed site for the Eyre Peninsula Desalination Plant is located on the outskirts of the town of Port Lincoln, South Australia. The location for the site has a history of development as it is in an industrial area, where it was formerly utilised by BHP as a sand mine. Although majority of the site is surrounded by vegetation, west of the site is the Eyre Peninsular Wastewater Treatment Plant, an Aquaculture facility, and a boat ramp. There is also a railway line which is no longer in use.

A preliminary site investigation was conducted to identify site contamination issues which may have resulted from past or current site uses. It was found that the following historical and existing activities could contribute to site contamination:

- Transport of sand to and from the site via railway
- Transport of sand from the site via ships
- Metal fabrication
- Railway operations
- Bulk shipping facilities
- Fill or soil importation
- Abrasive blasting
- Diesel above storage tanks
- Sewerage treatment works and effluent disposal (discharge to marine waters)
- Fishing activities
- Shipping and vessel activities

2.1 Contaminants List

Based on known activities to have occurred in the area, sediment samples will be tested for physical and chemical analytes as listed in Table 2.1.

Table 2.1 Contaminants list for laboratory testing

Analytes		PQL
Particle Size Distribution (sieve and hydrometer)		± 1%
Total Organic Carbon (%)		0.10%
TRH (incl. NEPM Fraction) – Low Level (mg/kg)	C_6-C_9	25
	C_{10}-C_{14}	25
	C_{15}-C_{28}	25
	C_{29}-C_{36}	25
	TRH - Total	100
Low level BTEX + VHCs (mg/kg)	Benzene	0.2
	Toluene	0.2

Analytes		PQL
	Ethylbenzene	0.2
	Xylene – Total	0.6
	VCHs	0.05-5
Pesticides. Herbicides and Chlorinated Organics (µg/kg)	PAHs	5-10
	Phenolics Speciated	1-20
	OC Pesticides	1
	OP Pesticides	50-100
	PCBs – Total	5
	SVCHs	10-100
	Carbamates	10-100
	Synthetic Pyrethroids	10-100
	Triazine Herbicides	10-100
Phenoxy Acid Herbicides (µg/kg)		100
Organotins (µg/kg)		0.5-5
Cyanide – Total (Low Level) (mg/kg)		0.25
Nutrient Suite (mg/kg)	NO_2, NO_3, PO_4	0.5
	TKN, Org N, Total N	10
	Ammonia – KCl extractable	0.5
	Total P	10
Recoverable Metals (mg/kg)	Aluminium# (Al)	1
	Antimony (Sb)	0.5
	Arsenic (As)	0.5
	Cadmium (Cd)	0.1
	Chromium (Cr)	0.5
	Cobalt (Co)	0.5
	Copper (Cu)	0.5
	Iron (Fe)	1
	Lead (Pb)	0.5
	Manganese (Mn)	1
	Mercury (Hg)	0.01
	Nickel (Ni)	0.5
	Selenium (Se)	0.1
	Silver (Ag)	0.1

Analytes		PQL
	Vanadium (V)	0.5
	Zinc (Zn)	10.5
Praziquantel in Sediment (non-NATA)		-

Not a toxic contaminant but included because it can be a useful normalising element.

3 Sampling and Analysis

3.1 Sample Numbers and Locations

Dr Michael Sierp of Aquatic Biosecurity Pty Ltd selected ten sampling locations around Billy Lights Point. Six are located in shallow water depths but are predicted to be longer core lengths (maximum 5 m long) and four locations are located in deeper waters but are predicted to have shorter core lengths (up to 2 m long).

Should any locations happen to be areas populated by seagrass, an underwater camera will be used to guide the vessel to another area clear of seagrass. The location of all proposed sediment sampling sites is provided in Figure 3.1. Coordinates are summarised in Table 3.1.

Figure 3.1 Proposed sediment sampling locations

Table 3.1 Proposed sediment sampling locations

Sample ID	Latitude	Longitude	Easting	Northing
EPDP1				
EPDP2				
EPDP3				
EPDP4				
EPDP5				
EPDP6				
EPDP7				
EPDP8				
EPDP9				
EPDP10				

3.2 Sample Collection Methodology

3.2.1 Survey Vessel and Personnel

A suitable sampling vessel will be used to undertake sediment sampling. Prior to use the vessel will be thoroughly inspected and washed down to avoid accidental cross-contamination during sampling. Offshore sampling will be undertaken by Aquatic Biosecurity Pty Ltd. Samples will then be transferred ashore for processing by BMT personnel.

3.2.2 Sediment Coring

Sediment samples will be collected using a vibrocorer. The core tubes proposed are 2.09 mm tube thickness, 76.2 mm in outer diameter aluminium 3.66 m long. Each sample will be taken to the maximum depth or core refusal (whichever is least). The acceptability of each sediment core will be determined immediately following collection by Aquatic Biosecurity Pty Ltd and during processing onshore by BMT.

Samples will be taken from the full depth of the cores for analysis of potential contaminants. Each core will be subsampled in up to five horizons for the longer cores and four horizons in the shorter cores (see Figure 3.2). Should core lengths be less than predicted, sampling will occur at 0.5 m increments to the maximum depth obtained. Subsampling intervals may need to be adjusted to reflect observed difference in the sediment core (e.g. where distinct stratification is encountered).

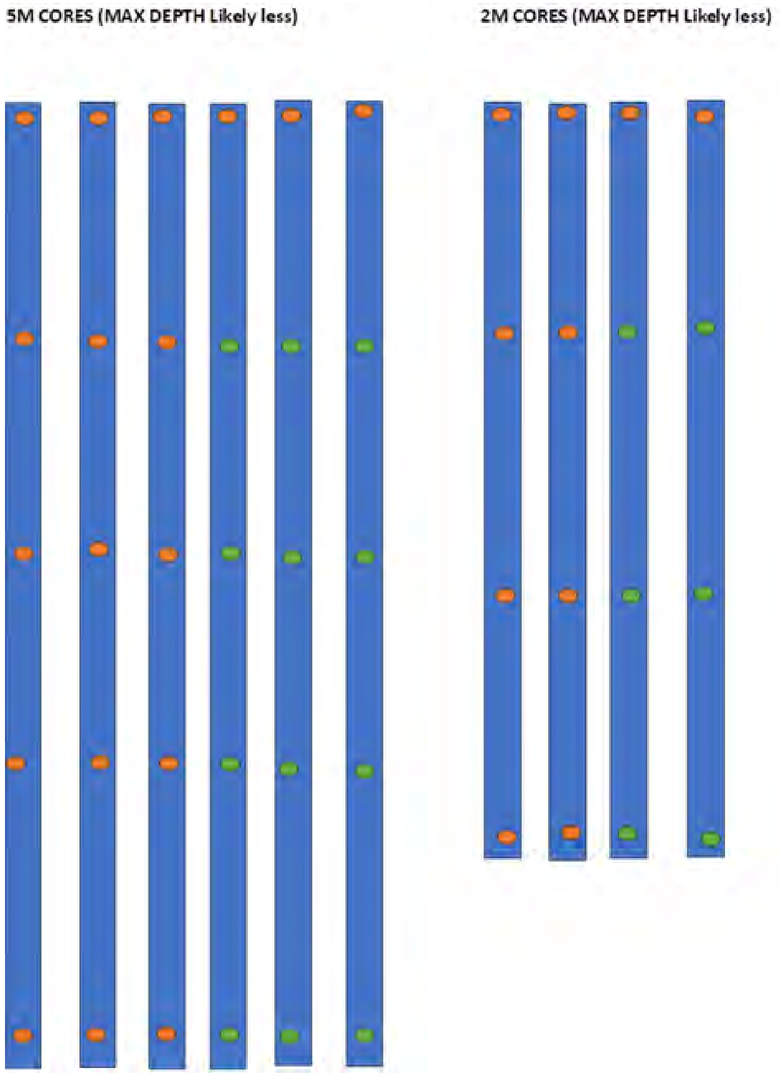


Figure 3.2 Coring diagram for required tests. Phase 1 initial testing (orange – 28 max). Phase 2 testing (green – 18 max)

3.2.3 Sample Handling and Chain of Custody

Sample management procedures will include the careful collection of sediment samples from the core tube, following the recovery of the sediment sample from the seabed. Photographs of the cores will be taken and field personnel will log each core profile for its physical characteristics and variations in sediment type and texture. The core length will be measured, and the appropriate sample interval subsampled and collected in a clean, glass bowl for homogenisation prior to the filling of analytical laboratory-supplied clean sampling jars.

Subsampling of cores will be undertaken in accordance with Section 3.2.2. Sample identifiers will include the location and depth interval. For example, EPDP1_0.00-0.50 will indicate that the sediment sample was collected from the first sampling location (Figure 3.1) over the interval from 0.00 m to 0.05 m. QA/QC samples will be blind-labelled to ensure that the laboratories cannot relate the QA sample back to the primary sample.

All sample handling and processing will be performed carefully to minimise contamination and sample mix-ups. Core tubes will be washed with perfluoroalkyl/polyfluoroalkyl (PFAS) and phosphate free detergent in an 8-stage cleaning cycle. All sample processing equipment will be cleaned prior to sample collection using a scrub with decontamination solution (e.g. Decon 90) followed by a rinse with seawater. Nitrile gloves will be worn by all field personnel handling the sediment, and gloves will be disposed of after processing of each core sample. Utmost care will be maintained in ensuring that cross-contamination between samples does not occur. Samples collected from each interval will be placed into laboratory provided, cleaned, and preserved containers (labelled prior to filling).

The workspace for sample handling and processing will be washed down regularly with ambient seawater to clean all surfaces and minimise the potential for dust contamination of samples. All sample processing will be undertaken away from any potential contamination sources such as engine exhausts, fuels, oils, greases etc.

Following sample processing and filling of sample containers, all samples will be immediately chilled. The chilled samples will be submitted to the laboratory under appropriate Chain of Custody documentation to ensure that the sample possession and processing can be traced from sample collection to reporting of results.

3.2.4 Core Log

All sediment samples will be geotechnically logged upon collection on standardised pro-forma and further information will be logged during handling and processing. The following information will be recorded:

<u>Logged at collection:</u>

- Project name
- The name of the sample collector
- Date and time of sampling
- Field sample number
- Northing and Easting of sample location (from onboard GPS)
- Tidal predictions and water depth at sample location (derived from onboard depth sounder)
- Weather and sea state conditions at the time of sampling

<u>Logged at processing:</u>

- Depth of core penetration/length of core
- Sediment colour and odour
- Field texture (fine sand, silt, clay, sand, clayey sand)
- Plasticity
- Estimated percentage of stones and/or shell grit

- General comments pertaining to the sample (e.g. presence of organic matter or benthic organisms, etc).

3.3 Field Quality Control

The following field and laboratory quality control samples will be obtained:

- Triplicate split samples (one location) where sediments will be thoroughly mixed and split into three sample containers set to assess laboratory variation, with one of the three samples sent to a second (reference) laboratory for analysis. This will only be done for one horizon of one core sample.
- Trip blank - one per day of sampling to provide an indication of cross contamination from volatile substances during field sampling.
- Trip spike - laboratory-prepared trip spikes consist of distilled, de-ionised water or sand spiked with known concentrations of BTEX and should be included in QA/QC programs where volatile TPH or BTEX concentrations are being measured. Laboratory-prepared trip spikes should be included at a rate of one per batch/day.
- Rinsate blanks - collected on separate sampling days by pouring laboratory supplied deionised water over sampling equipment (subsampling equipment/tools) after it has been decontaminated between sample sites and catching the rinse water in laboratory supplied containers for analysis. This is to assess whether the decontamination process has been adequately undertaken and there are no residual contaminants from previous sampling. Given the number of analytes being analysed for this project, rinsate samples will only be analysed for TRH/BTEXN, TBT and metals.

Note: Due to limitations with the number of core tubes available field triplicate samples will not be collected as part of field quality control. Field triplicates samples (10% of all sample locations) determine the small-scale variability of the sediment’s physical and chemical characteristics. At one location, three separate grabs are collected.

Table 3.2 Sample numbers summary

Parameter	Number/Description
Core samples	10 (number of horizons samples determined on the day)
Triplicate splits	One location (i.e. split the sample at one location into three sub-samples))
Trip blank	One each day of sampling
Trip spike	One each day of sampling
Rinsate blanks	Two samples per day (i.e. one for core sampler and one for mixing equipment/tools)

3.4 Health, Safety and Contingency Plan

A Job Hazard Analysis (JHA) will be completed in accordance with BMT and Aquatic Biosecurity Pty Ltd requirements prior to the commencement of fieldwork, to cover:

- Planning of coring activities
- Job safety analysis and risk assessment
- Staff awareness of the hazards of working on water and preparedness for a man-over-board scenario

- Delegation of sampling and vessel navigation responsibilities
- The equipment used and any potential to cause injury
- Hazards associated with fuels and chemicals used on board
- The proper handling of sediments (broken shells and low risk of contaminants)
- Emergency response and evacuation planning (in the event of an accident-causing serious injury).

3.4.1 Adverse Weather

The planning of field sampling will involve regular checking of available weather forecast services for the study area. In case of adverse weather conditions that would make sampling unacceptable due to strong winds and high waves, the sampling team and vessel operator would remain on stand-by until weather conditions improve to allow the rigorous and safe collection of sediment samples.

3.4.2 Equipment Failure

The corer and lifting arrangement will be sufficiently robust to afford good operation and no failure of the equipment is expected to occur during the sampling. Prior to sampling, all equipment will be thoroughly checked and repaired if necessary. Multiple spare core barrels, and tools to fix minor problems with coring equipment will be taken on the vessel in the event of gear failure.

In the unlikely event of equipment failure during sampling, repairs to any equipment would be undertaken as soon as possible to minimise delays as far as practical. The site is located near Port Lincoln, where replacement equipment could be sourced if required.

3.5 Laboratory Analysis

3.5.1 Analytical Laboratories

The primary and secondary analysis of sediment samples will be undertaken by analytical laboratories fully accredited by the National Association of Testing Authorities (NATA) for the required analyses. Both laboratories will follow laboratory QC procedures in accordance with requirements outlined in Appendix F of NAGD. This includes analysis of laboratory blanks, duplicates, certified reference materials and spiked samples.

3.5.2 Analytical Tests

Analysis will occur in two phases. Phases assume that full core (predicted) lengths will be obtained during sampling.

Phase 1: Initially, 28 samples (different horizons) from the 10 cores will be analysed for parameters outlined in Table 2.1. Designated samples for analysis are illustrated in Figure 3.2 (orange circles).

Should core samples from shallow locations (6) be shorter than predicted, subsamples from three full cores, and samples from the first horizon from the other three cores will be analysed, with the remaining samples held at the laboratory.

Should core samples from deep locations (4) be shorter than predicted, subsamples from two full cores, and samples from the first horizon from the other two cores will be analysed, with the remaining samples held at the laboratory.

Phase 2: If any contaminants of concern are identified, then the remaining samples (18) will be analysed for parameters outlined in Table 2.1.

3.5.3 Sample Containers

Sample volumes will be specified by the laboratory performing the analysis. Large cobble and gravel fragments should be removed from the sample prior to storage in containers. Based on the proposed analyses, the following sample containers would be required per sample:

- 2 x 250 mL glass jar – organic/inorganic chemical analysis
- 1 x medium plastic clip seal bag (50-100 g) – particle size distribution

3.6 Data Analysis, Assessment and Management

Concentrations of contaminants measured in sediment samples will be compared to:

- Screening levels as described in Table 2 of NAGD
- Table 1A(1) and Table 1B(6) of the NEPM Volume 2 Schedule B1
- Appendix 1 of WDF Standard.

The assessment against NAGD criteria involves the comparison of mean concentrations at the upper 95% confidence level (95%UCL) of the mean to the NAGD screening levels. The United States Environmental Protection Agency has software (ProUCL Version 5.2) that can calculate 95% present UCLs from data sets containing detect and non-detect observations. The statistical analysis will follow the approach given in Appendix A of the NAGD.

3.7 Data Quality Objectives and Data Validation

The data quality aim for this SAP is that the information collected is suitable for undertaking an assessment of the proposed disposal ground in accordance with the framework provided in the NAGD. To achieve this aim, data quality objectives outlined in Table 3.3 must be met.

The data quality objectives encompass:

- Data validation objectives - All laboratory analyses will be validated in accordance with Appendix A of NAGD (which are specific to marine sediments) to confirm suitable data quality for undertaking a rigorous baseline characterisation of the sediment. This will involve an assessment of the following:
  - Sample holding times and storage conditions
  - Laboratory blanks, duplicates and surrogate/matrix spikes
  - Triplicate sample splits and trip blank
  - Completeness objective - At least 95% of all data received should be validated as suitable for use.
- Chain-of-custody form objectives – completed forms shall accompany the samples.
- Laboratory sample receipt objectives – the laboratory shall provide written confirmation on whether: the sample names/numbers received agree with chain-custody forms; samples were received intact; samples were received at specified temperature; and samples were received within appropriate holding times.

Table 3.3 Data quality objectives for data validation

Parameter	Data Quality Objective
Holding Time	Samples received within specified holding time (NAGD Appendix H)

Parameter	Data Quality Objective
Field Triplicate Samples	Relative Standard Deviation <50%
Triplicate Split Samples	Relative Standard Deviation <50%
Laboratory Blanks	At or near the Limit of Reporting (LOR)
Laboratory Duplicate Samples	Relative Percent Difference (RPD) <35% or as per laboratory requirements
Laboratory Matrix Spikes	Recovery as per laboratory requirements
Surrogate Spikes	Recovery as per laboratory requirements
Chain-of-Custody Forms	100% complete and included in SAP implementation report
Sample Receipt from Laboratory	Sample names/numbers received agree with chain-of-custody forms Samples were received intact Samples received at specific temperature Samples received within laboratory holding times
Completeness Objective	At least 95% of all data received should be validated as suitable for use

3.8 Reporting

The reporting of sediment quality results will be undertaken in a SAP Implementation Report (SAPIR) that includes the following components:

- Summary of the SAP, or SAP appended to the report
- Outline of potential problems encountered and deviations from the SAP, including justification
- Description of the sampling carried out, along with the actual sampling locations, sample numbers (including replicates and QA samples), completed chain of custody (CoC) forms, field logs and description of sediments
- Comparison of the 95% UCL of mean chemical concentrations of sediments
- Assessment of QA/QC procedures for both field and laboratory data
- Data validation including comparison to data quality objectives
- Appendices including all laboratory and field data, photos and statistics
- Conclusions regarding baseline levels as well as any recommendations for further work if required.

4 References

[CoA] Commonwealth of Australia (2009). National assessment guidelines for dredging (NAGD). Department of the Environment, Water, Heritage and the Arts, Canberra.

[EPA] Environment Protection Authority (2013). Standard for the production and use of waste derived material.

FMG Engineering (2021) Preliminary site investigation, Former BHP Site, Draft A, report reference S54636/275827, dated 13 October 2021.

GHD (2012) Port Lincoln Development Plan Amendment, Phase 1 Environmental Site Assessment, report reference 33/16378, dated 12 October 2012.

Annex B Site sample description and photos

B.1 Sample Field Log

Table B.1. Description of samples at the time of processing

Site	Time	Length (m)	Strata	Colour	Odour	Texture	Composition	Stones (%)	Organics (%)	Shell (%)	Notes
EPW1	19:41	1.0	0.0-0.5	Green	-	Clay/silt	Bit plasticky	-	-	5	Black top, 5-6 cm sand
			0.5-1.0	Grey	-	Clay/silt	Bit plasticky	-	-	5	
EPW2	21:04	0.5	0.0-0.5	Grey/green	-	Silty sand, bit clay	Non-plastic	-	-	25	More shells, deeper you go. Clay more towards 0.5 m end.
EPW3	19:08	0.9	0.0-0.5	Grey	-	Sand	Non-plastic	-	-	30	Top 10-12 cm black in colour.
			0.5-1.0	Grey	-	Sand	Non-plastic	-	-	90	
EPW4	19:29	0.5	0.0-0.5	Grey/green	-	Silty sand	Non-plastic	-	-	30	Large shells present
EPW5	16:35	0.5	0.0-0.5	Dark grey	-	sand	Non-plastic	-	-	20	Some macroalgae, and polychaete worm present.
EPW6	16:08	0.9	0.0-0.5	Black streaks, green/grey	-	Silty sand	Non-plastic	-	-	30	Polychaete worm present in strata 0.0-0.5.
			0.5-1.0	Green/grey	-	Sand	Non-plastic	-	-	70	

EPW7	17:45	1.5	0.0-0.5	Black streaks/grey	-	Sand	Non-plastic	5	-	5	Macroalgae present.
			0.5-1.0	Black streaks/grey	-	Sand	Non-plastic	5	-	5	
			1.0-1.5	Black streaks/ grey	-	Sand	Non-plastic	5	-	5	
EPW8	21:36	0.65	0.0-0.5 (bottom)	Grey/green	Sulphur	Clay	Plastic/sticky	-	-	29	Took hours, bashed out corer. Pushed with various implements due to core being stuck.
			0.5-1.0 (top)	Grey/green	Sulphur	Clay	Plastic/sticky	-	-	29	
EPW8A	08:40 (1/11/ 23)	0.8	0.0-0.5	Green/grey	Sulphur	Clay	Plastic/sticky	-	-	5	Photo taken from top or core. Scraped off top 2 cm due to using angle grinder to cut tube/remove core. Probable contamination.
			0.5-1.0	Green/grey	Sulphur	Clay	Plastic/sticky	-	-	5	
EPW9	15:30										This sample site was used for carbon dating. Samples dry and compacted.
EPW10	17:02	0.9	0.0-0.5	Black streaks, green/grey	Sulphur	Silty sand	Plastic/sticky	-	-	10	
			0.5-1.0	Green/grey	-	Silty sand	Plastic/sticky	-	-	10	

EPW11	20:35	1.63	0.0-0.5	Dark grey	-	Sand	Non-plastic	-	-	5	Larger shells present
			0.5-1.0	Dark and light grey	-	Sand	Non-plastic	-	-	40	
			1.0-1.5	Dark and light grey	-	Sand	Non-plastic	-	-	80	
EPW12	20:13	0.7	0.0-0.5	Green/grey	-	Sand	Non-plastic	-	-	30	Macroalgae on top. Some large shells present.

B.2 Photographs

Site EP1

Site EP2

Site EP3

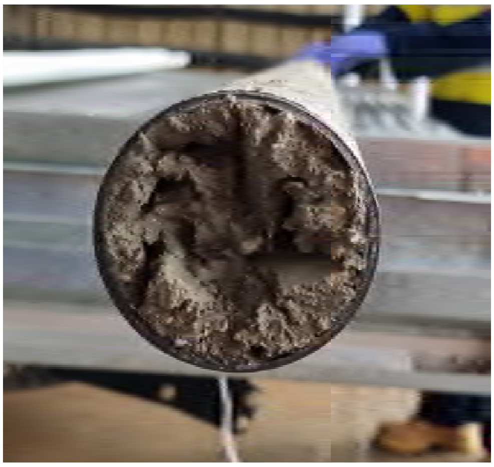
Site EP4

Site EP5

Site EP6

Site EP7

Site EP8



*Site 8A for results purposes

Site EP9

Site EP10

Site EP11

Site EP12

Annex C Laboratory Results

C.1 Envirolab

Envirolab Services (WA) Pty Ltd trading as MPL Laboratories
ABN 53 140 099 207
16-18 Hayden Court Myaree WA 6154
ph +61 8 9317 2505
lab@mpl.com.au
www.mpl.com.au

Certificate of Analysis PEK0250

Client Details

Client	BMT Commercial Australia Pty Ltd
Contact	Kathryn Wheatley
Address	PO Box 462, WEMBLEY, WA, 6913

Sample Details

Your Reference	SA Water DP
Number of Samples	2 Rinsate, 22 Sediment
Date Samples Received	03/11/2023
Date Instructions Received	03/11/2023

Analysis Details

Please refer to the following pages for results, methodology summary and quality control data.
Samples were analysed as received from the client. Results relate specifically to the samples as received.
Results are reported on a dry weight basis for solids and on an as received basis for other matrices.

Report Details

Date Results Requested by	17/11/2023
Date of Issue	29/11/2023

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Accredited for compliance with ISO/IEC 17025. Tests not covered by NATA are denoted with *.

Authorisation Details

Results Approved By	Diego Bigolin, Supervisor, Inorganics Heram Halim, Operations Manager Huong Patfield, Organics Chemist Stacey Hawkins, ASS/AMD Supervisor Travis Carey, Organics Supervisor
Laboratory Manager	Michael Kubiak

Certificate of Analysis PEK0250

Samples in this Report

Envirolab ID	Sample ID	Depth	Matrix	Date Sampled	Date Received
PEK0250-01	EPW6	0.00-0.50	Sediment	31/10/2023	03/11/2023
PEK0250-02	EPW5	0.00-0.50	Sediment	31/10/2023	03/11/2023
PEK0250-03	EPW10	0.00-0.50	Sediment	31/10/2023	03/11/2023
PEK0250-04	EPW10	0.50-1.00	Sediment	31/10/2023	03/11/2023
PEK0250-05	EPW7	0.50-1.00	Sediment	31/10/2023	03/11/2023
PEK0250-06	EPW6	0.50-1.00	Sediment	31/10/2023	03/11/2023
PEK0250-07	EPW3	0.50-1.00	Sediment	31/10/2023	03/11/2023
PEK0250-08	EPW7	0.00-0.50	Sediment	31/10/2023	03/11/2023
PEK0250-09	EPW7	1.00-1.50	Sediment	31/10/2023	03/11/2023
PEK0250-10	EPW3	0.00-0.50	Sediment	31/10/2023	03/11/2023
PEK0250-11	EPW1	0.00-0.50	Sediment	31/10/2023	03/11/2023
PEK0250-12	EPW8	0.50-1.00	Sediment	31/10/2023	03/11/2023
PEK0250-13	EPW11	1.00-1.50	Sediment	31/10/2023	03/11/2023
PEK0250-14	EPW1	0.50-1.00	Sediment	31/10/2023	03/11/2023
PEK0250-15	EPW11	0.50-1.00	Sediment	31/10/2023	03/11/2023
PEK0250-16	EPW11	0.00-0.50	Sediment	31/10/2023	03/11/2023
PEK0250-17	EPW2	0.00-0.50	Sediment	31/10/2023	03/11/2023
PEK0250-18	EPW12	0.00-0.50	Sediment	31/10/2023	03/11/2023
PEK0250-19	EPW4	0.00-0.50	Sediment	31/10/2023	03/11/2023
PEK0250-20	EPW8	0.00-0.50	Sediment	31/10/2023	03/11/2023
PEK0250-21	EPW5		Rinsate	31/10/2023	03/11/2023
PEK0250-22	EPW12		Rinsate	31/10/2023	03/11/2023
PEK0250-23	EPW8A	0.00-0.50	Sediment	31/10/2023	03/11/2023
PEK0250-24	EPW8A	0.50-1.00	Sediment	31/10/2023	03/11/2023

Sample Comments

EPW8	Insufficient sample for PSD - not tested.
EPW5	Sample(s) was/were received with headspace, analytical results may be affected.

Certificate of Analysis PEK0250

Volatile Organic Compounds (Sediment)

Envirolab ID	Units	PQL	PEK0250-01	PEK0250-02	PEK0250-03	PEK0250-04	PEK0250-05
Your Reference			EPW6	EPW5	EPW10	EPW10	EPW7
Date Sampled			31/10/2023	31/10/2023	31/10/2023	31/10/2023	31/10/2023
Depth			0.00-0.50	0.00-0.50	0.00-0.50	0.50-1.00	0.50-1.00
Dichlorodifluoromethane (Freon-12)	mg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Chloromethane	mg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Vinyl chloride	mg/kg	0.30	<0.30	<0.30	<0.30	<0.30	<0.30
Bromomethane	mg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Chloroethane	mg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Trichlorofluoromethane (Freon-11)	mg/kg	0.70	<0.70	<0.70	<0.70	<0.70	<0.70
1,1-Dichloroethene	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
trans-1,2-Dichloroethene	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
1,1-Dichloroethane	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
2,2-Dichloropropane	mg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
cis-1,2-Dichloroethene	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Bromochloromethane	mg/kg	0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Chloroform	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
1,1,1-Trichloroethane	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
1,1-Dichloropropene	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Carbon Tetrachloride	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
1,2-Dichloroethane	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Trichloroethene	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
1,2-Dichloropropane	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Dibromomethane	mg/kg	0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Bromodichloromethane	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
cis-1,3-Dichloropropene	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
trans-1,3-Dichloropropene	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
1,1,2-Trichloroethane	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
1,3-Dichloropropane	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Tetrachloroethene	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Dibromochloromethane	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
1,2-Dibromoethane	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Chlorobenzene	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
1,1,1,2-Tetrachloroethane	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Bromoform	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
1,1,2,2-Tetrachloroethane	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
1,2,3-Trichloropropane	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Bromobenzene	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
2-Chlorotoluene	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
4-Chlorotoluene	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
1,3-Dichlorobenzene	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
1,4-Dichlorobenzene	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
1,2-Dichlorobenzene	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
1,2-Dibromo-3-chloropropane	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Hexachlorobutadiene	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
1,2,4-Trichlorobenzene	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
1,2,3-Trichlorobenzene	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Surrogate Dibromofluoromethane	%		*98.4*	*102*	*102*	*99.9*	*99.0*
Surrogate aaa-Trifluorotoluene	%		*102*	*107*	*106*	*96.8*	*109*

Volatile Organic Compounds (Sediment)

Envirolab ID	Units	PQL	PEK0250-01	PEK0250-02	PEK0250-03	PEK0250-04	PEK0250-05
Your Reference			EPW6	EPW5	EPW10	EPW10	EPW7
Date Sampled			31/10/2023	31/10/2023	31/10/2023	31/10/2023	31/10/2023
Depth			0.00-0.50	0.00-0.50	0.00-0.50	0.50-1.00	0.50-1.00
Surrogate Toluene-D8	%		*97.2*	*100*	*99.6*	*99.9*	*98.4*
Surrogate 4-Bromofluorobenzene	%		*102*	*99.5*	*105*	*102*	*100*

Envirolab ID	Units	PQL	PEK0250-06	PEK0250-07	PEK0250-08	PEK0250-09	PEK0250-10
Your Reference			EPW6	EPW3	EPW7	EPW7	EPW3
Date Sampled			31/10/2023	31/10/2023	31/10/2023	31/10/2023	31/10/2023
Depth			0.50-1.00	0.50-1.00	0.00-0.50	1.00-1.50	0.00-0.50
Dichlorodifluoromethane (Freon-12)	mg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Chloromethane	mg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Vinyl chloride	mg/kg	0.30	<0.30	<0.30	<0.30	<0.30	<0.30
Bromomethane	mg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Chloroethane	mg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Trichlorofluoromethane (Freon-11)	mg/kg	0.70	<0.70	<0.70	<0.70	<0.70	<0.70
1,1-Dichloroethene	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
trans-1,2-Dichloroethene	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
1,1-Dichloroethane	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
2,2-Dichloropropane	mg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
cis-1,2-Dichloroethene	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Bromochloromethane	mg/kg	0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Chloroform	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
1,1,1-Trichloroethane	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
1,1-Dichloropropene	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Carbon Tetrachloride	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
1,2-Dichloroethane	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Trichloroethene	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
1,2-Dichloropropane	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Dibromomethane	mg/kg	0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Bromodichloromethane	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
cis-1,3-Dichloropropene	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
trans-1,3-Dichloropropene	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
1,1,2-Trichloroethane	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
1,3-Dichloropropane	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Tetrachloroethene	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Dibromochloromethane	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
1,2-Dibromoethane	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Chlorobenzene	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
1,1,1,2-Tetrachloroethane	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Bromoform	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
1,1,2,2-Tetrachloroethane	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
1,2,3-Trichloropropane	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Bromobenzene	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
2-Chlorotoluene	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
4-Chlorotoluene	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
1,3-Dichlorobenzene	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
1,4-Dichlorobenzene	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
1,2-Dichlorobenzene	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10

Volatile Organic Compounds (Sediment)

Envirolab ID	Units	PQL	PEK0250-06	PEK0250-07	PEK0250-08	PEK0250-09	PEK0250-10
Your Reference			EPW6	EPW3	EPW7	EPW7	EPW3
Date Sampled			31/10/2023	31/10/2023	31/10/2023	31/10/2023	31/10/2023
Depth			0.50-1.00	0.50-1.00	0.00-0.50	1.00-1.50	0.00-0.50
1,2-Dibromo-3-chloropropane	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Hexachlorobutadiene	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
1,2,4-Trichlorobenzene	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
1,2,3-Trichlorobenzene	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Surrogate Dibromofluoromethane	%		*101*	*99.1*	*101*	*98.8*	*103*
Surrogate aaa-Trifluorotoluene	%		*99.8*	*113*	*110*	*109*	*107*
Surrogate Toluene-D8	%		*98.7*	*98.0*	*99.5*	*99.2*	*102*
Surrogate 4-Bromofluorobenzene	%		*101*	*99.1*	*103*	*99.5*	*98.6*

Envirolab ID	Units	PQL	PEK0250-11	PEK0250-12	PEK0250-13	PEK0250-14	PEK0250-15
Your Reference			EPW1	EPW8	EPW11	EPW1	EPW11
Date Sampled			31/10/2023	31/10/2023	31/10/2023	31/10/2023	31/10/2023
Depth			0.00-0.50	0.50-1.00	1.00-1.50	0.50-1.00	0.50-1.00
Dichlorodifluoromethane (Freon-12)	mg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Chloromethane	mg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Vinyl chloride	mg/kg	0.30	<0.30	<0.30	<0.30	<0.30	<0.30
Bromomethane	mg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Chloroethane	mg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Trichlorofluoromethane (Freon-11)	mg/kg	0.70	<0.70	<0.70	<0.70	<0.70	<0.70
1,1-Dichloroethene	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
trans-1,2-Dichloroethene	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
1,1-Dichloroethane	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
2,2-Dichloropropane	mg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
cis-1,2-Dichloroethene	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Bromochloromethane	mg/kg	0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Chloroform	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
1,1,1-Trichloroethane	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
1,1-Dichloropropene	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Carbon Tetrachloride	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
1,2-Dichloroethane	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Trichloroethene	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
1,2-Dichloropropane	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Dibromomethane	mg/kg	0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Bromodichloromethane	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
cis-1,3-Dichloropropene	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
trans-1,3-Dichloropropene	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
1,1,2-Trichloroethane	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
1,3-Dichloropropane	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Tetrachloroethene	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Dibromochloromethane	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
1,2-Dibromoethane	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Chlorobenzene	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
1,1,1,2-Tetrachloroethane	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Bromoform	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
1,1,2,2-Tetrachloroethane	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
1,2,3-Trichloropropane	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10

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Volatile Organic Compounds (Sediment)

Envirolab ID	Units	PQL	PEK0250-11	PEK0250-12	PEK0250-13	PEK0250-14	PEK0250-15
Your Reference			EPW1	EPW8	EPW11	EPW1	EPW11
Date Sampled			31/10/2023	31/10/2023	31/10/2023	31/10/2023	31/10/2023
Depth			0.00-0.50	0.50-1.00	1.00-1.50	0.50-1.00	0.50-1.00
Bromobenzene	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
2-Chlorotoluene	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
4-Chlorotoluene	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
1,3-Dichlorobenzene	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
1,4-Dichlorobenzene	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
1,2-Dichlorobenzene	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
1,2-Dibromo-3-chloropropane	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Hexachlorobutadiene	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
1,2,4-Trichlorobenzene	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
1,2,3-Trichlorobenzene	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Surrogate Dibromofluoromethane	%		*99.0*	*101*	*102*	*101*	*102*
Surrogate aaa-Trifluorotoluene	%		*101*	*99.9*	*107*	*101*	*104*
Surrogate Toluene-D8	%		*99.0*	*98.8*	*101*	*100*	*98.3*
Surrogate 4-Bromofluorobenzene	%		*101*	*100*	*101*	*102*	*99.3*

Envirolab ID	Units	PQL	PEK0250-16	PEK0250-17	PEK0250-18	PEK0250-19	PEK0250-20
Your Reference			EPW11	EPW2	EPW12	EPW4	EPW8
Date Sampled			31/10/2023	31/10/2023	31/10/2023	31/10/2023	31/10/2023
Depth			0.00-0.50	0.00-0.50	0.00-0.50	0.00-0.50	0.00-0.50
Dichlorodifluoromethane (Freon-12)	mg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Chloromethane	mg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Vinyl chloride	mg/kg	0.30	<0.30	<0.30	<0.30	<0.30	<0.30
Bromomethane	mg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Chloroethane	mg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Trichlorofluoromethane (Freon-11)	mg/kg	0.70	<0.70	<0.70	<0.70	<0.70	<0.70
1,1-Dichloroethene	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
trans-1,2-Dichloroethene	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
1,1-Dichloroethane	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
2,2-Dichloropropane	mg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
cis-1,2-Dichloroethene	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Bromochloromethane	mg/kg	0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Chloroform	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
1,1,1-Trichloroethane	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
1,1-Dichloropropene	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Carbon Tetrachloride	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
1,2-Dichloroethane	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Trichloroethene	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
1,2-Dichloropropane	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Dibromomethane	mg/kg	0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Bromodichloromethane	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
cis-1,3-Dichloropropene	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
trans-1,3-Dichloropropene	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
1,1,2-Trichloroethane	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
1,3-Dichloropropane	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Tetrachloroethene	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Dibromochloromethane	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10

Volatile Organic Compounds (Sediment)

Envirolab ID	**Units**	**PQL**	PEK0250-16	PEK0250-17	PEK0250-18	PEK0250-19	PEK0250-20
Your Reference			EPW11	EPW2	EPW12	EPW4	EPW8
Date Sampled			31/10/2023	31/10/2023	31/10/2023	31/10/2023	31/10/2023
Depth			0.00-0.50	0.00-0.50	0.00-0.50	0.00-0.50	0.00-0.50
1,2-Dibromoethane	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Chlorobenzene	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
1,1,1,2-Tetrachloroethane	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Bromoform	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
1,1,2,2-Tetrachloroethane	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
1,2,3-Trichloropropane	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Bromobenzene	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
2-Chlorotoluene	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
4-Chlorotoluene	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
1,3-Dichlorobenzene	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
1,4-Dichlorobenzene	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
1,2-Dichlorobenzene	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
1,2-Dibromo-3-chloropropane	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Hexachlorobutadiene	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
1,2,4-Trichlorobenzene	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
1,2,3-Trichlorobenzene	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Surrogate Dibromofluoromethane	%		*102*	*105*	*101*	*101*	*101*
Surrogate aaa-Trifluorotoluene	%		*106*	*102*	*102*	*98.5*	*95.7*
Surrogate Toluene-D8	%		*100*	*99.2*	*98.9*	*98.6*	*98.4*
Surrogate 4-Bromofluorobenzene	%		*98.1*	*102*	*101*	*99.5*	*103*

Envirolab ID	**Units**	**PQL**	PEK0250-23	PEK0250-24
Your Reference			EPW8A	EPW8A
Date Sampled			31/10/2023	31/10/2023
Depth			0.00-0.50	0.50-1.00
Dichlorodifluoromethane (Freon-12)	mg/kg	1.0	<1.0	<1.0
Chloromethane	mg/kg	1.0	<1.0	<1.0
Vinyl chloride	mg/kg	0.30	<0.30	<0.30
Bromomethane	mg/kg	1.0	<1.0	<1.0
Chloroethane	mg/kg	1.0	<1.0	<1.0
Trichlorofluoromethane (Freon-11)	mg/kg	0.70	<0.70	<0.70
1,1-Dichloroethene	mg/kg	0.10	<0.10	<0.10
trans-1,2-Dichloroethene	mg/kg	0.10	<0.10	<0.10
1,1-Dichloroethane	mg/kg	0.10	<0.10	<0.10
2,2-Dichloropropane	mg/kg	1.0	<1.0	<1.0
cis-1,2-Dichloroethene	mg/kg	0.10	<0.10	<0.10
Bromochloromethane	mg/kg	0.50	<0.50	<0.50
Chloroform	mg/kg	0.10	<0.10	<0.10
1,1,1-Trichloroethane	mg/kg	0.10	<0.10	<0.10
1,1-Dichloropropene	mg/kg	0.10	<0.10	<0.10
Carbon Tetrachloride	mg/kg	0.10	<0.10	<0.10
1,2-Dichloroethane	mg/kg	0.10	<0.10	<0.10
Trichloroethene	mg/kg	0.10	<0.10	<0.10
1,2-Dichloropropane	mg/kg	0.10	<0.10	<0.10
Dibromomethane	mg/kg	0.50	<0.50	<0.50
Bromodichloromethane	mg/kg	0.10	<0.10	<0.10

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Volatile Organic Compounds (Sediment)

Envirolab ID	Units	PQL	PEK0250-23	PEK0250-24
Your Reference			EPW8A	EPW8A
Date Sampled			31/10/2023	31/10/2023
Depth			0.00-0.50	0.50-1.00
cis-1,3-Dichloropropene	mg/kg	0.10	<0.10	<0.10
trans-1,3-Dichloropropene	mg/kg	0.10	<0.10	<0.10
1,1,2-Trichloroethane	mg/kg	0.10	<0.10	<0.10
1,3-Dichloropropane	mg/kg	0.10	<0.10	<0.10
Tetrachloroethene	mg/kg	0.10	<0.10	<0.10
Dibromochloromethane	mg/kg	0.10	<0.10	<0.10
1,2-Dibromoethane	mg/kg	0.10	<0.10	<0.10
Chlorobenzene	mg/kg	0.10	<0.10	<0.10
1,1,1,2-Tetrachloroethane	mg/kg	0.10	<0.10	<0.10
Bromoform	mg/kg	0.10	<0.10	<0.10
1,1,2,2-Tetrachloroethane	mg/kg	0.10	<0.10	<0.10
1,2,3-Trichloropropane	mg/kg	0.10	<0.10	<0.10
Bromobenzene	mg/kg	0.10	<0.10	<0.10
2-Chlorotoluene	mg/kg	0.10	<0.10	<0.10
4-Chlorotoluene	mg/kg	0.10	<0.10	<0.10
1,3-Dichlorobenzene	mg/kg	0.10	<0.10	<0.10
1,4-Dichlorobenzene	mg/kg	0.10	<0.10	<0.10
1,2-Dichlorobenzene	mg/kg	0.10	<0.10	<0.10
1,2-Dibromo-3-chloropropane	mg/kg	0.10	<0.10	<0.10
Hexachlorobutadiene	mg/kg	0.10	<0.10	<0.10
1,2,4-Trichlorobenzene	mg/kg	0.10	<0.10	<0.10
1,2,3-Trichlorobenzene	mg/kg	0.10	<0.10	<0.10
Surrogate Dibromofluoromethane	%		*102*	*104*
Surrogate aaa-Trifluorotoluene	%		*98.4*	*98.9*
Surrogate Toluene-D8	%		*99.9*	*102*
Surrogate 4-Bromofluorobenzene	%		*99.6*	*100*

Certificate of Analysis PEK0250

Volatile TRH and BTEX (Rinsate)

Envirolab ID	Units	PQL	PEK0250-21	PEK0250-22
Your Reference			EPW5	EPW12
Date Sampled			31/10/2023	31/10/2023
TRH C6-C9	µg/L	10	<10	<10
TRH C6-C10	µg/L	10	<10	<10
TRH C6-C10 less BTEX (F1)	µg/L	10	<10	<10
Methyl tert butyl ether (MTBE)	µg/L	1.0	<1.0	<1.0
Benzene	µg/L	1.0	<1.0	<1.0
Toluene	µg/L	1.0	<1.0	<1.0
Ethylbenzene	µg/L	1.0	<1.0	<1.0
meta+para Xylene	µg/L	2.0	<2.0	<2.0
ortho-Xylene	µg/L	1.0	<1.0	<1.0
Total Xylene	µg/L	3.0	<3.0	<3.0
Naphthalene (value used in F2 calc)	µg/L	1.0	<1.0	<1.0
Surrogate Dibromofluoromethane	%		*92.7*	*92.7*
Surrogate Toluene-D8	%		*98.4*	*101*
Surrogate 4-Bromofluorobenzene	%		*97.6*	*102*

Certificate of Analysis PEK0250

Volatile TRH and BTEX - NAGD (Sediment)

Envirolab ID	Units	PQL	PEK0250-01	PEK0250-02	PEK0250-03	PEK0250-04	PEK0250-05
Your Reference			EPW6	EPW5	EPW10	EPW10	EPW7
Date Sampled			31/10/2023	31/10/2023	31/10/2023	31/10/2023	31/10/2023
Depth			0.00-0.50	0.00-0.50	0.00-0.50	0.50-1.00	0.50-1.00
TRH C6-C9	mg/kg	25	<25	<25	<25	<25	<25
TRH C6-C10	mg/kg	25	<25	<25	<25	<25	<25
Benzene	mg/kg	0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Toluene	mg/kg	0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Ethylbenzene	mg/kg	0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Total Xylene	mg/kg	0.60	<0.60	<0.60	<0.60	<0.60	<0.60
Surrogate aaa-Trifluorotoluene	%		*97.8*	*99.8*	*100*	*90.7*	*104*

Envirolab ID	Units	PQL	PEK0250-06	PEK0250-07	PEK0250-08	PEK0250-09	PEK0250-10
Your Reference			EPW6	EPW3	EPW7	EPW7	EPW3
Date Sampled			31/10/2023	31/10/2023	31/10/2023	31/10/2023	31/10/2023
Depth			0.50-1.00	0.50-1.00	0.00-0.50	1.00-1.50	0.00-0.50
TRH C6-C9	mg/kg	25	<25	<25	<25	<25	<25
TRH C6-C10	mg/kg	25	<25	<25	<25	<25	<25
Benzene	mg/kg	0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Toluene	mg/kg	0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Ethylbenzene	mg/kg	0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Total Xylene	mg/kg	0.60	<0.60	<0.60	<0.60	<0.60	<0.60
Surrogate aaa-Trifluorotoluene	%		*94.0*	*108*	*105*	*103*	*98.0*

Envirolab ID	Units	PQL	PEK0250-11	PEK0250-12	PEK0250-13	PEK0250-14	PEK0250-15
Your Reference			EPW1	EPW8	EPW11	EPW1	EPW11
Date Sampled			31/10/2023	31/10/2023	31/10/2023	31/10/2023	31/10/2023
Depth			0.00-0.50	0.50-1.00	1.00-1.50	0.50-1.00	0.50-1.00
TRH C6-C9	mg/kg	25	<25	<25	<25	<25	<25
TRH C6-C10	mg/kg	25	<25	<25	<25	<25	<25
Benzene	mg/kg	0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Toluene	mg/kg	0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Ethylbenzene	mg/kg	0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Total Xylene	mg/kg	0.60	<0.60	<0.60	<0.60	<0.60	<0.60
Surrogate aaa-Trifluorotoluene	%		*94.3*	*94.8*	*98.7*	*95.2*	*98.8*

Envirolab ID	Units	PQL	PEK0250-16	PEK0250-17	PEK0250-18	PEK0250-19	PEK0250-20
Your Reference			EPW11	EPW2	EPW12	EPW4	EPW8
Date Sampled			31/10/2023	31/10/2023	31/10/2023	31/10/2023	31/10/2023
Depth			0.00-0.50	0.00-0.50	0.00-0.50	0.00-0.50	0.00-0.50
TRH C6-C9	mg/kg	25	<25	<25	<25	<25	<25
TRH C6-C10	mg/kg	25	<25	<25	<25	<25	<25
Benzene	mg/kg	0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Toluene	mg/kg	0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Ethylbenzene	mg/kg	0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Total Xylene	mg/kg	0.60	<0.60	<0.60	<0.60	<0.60	<0.60
Surrogate aaa-Trifluorotoluene	%		*100*	*97.6*	*98.0*	*92.7*	*91.8*

Volatile TRH and BTEX - NAGD (Sediment)

Envirolab ID	Units	PQL	PEK0250-23	PEK0250-24
Your Reference			EPW8A	EPW8A
Date Sampled			31/10/2023	31/10/2023
Depth			0.00-0.50	0.50-1.00
TRH C6-C9	mg/kg	25	<25	<25
TRH C6-C10	mg/kg	25	<25	<25
Benzene	mg/kg	0.20	<0.20	<0.20
Toluene	mg/kg	0.20	<0.20	<0.20
Ethylbenzene	mg/kg	0.20	<0.20	<0.20
Total Xylene	mg/kg	0.60	<0.60	<0.60
Surrogate aaa-Trifluorotoluene	%		*92.4*	*92.7*

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Semi-volatile TRH (Rinsate)

Envirolab ID	Units	PQL	PEK0250-21	PEK0250-22
Your Reference			EPW5	EPW12
Date Sampled			31/10/2023	31/10/2023
TRH C10-C14	µg/L	50	<50	<50
TRH C15-C28	µg/L	100	<100	<100
TRH C29-C36	µg/L	100	<100	<100
Total +ve TRH C10-C36	µg/L	50	<50	<50
TRH >C10-C16	µg/L	50	<50	<50
TRH >C10-C16 less Naphthalene F2	µg/L	50	<50	<50
TRH >C16-C34 (F3)	µg/L	100	<100	<100
TRH >C34-C40 (F4)	µg/L	100	<100	<100
Total +ve TRH >C10-C40	µg/L	50	<50	<50
Surrogate o-Terphenyl	%		*80.9*	*89.7*

Semi-volatile TRH - NAGD (Sediment)

Envirolab ID	Units	PQL	PEK0250-01	PEK0250-02	PEK0250-03	PEK0250-04	PEK0250-05
Your Reference			EPW6	EPW5	EPW10	EPW10	EPW7
Date Sampled			31/10/2023	31/10/2023	31/10/2023	31/10/2023	31/10/2023
Depth			0.00-0.50	0.00-0.50	0.00-0.50	0.50-1.00	0.50-1.00
TRH C10-C14	mg/kg	25	<25	<25	<25	<25	<25
TRH C15-C28	mg/kg	25	<25	<25	<25	<25	<25
TRH C29-C36	mg/kg	25	<25	<25	<25	<25	<25
Total +ve TRH C10-C36	mg/kg	25	<25	<25	<25	<25	<25
TRH >C10-C16	mg/kg	25	<25	<25	<25	<25	<25
TRH >C16-C34 (F3)	mg/kg	25	<25	<25	<25	<25	<25
TRH >C34-C40 (F4)	mg/kg	25	<25	<25	<25	<25	<25
Surrogate o-Terphenyl	%		*86.9*	*87.8*	*84.4*	*80.4*	*84.5*

Envirolab ID	Units	PQL	PEK0250-06	PEK0250-07	PEK0250-08	PEK0250-09	PEK0250-10
Your Reference			EPW6	EPW3	EPW7	EPW7	EPW3
Date Sampled			31/10/2023	31/10/2023	31/10/2023	31/10/2023	31/10/2023
Depth			0.50-1.00	0.50-1.00	0.00-0.50	1.00-1.50	0.00-0.50
TRH C10-C14	mg/kg	25	<25	<25	<25	<25	<25
TRH C15-C28	mg/kg	25	<25	<25	<25	<25	<25
TRH C29-C36	mg/kg	25	<25	<25	<25	<25	<25
Total +ve TRH C10-C36	mg/kg	25	<25	<25	<25	<25	<25
TRH >C10-C16	mg/kg	25	<25	<25	<25	<25	<25
TRH >C16-C34 (F3)	mg/kg	25	<25	<25	<25	<25	<25
TRH >C34-C40 (F4)	mg/kg	25	<25	<25	<25	<25	<25
Surrogate o-Terphenyl	%		*79.2*	*80.3*	*85.4*	*76.8*	*78.8*

Envirolab ID	Units	PQL	PEK0250-11	PEK0250-12	PEK0250-13	PEK0250-14	PEK0250-15
Your Reference			EPW1	EPW8	EPW11	EPW1	EPW11
Date Sampled			31/10/2023	31/10/2023	31/10/2023	31/10/2023	31/10/2023
Depth			0.00-0.50	0.50-1.00	1.00-1.50	0.50-1.00	0.50-1.00
TRH C10-C14	mg/kg	25	<25	<25	<25	<25	<25
TRH C15-C28	mg/kg	25	<25	<25	<25	<25	<25
TRH C29-C36	mg/kg	25	<25	<25	<25	<25	<25
Total +ve TRH C10-C36	mg/kg	25	<25	<25	<25	<25	<25
TRH >C10-C16	mg/kg	25	<25	<25	<25	<25	<25
TRH >C16-C34 (F3)	mg/kg	25	<25	<25	<25	<25	<25
TRH >C34-C40 (F4)	mg/kg	25	<25	<25	<25	<25	<25
Surrogate o-Terphenyl	%		*80.5*	*85.4*	*79.4*	*82.0*	*76.8*

Envirolab ID	Units	PQL	PEK0250-16	PEK0250-17	PEK0250-18	PEK0250-19	PEK0250-20
Your Reference			EPW11	EPW2	EPW12	EPW4	EPW8
Date Sampled			31/10/2023	31/10/2023	31/10/2023	31/10/2023	31/10/2023
Depth			0.00-0.50	0.00-0.50	0.00-0.50	0.00-0.50	0.00-0.50
TRH C10-C14	mg/kg	25	<25	<25	<25	<25	<25
TRH C15-C28	mg/kg	25	<25	<25	<25	<25	<25
TRH C29-C36	mg/kg	25	<25	<25	<25	<25	<25
Total +ve TRH C10-C36	mg/kg	25	<25	<25	<25	<25	<25
TRH >C10-C16	mg/kg	25	<25	<25	<25	<25	<25
TRH >C16-C34 (F3)	mg/kg	25	<25	<25	<25	<25	<25
TRH >C34-C40 (F4)	mg/kg	25	<25	<25	<25	<25	<25
Surrogate o-Terphenyl	%		*82.4*	*86.6*	*82.1*	*79.1*	*84.3*

Semi-volatile TRH - NAGD (Sediment)

Envirolab ID	Units	PQL	PEK0250-23	PEK0250-24
Your Reference			EPW8A	EPW8A
Date Sampled			31/10/2023	31/10/2023
Depth			0.00-0.50	0.50-1.00
TRH C10-C14	mg/kg	25	<25	<25
TRH C15-C28	mg/kg	25	<25	<25
TRH C29-C36	mg/kg	25	<25	<25
Total +ve TRH C10-C36	mg/kg	25	<25	<25
TRH >C10-C16	mg/kg	25	<25	<25
TRH >C16-C34 (F3)	mg/kg	25	<25	<25
TRH >C34-C40 (F4)	mg/kg	25	<25	<25
Surrogate o-Terphenyl	%		*82.1*	*79.5*

Certificate of Analysis PEK0250

Polycyclic Aromatic Hydrocarbons - NAGD (Sediment)

Envirolab ID	**Units**	**PQL**	PEK0250-01	PEK0250-02	PEK0250-03	PEK0250-04	PEK0250-05
Your Reference			EPW6	EPW5	EPW10	EPW10	EPW7
Date Sampled			31/10/2023	31/10/2023	31/10/2023	31/10/2023	31/10/2023
Depth			0.00-0.50	0.00-0.50	0.00-0.50	0.50-1.00	0.50-1.00
Naphthalene	µg/kg	5.0	<5.0	<5.0	<5.0	<5.0	<5.0
2-Methylnaphthalene	µg/kg	5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Acenaphthylene	µg/kg	5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Acenaphthene	µg/kg	5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Fluorene	µg/kg	5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Phenanthrene	µg/kg	5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Anthracene	µg/kg	5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Fluoranthene	µg/kg	5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Pyrene	µg/kg	5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Benzo(a)anthracene	µg/kg	5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Chrysene	µg/kg	5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Benzo(b,j,k)fluoranthene	µg/kg	10	<10	<10	<10	<10	<10
Benzo(e)pyrene	µg/kg	5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Benzo(a)pyrene	µg/kg	5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Perylene	µg/kg	5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Indeno(1,2,3-c,d)pyrene	µg/kg	5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Dibenzo(a,h)anthracene	µg/kg	5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Benzo(g,h,i)perylene	µg/kg	5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Coronene	µg/kg	5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Surrogate p-Terphenyl-D14	%		*79.9*	*76.5*	*77.5*	*75.7*	*70.9*

Envirolab ID	**Units**	**PQL**	PEK0250-06	PEK0250-07	PEK0250-08	PEK0250-09	PEK0250-10
Your Reference			EPW6	EPW3	EPW7	EPW7	EPW3
Date Sampled			31/10/2023	31/10/2023	31/10/2023	31/10/2023	31/10/2023
Depth			0.50-1.00	0.50-1.00	0.00-0.50	1.00-1.50	0.00-0.50
Naphthalene	µg/kg	5.0	<5.0	<5.0	<5.0	<5.0	<5.0
2-Methylnaphthalene	µg/kg	5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Acenaphthylene	µg/kg	5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Acenaphthene	µg/kg	5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Fluorene	µg/kg	5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Phenanthrene	µg/kg	5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Anthracene	µg/kg	5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Fluoranthene	µg/kg	5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Pyrene	µg/kg	5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Benzo(a)anthracene	µg/kg	5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Chrysene	µg/kg	5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Benzo(b,j,k)fluoranthene	µg/kg	10	<10	<10	<10	<10	<10
Benzo(e)pyrene	µg/kg	5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Benzo(a)pyrene	µg/kg	5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Perylene	µg/kg	5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Indeno(1,2,3-c,d)pyrene	µg/kg	5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Dibenzo(a,h)anthracene	µg/kg	5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Benzo(g,h,i)perylene	µg/kg	5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Coronene	µg/kg	5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Surrogate p-Terphenyl-D14	%		*66.9*	*64.9*	*75.7*	*63.2*	*63.2*

Polycyclic Aromatic Hydrocarbons - NAGD (Sediment)

Envirolab ID	**Units**	**PQL**	PEK0250-11	PEK0250-12	PEK0250-13	PEK0250-14	PEK0250-15
Your Reference			EPW1	EPW8	EPW11	EPW1	EPW11
Date Sampled			31/10/2023	31/10/2023	31/10/2023	31/10/2023	31/10/2023
Depth			0.00-0.50	0.50-1.00	1.00-1.50	0.50-1.00	0.50-1.00
Naphthalene	µg/kg	5.0	<5.0	<5.0	<5.0	<5.0	<5.0
2-Methylnaphthalene	µg/kg	5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Acenaphthylene	µg/kg	5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Acenaphthene	µg/kg	5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Fluorene	µg/kg	5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Phenanthrene	µg/kg	5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Anthracene	µg/kg	5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Fluoranthene	µg/kg	5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Pyrene	µg/kg	5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Benzo(a)anthracene	µg/kg	5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Chrysene	µg/kg	5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Benzo(b,j,k)fluoranthene	µg/kg	10	<10	<10	<10	<10	<10
Benzo(e)pyrene	µg/kg	5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Benzo(a)pyrene	µg/kg	5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Perylene	µg/kg	5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Indeno(1,2,3-c,d)pyrene	µg/kg	5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Dibenzo(a,h)anthracene	µg/kg	5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Benzo(g,h,i)perylene	µg/kg	5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Coronene	µg/kg	5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Surrogate p-Terphenyl-D14	%		*72.4*	*71.2*	*67.3*	*74.7*	*66.4*

Envirolab ID	**Units**	**PQL**	PEK0250-16	PEK0250-17	PEK0250-18	PEK0250-19	PEK0250-20
Your Reference			EPW11	EPW2	EPW12	EPW4	EPW8
Date Sampled			31/10/2023	31/10/2023	31/10/2023	31/10/2023	31/10/2023
Depth			0.00-0.50	0.00-0.50	0.00-0.50	0.00-0.50	0.00-0.50
Naphthalene	µg/kg	5.0	<5.0	<5.0	<5.0	<5.0	<5.0
2-Methylnaphthalene	µg/kg	5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Acenaphthylene	µg/kg	5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Acenaphthene	µg/kg	5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Fluorene	µg/kg	5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Phenanthrene	µg/kg	5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Anthracene	µg/kg	5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Fluoranthene	µg/kg	5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Pyrene	µg/kg	5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Benzo(a)anthracene	µg/kg	5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Chrysene	µg/kg	5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Benzo(b,j,k)fluoranthene	µg/kg	10	<10	<10	<10	<10	<10
Benzo(e)pyrene	µg/kg	5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Benzo(a)pyrene	µg/kg	5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Perylene	µg/kg	5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Indeno(1,2,3-c,d)pyrene	µg/kg	5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Dibenzo(a,h)anthracene	µg/kg	5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Benzo(g,h,i)perylene	µg/kg	5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Coronene	µg/kg	5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Surrogate p-Terphenyl-D14	%		*69.1*	*83.0*	*74.6*	*80.2*	*72.6*

Certificate of Analysis PEK0250

Polycyclic Aromatic Hydrocarbons - NAGD (Sediment)

Envirolab ID	Units	PQL	PEK0250-23	PEK0250-24
Your Reference			EPW8A	EPW8A
Date Sampled			31/10/2023	31/10/2023
Depth			0.00-0.50	0.50-1.00
Naphthalene	µg/kg	5.0	<5.0	<5.0
2-Methylnaphthalene	µg/kg	5.0	<5.0	<5.0
Acenaphthylene	µg/kg	5.0	<5.0	<5.0
Acenaphthene	µg/kg	5.0	<5.0	<5.0
Fluorene	µg/kg	5.0	<5.0	<5.0
Phenanthrene	µg/kg	5.0	<5.0	<5.0
Anthracene	µg/kg	5.0	<5.0	<5.0
Fluoranthene	µg/kg	5.0	<5.0	<5.0
Pyrene	µg/kg	5.0	<5.0	<5.0
Benzo(a)anthracene	µg/kg	5.0	<5.0	<5.0
Chrysene	µg/kg	5.0	<5.0	<5.0
Benzo(b,j,k)fluoranthene	µg/kg	10	<10	<10
Benzo(e)pyrene	µg/kg	5.0	<5.0	<5.0
Benzo(a)pyrene	µg/kg	5.0	<5.0	<5.0
Perylene	µg/kg	5.0	<5.0	<5.0
Indeno(1,2,3-c,d)pyrene	µg/kg	5.0	<5.0	<5.0
Dibenzo(a,h)anthracene	µg/kg	5.0	<5.0	<5.0
Benzo(g,h,i)perylene	µg/kg	5.0	<5.0	<5.0
Coronene	µg/kg	5.0	<5.0	<5.0
Surrogate p-Terphenyl-D14	%		*85.8*	*72.8*

Organochlorine Pesticides - NAGD (Sediment)

Envirolab ID	Units	PQL	PEK0250-01	PEK0250-02	PEK0250-03	PEK0250-04	PEK0250-05
Your Reference			EPW6	EPW5	EPW10	EPW10	EPW7
Date Sampled			31/10/2023	31/10/2023	31/10/2023	31/10/2023	31/10/2023
Depth			0.00-0.50	0.00-0.50	0.00-0.50	0.50-1.00	0.50-1.00
alpha-BHC	µg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Hexachlorobenzene	µg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
beta-BHC	µg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
gamma-BHC	µg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
delta-BHC	µg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Heptachlor	µg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Aldrin	µg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Heptachlor epoxide	µg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
trans-Chlordane	µg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
cis-Chlordane	µg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Oxychlordane	µg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Endosulfan I	µg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
4,4'-DDE	µg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Dieldrin	µg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Endrin	µg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
4,4'-DDD	µg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Endosulfan II	µg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
4,4'-DDT	µg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Endosulfan sulfate	µg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Methoxychlor	µg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Surrogate 2-Chlorophenol-D4	%		*53.0 [7]*	*53.5 [7]*	*63.0*	*64.3*	*54.5 [7]*

Envirolab ID	Units	PQL	PEK0250-06	PEK0250-07	PEK0250-08	PEK0250-09	PEK0250-10
Your Reference			EPW6	EPW3	EPW7	EPW7	EPW3
Date Sampled			31/10/2023	31/10/2023	31/10/2023	31/10/2023	31/10/2023
Depth			0.50-1.00	0.50-1.00	0.00-0.50	1.00-1.50	0.00-0.50
alpha-BHC	µg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Hexachlorobenzene	µg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
beta-BHC	µg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
gamma-BHC	µg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
delta-BHC	µg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Heptachlor	µg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Aldrin	µg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Heptachlor epoxide	µg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
trans-Chlordane	µg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
cis-Chlordane	µg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Oxychlordane	µg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Endosulfan I	µg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
4,4'-DDE	µg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Dieldrin	µg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Endrin	µg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
4,4'-DDD	µg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Endosulfan II	µg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
4,4'-DDT	µg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Endosulfan sulfate	µg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Methoxychlor	µg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<1.0

Organochlorine Pesticides - NAGD (Sediment)

Envirolab ID	Units	PQL	PEK0250-06	PEK0250-07	PEK0250-08	PEK0250-09	PEK0250-10
Your Reference			EPW6	EPW3	EPW7	EPW7	EPW3
Date Sampled			31/10/2023	31/10/2023	31/10/2023	31/10/2023	31/10/2023
Depth			0.50-1.00	0.50-1.00	0.00-0.50	1.00-1.50	0.00-0.50
Surrogate 2-Chlorophenol-D4	%		*55.1 [7]*	*85.6*	*62.7*	*## [7]*	*40.7 [7]*

Envirolab ID	Units	PQL	PEK0250-11	PEK0250-12	PEK0250-13	PEK0250-14	PEK0250-15
Your Reference			EPW1	EPW8	EPW11	EPW1	EPW11
Date Sampled			31/10/2023	31/10/2023	31/10/2023	31/10/2023	31/10/2023
Depth			0.00-0.50	0.50-1.00	1.00-1.50	0.50-1.00	0.50-1.00
alpha-BHC	µg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Hexachlorobenzene	µg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
beta-BHC	µg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
gamma-BHC	µg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
delta-BHC	µg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Heptachlor	µg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Aldrin	µg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Heptachlor epoxide	µg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
trans-Chlordane	µg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
cis-Chlordane	µg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Oxychlordane	µg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Endosulfan I	µg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
4,4'-DDE	µg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Dieldrin	µg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Endrin	µg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
4,4'-DDD	µg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Endosulfan II	µg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
4,4'-DDT	µg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Endosulfan sulfate	µg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Methoxychlor	µg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Surrogate 2-Chlorophenol-D4	%		*70.6*	*45.5 [7]*	*68.3*	*37.4 [7]*	*## [7]*

Envirolab ID	Units	PQL	PEK0250-16	PEK0250-17	PEK0250-18	PEK0250-19	PEK0250-20
Your Reference			EPW11	EPW2	EPW12	EPW4	EPW8
Date Sampled			31/10/2023	31/10/2023	31/10/2023	31/10/2023	31/10/2023
Depth			0.00-0.50	0.00-0.50	0.00-0.50	0.00-0.50	0.00-0.50
alpha-BHC	µg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Hexachlorobenzene	µg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
beta-BHC	µg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
gamma-BHC	µg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
delta-BHC	µg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Heptachlor	µg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Aldrin	µg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Heptachlor epoxide	µg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
trans-Chlordane	µg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
cis-Chlordane	µg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Oxychlordane	µg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Endosulfan I	µg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
4,4'-DDE	µg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Dieldrin	µg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Endrin	µg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<1.0

Certificate of Analysis PEK0250

Organochlorine Pesticides - NAGD (Sediment)

Envirolab ID	Units	PQL	PEK0250-16	PEK0250-17	PEK0250-18	PEK0250-19	PEK0250-20
Your Reference			EPW11	EPW2	EPW12	EPW4	EPW8
Date Sampled			31/10/2023	31/10/2023	31/10/2023	31/10/2023	31/10/2023
Depth			0.00-0.50	0.00-0.50	0.00-0.50	0.00-0.50	0.00-0.50
4,4'-DDD	µg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Endosulfan II	µg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
4,4'-DDT	µg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Endosulfan sulfate	µg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Methoxychlor	µg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Surrogate 2-Chlorophenol-D4	%		*45.3 [7]*	*60.9*	*## [7]*	*84.7*	*48.6 [7]*

Envirolab ID	Units	PQL	PEK0250-23	PEK0250-24
Your Reference			EPW8A	EPW8A
Date Sampled			31/10/2023	31/10/2023
Depth			0.00-0.50	0.50-1.00
alpha-BHC	µg/kg	1.0	<1.0	<1.0
Hexachlorobenzene	µg/kg	1.0	<1.0	<1.0
beta-BHC	µg/kg	1.0	<1.0	<1.0
gamma-BHC	µg/kg	1.0	<1.0	<1.0
delta-BHC	µg/kg	1.0	<1.0	<1.0
Heptachlor	µg/kg	1.0	<1.0	<1.0
Aldrin	µg/kg	1.0	<1.0	<1.0
Heptachlor epoxide	µg/kg	1.0	<1.0	<1.0
trans-Chlordane	µg/kg	1.0	<1.0	<1.0
cis-Chlordane	µg/kg	1.0	<1.0	<1.0
Oxychlordane	µg/kg	1.0	<1.0	<1.0
Endosulfan I	µg/kg	1.0	<1.0	<1.0
4,4'-DDE	µg/kg	1.0	<1.0	<1.0
Dieldrin	µg/kg	1.0	<1.0	<1.0
Endrin	µg/kg	1.0	<1.0	<1.0
4,4'-DDD	µg/kg	1.0	<1.0	<1.0
Endosulfan II	µg/kg	1.0	<1.0	<1.0
4,4'-DDT	µg/kg	1.0	<1.0	<1.0
Endosulfan sulfate	µg/kg	1.0	<1.0	<1.0
Methoxychlor	µg/kg	1.0	<1.0	<1.0
Surrogate 2-Chlorophenol-D4	%		*64.8*	*65.6*

Organophosphorus Pesticides - NAGD (Sediment)

Envirolab ID	Units	PQL	PEK0250-01	PEK0250-02	PEK0250-03	PEK0250-04	PEK0250-05
Your Reference			EPW6	EPW5	EPW10	EPW10	EPW7
Date Sampled			31/10/2023	31/10/2023	31/10/2023	31/10/2023	31/10/2023
Depth			0.00-0.50	0.00-0.50	0.00-0.50	0.50-1.00	0.50-1.00
Dichlorvos	µg/kg	50	<50	<50	<50	<50	<50
Dimethoate	µg/kg	50	<50	<50	<50	<50	<50
Diazinon	µg/kg	50	<50	<50	<50	<50	<50
Chlorpyrifos-methyl	µg/kg	50	<50	<50	<50	<50	<50
Ronnel	µg/kg	50	<50	<50	<50	<50	<50
Fenitrothion	µg/kg	50	<50	<50	<50	<50	<50
Malathion	µg/kg	50	<50	<50	<50	<50	<50
Chlorpyrifos	µg/kg	50	<50	<50	<50	<50	<50
Parathion	µg/kg	50	<50	<50	<50	<50	<50
Bromophos-ethyl	µg/kg	50	<50	<50	<50	<50	<50
Ethion	µg/kg	50	<50	<50	<50	<50	<50
Azinphos-methyl	µg/kg	50	<50	<50	<50	<50	<50
Surrogate 2-Chlorophenol-D4	%		*53.0 [7]*	*53.5 [7]*	*63.0*	*64.3*	*54.5 [7]*

Envirolab ID	Units	PQL	PEK0250-06	PEK0250-07	PEK0250-08	PEK0250-09	PEK0250-10
Your Reference			EPW6	EPW3	EPW7	EPW7	EPW3
Date Sampled			31/10/2023	31/10/2023	31/10/2023	31/10/2023	31/10/2023
Depth			0.50-1.00	0.50-1.00	0.00-0.50	1.00-1.50	0.00-0.50
Dichlorvos	µg/kg	50	<50	<50	<50	<50	<50
Dimethoate	µg/kg	50	<50	<50	<50	<50	<50
Diazinon	µg/kg	50	<50	<50	<50	<50	<50
Chlorpyrifos-methyl	µg/kg	50	<50	<50	<50	<50	<50
Ronnel	µg/kg	50	<50	<50	<50	<50	<50
Fenitrothion	µg/kg	50	<50	<50	<50	<50	<50
Malathion	µg/kg	50	<50	<50	<50	<50	<50
Chlorpyrifos	µg/kg	50	<50	<50	<50	<50	<50
Parathion	µg/kg	50	<50	<50	<50	<50	<50
Bromophos-ethyl	µg/kg	50	<50	<50	<50	<50	<50
Ethion	µg/kg	50	<50	<50	<50	<50	<50
Azinphos-methyl	µg/kg	50	<50	<50	<50	<50	<50
Surrogate 2-Chlorophenol-D4	%		*55.1 [7]*	*85.6*	*62.7*	*## [7]*	*40.7 [7]*

Envirolab ID	Units	PQL	PEK0250-11	PEK0250-12	PEK0250-13	PEK0250-14	PEK0250-15
Your Reference			EPW1	EPW8	EPW11	EPW1	EPW11
Date Sampled			31/10/2023	31/10/2023	31/10/2023	31/10/2023	31/10/2023
Depth			0.00-0.50	0.50-1.00	1.00-1.50	0.50-1.00	0.50-1.00
Dichlorvos	µg/kg	50	<50	<50	<50	<50	<50
Dimethoate	µg/kg	50	<50	<50	<50	<50	<50
Diazinon	µg/kg	50	<50	<50	<50	<50	<50
Chlorpyrifos-methyl	µg/kg	50	<50	<50	<50	<50	<50
Ronnel	µg/kg	50	<50	<50	<50	<50	<50
Fenitrothion	µg/kg	50	<50	<50	<50	<50	<50
Malathion	µg/kg	50	<50	<50	<50	<50	<50
Chlorpyrifos	µg/kg	50	<50	<50	<50	<50	<50
Parathion	µg/kg	50	<50	<50	<50	<50	<50
Bromophos-ethyl	µg/kg	50	<50	<50	<50	<50	<50
Ethion	µg/kg	50	<50	<50	<50	<50	<50

Organophosphorus Pesticides - NAGD (Sediment)

Envirolab ID	Units	PQL	PEK0250-11	PEK0250-12	PEK0250-13	PEK0250-14	PEK0250-15
Your Reference			EPW1	EPW8	EPW11	EPW1	EPW11
Date Sampled			31/10/2023	31/10/2023	31/10/2023	31/10/2023	31/10/2023
Depth			0.00-0.50	0.50-1.00	1.00-1.50	0.50-1.00	0.50-1.00
Azinphos-methyl	µg/kg	50	<50	<50	<50	<50	<50
Surrogate 2-Chlorophenol-D4	%		*70.6*	*45.5 [7]*	*68.3*	*37.4 [7]*	*## [7]*

Envirolab ID	Units	PQL	PEK0250-16	PEK0250-17	PEK0250-18	PEK0250-19	PEK0250-20
Your Reference			EPW11	EPW2	EPW12	EPW4	EPW8
Date Sampled			31/10/2023	31/10/2023	31/10/2023	31/10/2023	31/10/2023
Depth			0.00-0.50	0.00-0.50	0.00-0.50	0.00-0.50	0.00-0.50
Dichlorvos	µg/kg	50	<50	<50	<50	<50	<50
Dimethoate	µg/kg	50	<50	<50	<50	<50	<50
Diazinon	µg/kg	50	<50	<50	<50	<50	<50
Chlorpyrifos-methyl	µg/kg	50	<50	<50	<50	<50	<50
Ronnel	µg/kg	50	<50	<50	<50	<50	<50
Fenitrothion	µg/kg	50	<50	<50	<50	<50	<50
Malathion	µg/kg	50	<50	<50	<50	<50	<50
Chlorpyrifos	µg/kg	50	<50	<50	<50	<50	<50
Parathion	µg/kg	50	<50	<50	<50	<50	<50
Bromophos-ethyl	µg/kg	50	<50	<50	<50	<50	<50
Ethion	µg/kg	50	<50	<50	<50	<50	<50
Azinphos-methyl	µg/kg	50	<50	<50	<50	<50	<50
Surrogate 2-Chlorophenol-D4	%		*45.3 [7]*	*60.9*	*## [7]*	*50.5 [7]*	*48.6 [7]*

Envirolab ID	Units	PQL	PEK0250-23	PEK0250-24
Your Reference			EPW8A	EPW8A
Date Sampled			31/10/2023	31/10/2023
Depth			0.00-0.50	0.50-1.00
Dichlorvos	µg/kg	50	<50	<50
Dimethoate	µg/kg	50	<50	<50
Diazinon	µg/kg	50	<50	<50
Chlorpyrifos-methyl	µg/kg	50	<50	<50
Ronnel	µg/kg	50	<50	<50
Fenitrothion	µg/kg	50	<50	<50
Malathion	µg/kg	50	<50	<50
Chlorpyrifos	µg/kg	50	<50	<50
Parathion	µg/kg	50	<50	<50
Bromophos-ethyl	µg/kg	50	<50	<50
Ethion	µg/kg	50	<50	<50
Azinphos-methyl	µg/kg	50	<50	<50
Surrogate 2-Chlorophenol-D4	%		*64.8*	*65.6*

Polychlorinated Biphenyls - Trace Level (Sediment)

Envirolab ID	Units	PQL	PEK0250-23	PEK0250-24
Your Reference			EPW8A	EPW8A
Date Sampled			31/10/2023	31/10/2023
Depth			0.00-0.50	0.50-1.00
Aroclor 1016	µg/kg	5.0	<5.0	<5.0
Aroclor 1221	µg/kg	5.0	<5.0	<5.0
Aroclor 1232	µg/kg	5.0	<5.0	<5.0
Aroclor 1242	µg/kg	5.0	<5.0	<5.0
Aroclor 1248	µg/kg	5.0	<5.0	<5.0
Aroclor 1254	µg/kg	5.0	<5.0	<5.0
Aroclor 1260	µg/kg	5.0	<5.0	<5.0
Total +ve PCB (1016-1260)	µg/kg	5.0	<5.0	<5.0
PCB C103	µg/kg		0.0	0.0
Surrogate 2-Fluorobiphenyl	%		*62.0*	*64.6*

Certificate of Analysis PEK0250

Polychlorinated Biphenyls - NAGD (Sediment)

Envirolab ID	Units	PQL	PEK0250-01	PEK0250-02	PEK0250-03	PEK0250-04	PEK0250-05
Your Reference			EPW6	EPW5	EPW10	EPW10	EPW7
Date Sampled			31/10/2023	31/10/2023	31/10/2023	31/10/2023	31/10/2023
Depth			0.00-0.50	0.00-0.50	0.00-0.50	0.50-1.00	0.50-1.00
Total PCBs	µg/kg	5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Surrogate 2-Fluorobiphenyl	%		*61.5*	*64.0*	*63.4*	*64.5*	*63.8*

Envirolab ID	Units	PQL	PEK0250-06	PEK0250-07	PEK0250-08	PEK0250-09	PEK0250-10
Your Reference			EPW6	EPW3	EPW7	EPW7	EPW3
Date Sampled			31/10/2023	31/10/2023	31/10/2023	31/10/2023	31/10/2023
Depth			0.50-1.00	0.50-1.00	0.00-0.50	1.00-1.50	0.00-0.50
Total PCBs	µg/kg	5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Surrogate 2-Fluorobiphenyl	%		*63.1*	*62.9*	*68.1*	*66.0*	*65.3*

Envirolab ID	Units	PQL	PEK0250-11	PEK0250-12	PEK0250-13	PEK0250-14	PEK0250-15
Your Reference			EPW1	EPW8	EPW11	EPW1	EPW11
Date Sampled			31/10/2023	31/10/2023	31/10/2023	31/10/2023	31/10/2023
Depth			0.00-0.50	0.50-1.00	1.00-1.50	0.50-1.00	0.50-1.00
Total PCBs	µg/kg	5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Surrogate 2-Fluorobiphenyl	%		*65.3*	*60.9*	*64.0*	*63.9*	*63.4*

Envirolab ID	Units	PQL	PEK0250-16	PEK0250-17	PEK0250-18	PEK0250-19	PEK0250-20
Your Reference			EPW11	EPW2	EPW12	EPW4	EPW8
Date Sampled			31/10/2023	31/10/2023	31/10/2023	31/10/2023	31/10/2023
Depth			0.00-0.50	0.00-0.50	0.00-0.50	0.00-0.50	0.00-0.50
Total PCBs	µg/kg	5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Surrogate 2-Fluorobiphenyl	%		*65.9*	*64.9*	*67.8*	*63.9*	*64.0*

Envirolab ID	Units	PQL	PEK0250-23	PEK0250-24
Your Reference			EPW8A	EPW8A
Date Sampled			31/10/2023	31/10/2023
Depth			0.00-0.50	0.50-1.00
Total PCBs	µg/kg	5.0	<5.0	<5.0
Surrogate 2-Fluorobiphenyl	%		*62.0*	*64.6*

Certificate of Analysis PEK0250

Semi Volatile Organic Compounds (Sediment)

Envirolab ID	Units	PQL	PEK0250-01	PEK0250-02	PEK0250-03	PEK0250-04	PEK0250-05
Your Reference			EPW6	EPW5	EPW10	EPW10	EPW7
Date Sampled			31/10/2023	31/10/2023	31/10/2023	31/10/2023	31/10/2023
Depth			0.00-0.50	0.00-0.50	0.00-0.50	0.50-1.00	0.50-1.00
Pentachloroethane	µg/kg	10	<10	<10	<10	<10	<10
1,3-Dichlorobenzene	µg/kg	10	<10	<10	<10	<10	<10
1,4-Dichlorobenzene	µg/kg	10	<10	<10	<10	<10	<10
1,2-Dichlorobenzene	µg/kg	10	<10	<10	<10	<10	<10
Hexachloroethane	µg/kg	10	<10	<10	<10	<10	<10
1,3,5-Trichlorobenzene	µg/kg	10	<10	<10	<10	<10	<10
1,2,4-Trichlorobenzene	µg/kg	10	<10	<10	<10	<10	<10
Hexachloropropene	µg/kg	10	<10	<10	<10	<10	<10
Hexachlorobutadiene	µg/kg	10	<10	<10	<10	<10	<10
1,2,3-Trichlorobenzene	µg/kg	10	<10	<10	<10	<10	<10
Hexachlorocyclopentadiene	µg/kg	100	<100	<100	<100	<100	<100
1,2,3,5-Tetrachlorobenzene	µg/kg	10	<10	<10	<10	<10	<10
1,2,4,5-Tetrachlorobenzene	µg/kg	10	<10	<10	<10	<10	<10
1,2,3,4-Tetrachlorobenzene	µg/kg	10	<10	<10	<10	<10	<10
Pentachlorobenzene	µg/kg	10	<10	<10	<10	<10	<10
Hexachlorobenzene	µg/kg	10	<10	<10	<10	<10	<10
Surrogate p-Terphenyl-D14	%		*79.9*	*76.5*	*77.5*	*75.7*	*70.9*

Envirolab ID	Units	PQL	PEK0250-06	PEK0250-07	PEK0250-08	PEK0250-09	PEK0250-10
Your Reference			EPW6	EPW3	EPW7	EPW7	EPW3
Date Sampled			31/10/2023	31/10/2023	31/10/2023	31/10/2023	31/10/2023
Depth			0.50-1.00	0.50-1.00	0.00-0.50	1.00-1.50	0.00-0.50
Pentachloroethane	µg/kg	10	<10	<10	<10	<10	<10
1,3-Dichlorobenzene	µg/kg	10	<10	<10	<10	<10	<10
1,4-Dichlorobenzene	µg/kg	10	<10	<10	<10	<10	<10
1,2-Dichlorobenzene	µg/kg	10	<10	<10	<10	<10	<10
Hexachloroethane	µg/kg	10	<10	<10	<10	<10	<10
1,3,5-Trichlorobenzene	µg/kg	10	<10	<10	<10	<10	<10
1,2,4-Trichlorobenzene	µg/kg	10	<10	<10	<10	<10	<10
Hexachloropropene	µg/kg	10	<10	<10	<10	<10	<10
Hexachlorobutadiene	µg/kg	10	<10	<10	<10	<10	<10
1,2,3-Trichlorobenzene	µg/kg	10	<10	<10	<10	<10	<10
Hexachlorocyclopentadiene	µg/kg	100	<100	<100	<100	<100	<100
1,2,3,5-Tetrachlorobenzene	µg/kg	10	<10	<10	<10	<10	<10
1,2,4,5-Tetrachlorobenzene	µg/kg	10	<10	<10	<10	<10	<10
1,2,3,4-Tetrachlorobenzene	µg/kg	10	<10	<10	<10	<10	<10
Pentachlorobenzene	µg/kg	10	<10	<10	<10	<10	<10
Hexachlorobenzene	µg/kg	10	<10	<10	<10	<10	<10
Surrogate p-Terphenyl-D14	%		*66.9*	*64.9*	*75.7*	*63.2*	*63.2*

Envirolab ID	Units	PQL	PEK0250-11	PEK0250-12	PEK0250-13	PEK0250-14	PEK0250-15
Your Reference			EPW1	EPW8	EPW11	EPW1	EPW11
Date Sampled			31/10/2023	31/10/2023	31/10/2023	31/10/2023	31/10/2023
Depth			0.00-0.50	0.50-1.00	1.00-1.50	0.50-1.00	0.50-1.00
Pentachloroethane	µg/kg	10	<10	<10	<10	<10	<10
1,3-Dichlorobenzene	µg/kg	10	<10	<10	<10	<10	<10
1,4-Dichlorobenzene	µg/kg	10	<10	<10	<10	<10	<10

Semi Volatile Organic Compounds (Sediment)

Envirolab ID	Units	PQL	PEK0250-11	PEK0250-12	PEK0250-13	PEK0250-14	PEK0250-15
Your Reference			EPW1	EPW8	EPW11	EPW1	EPW11
Date Sampled			31/10/2023	31/10/2023	31/10/2023	31/10/2023	31/10/2023
Depth			0.00-0.50	0.50-1.00	1.00-1.50	0.50-1.00	0.50-1.00
1,2-Dichlorobenzene	µg/kg	10	<10	<10	<10	<10	<10
Hexachloroethane	µg/kg	10	<10	<10	<10	<10	<10
1,3,5-Trichlorobenzene	µg/kg	10	<10	<10	<10	<10	<10
1,2,4-Trichlorobenzene	µg/kg	10	<10	<10	<10	<10	<10
Hexachloropropene	µg/kg	10	<10	<10	<10	<10	<10
Hexachlorobutadiene	µg/kg	10	<10	<10	<10	<10	<10
1,2,3-Trichlorobenzene	µg/kg	10	<10	<10	<10	<10	<10
Hexachlorocyclopentadiene	µg/kg	100	<100	<100	<100	<100	<100
1,2,3,5-Tetrachlorobenzene	µg/kg	10	<10	<10	<10	<10	<10
1,2,4,5-Tetrachlorobenzene	µg/kg	10	<10	<10	<10	<10	<10
1,2,3,4-Tetrachlorobenzene	µg/kg	10	<10	<10	<10	<10	<10
Pentachlorobenzene	µg/kg	10	<10	<10	<10	<10	<10
Hexachlorobenzene	µg/kg	10	<10	<10	<10	<10	<10
Surrogate p-Terphenyl-D14	%		*72.4*	*71.2*	*67.3*	*74.7*	*66.4*

Envirolab ID	Units	PQL	PEK0250-16	PEK0250-17	PEK0250-18	PEK0250-19	PEK0250-20
Your Reference			EPW11	EPW2	EPW12	EPW4	EPW8
Date Sampled			31/10/2023	31/10/2023	31/10/2023	31/10/2023	31/10/2023
Depth			0.00-0.50	0.00-0.50	0.00-0.50	0.00-0.50	0.00-0.50
Pentachloroethane	µg/kg	10	<10	<10	<10	<10	<10
1,3-Dichlorobenzene	µg/kg	10	<10	<10	<10	<10	<10
1,4-Dichlorobenzene	µg/kg	10	<10	<10	<10	<10	<10
1,2-Dichlorobenzene	µg/kg	10	<10	<10	<10	<10	<10
Hexachloroethane	µg/kg	10	<10	<10	<10	<10	<10
1,3,5-Trichlorobenzene	µg/kg	10	<10	<10	<10	<10	<10
1,2,4-Trichlorobenzene	µg/kg	10	<10	<10	<10	<10	<10
Hexachloropropene	µg/kg	10	<10	<10	<10	<10	<10
Hexachlorobutadiene	µg/kg	10	<10	<10	<10	<10	<10
1,2,3-Trichlorobenzene	µg/kg	10	<10	<10	<10	<10	<10
Hexachlorocyclopentadiene	µg/kg	100	<100	<100	<100	<100	<100
1,2,3,5-Tetrachlorobenzene	µg/kg	10	<10	<10	<10	<10	<10
1,2,4,5-Tetrachlorobenzene	µg/kg	10	<10	<10	<10	<10	<10
1,2,3,4-Tetrachlorobenzene	µg/kg	10	<10	<10	<10	<10	<10
Pentachlorobenzene	µg/kg	10	<10	<10	<10	<10	<10
Hexachlorobenzene	µg/kg	10	<10	<10	<10	<10	<10
Surrogate p-Terphenyl-D14	%		*69.1*	*83.0*	*74.6*	*80.2*	*72.6*

Envirolab ID	Units	PQL	PEK0250-23	PEK0250-24
Your Reference			EPW8A	EPW8A
Date Sampled			31/10/2023	31/10/2023
Depth			0.00-0.50	0.50-1.00
Pentachloroethane	µg/kg	10	<10	<10
1,3-Dichlorobenzene	µg/kg	10	<10	<10
1,4-Dichlorobenzene	µg/kg	10	<10	<10
1,2-Dichlorobenzene	µg/kg	10	<10	<10
Hexachloroethane	µg/kg	10	<10	<10
1,3,5-Trichlorobenzene	µg/kg	10	<10	<10

Certificate of Analysis PEK0250

Semi Volatile Organic Compounds (Sediment)

Envirolab ID	Units	PQL	PEK0250-23	PEK0250-24
Your Reference			EPW8A	EPW8A
Date Sampled			31/10/2023	31/10/2023
Depth			0.00-0.50	0.50-1.00
1,2,4-Trichlorobenzene	µg/kg	10	<10	<10
Hexachloropropene	µg/kg	10	<10	<10
Hexachlorobutadiene	µg/kg	10	<10	<10
1,2,3-Trichlorobenzene	µg/kg	10	<10	<10
Hexachlorocyclopentadiene	µg/kg	100	<100	<100
1,2,3,5-Tetrachlorobenzene	µg/kg	10	<10	<10
1,2,4,5-Tetrachlorobenzene	µg/kg	10	<10	<10
1,2,3,4-Tetrachlorobenzene	µg/kg	10	<10	<10
Pentachlorobenzene	µg/kg	10	<10	<10
Hexachlorobenzene	µg/kg	10	<10	<10
Surrogate p-Terphenyl-D14	%		*85.8*	*72.8*

Speciated Phenols (Sediment)

Envirolab ID	Units	PQL	PEK0250-01	PEK0250-02	PEK0250-03	PEK0250-04	PEK0250-05
Your Reference			EPW6	EPW5	EPW10	EPW10	EPW7
Date Sampled			31/10/2023	31/10/2023	31/10/2023	31/10/2023	31/10/2023
Depth			0.00-0.50	0.00-0.50	0.00-0.50	0.50-1.00	0.50-1.00
Phenol	mg/kg	0.20	<0.20	<0.20	<0.20	<0.20	<0.20
2-Chlorophenol	mg/kg	0.20	<0.20	<0.20	<0.20	<0.20	<0.20
2-Methylphenol	mg/kg	0.20	<0.20	<0.20	<0.20	<0.20	<0.20
3/4-Methylphenol	mg/kg	0.40	<0.40	<0.40	<0.40	<0.40	<0.40
2-Nitrophenol	mg/kg	0.20	<0.20	<0.20	<0.20	<0.20	<0.20
2,4-Dimethylphenol	mg/kg	0.20	<0.20	<0.20	<0.20	<0.20	<0.20
2,4-Dichlorophenol	mg/kg	0.20	<0.20	<0.20	<0.20	<0.20	<0.20
2,6-Dichlorophenol	mg/kg	0.20	<0.20	<0.20	<0.20	<0.20	<0.20
4-Chloro-3-methylphenol	mg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
2,4,6-Trichlorophenol	mg/kg	0.20	<0.20	<0.20	<0.20	<0.20	<0.20
2,4,5-Trichlorophenol	mg/kg	0.20	<0.20	<0.20	<0.20	<0.20	<0.20
2,4-Dinitrophenol	mg/kg	4.0	<4.0	<4.0	<4.0	<4.0	<4.0
4-Nitrophenol	mg/kg	4.0	<4.0	<4.0	<4.0	<4.0	<4.0
2,3,4,5 & 2,3,4,6-Tetrachlorophenol	mg/kg	0.40	<0.40	<0.40	<0.40	<0.40	<0.40
2,3,5,6-Tetrachlorophenol	mg/kg	0.20	<0.20	<0.20	<0.20	<0.20	<0.20
4,6-Dinitro-2-methylphenol	mg/kg	10	<10	<10	<10	<10	<10
Pentachlorophenol	mg/kg	2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Dinoseb	mg/kg	10	<10	<10	<10	<10	<10
2-Cyclohexyl-4,6-Dinitrophenol	mg/kg	20	<20	<20	<20	<20	<20
Surrogate 2-Fluorophenol	%		*101*	*98.5*	*99.4*	*99.8*	*96.9*
Surrogate Phenol-D6	%		*85.4*	*84.4*	*81.3*	*82.2*	*79.0*

Envirolab ID	Units	PQL	PEK0250-06	PEK0250-07	PEK0250-08	PEK0250-09	PEK0250-10
Your Reference			EPW6	EPW3	EPW7	EPW7	EPW3
Date Sampled			31/10/2023	31/10/2023	31/10/2023	31/10/2023	31/10/2023
Depth			0.50-1.00	0.50-1.00	0.00-0.50	1.00-1.50	0.00-0.50
Phenol	mg/kg	0.20	<0.20	<0.20	<0.20	<0.20	<0.20
2-Chlorophenol	mg/kg	0.20	<0.20	<0.20	<0.20	<0.20	<0.20
2-Methylphenol	mg/kg	0.20	<0.20	<0.20	<0.20	<0.20	<0.20
3/4-Methylphenol	mg/kg	0.40	<0.40	<0.40	<0.40	<0.40	<0.40
2-Nitrophenol	mg/kg	0.20	<0.20	<0.20	<0.20	<0.20	<0.20
2,4-Dimethylphenol	mg/kg	0.20	<0.20	<0.20	<0.20	<0.20	<0.20
2,4-Dichlorophenol	mg/kg	0.20	<0.20	<0.20	<0.20	<0.20	<0.20
2,6-Dichlorophenol	mg/kg	0.20	<0.20	<0.20	<0.20	<0.20	<0.20
4-Chloro-3-methylphenol	mg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
2,4,6-Trichlorophenol	mg/kg	0.20	<0.20	<0.20	<0.20	<0.20	<0.20
2,4,5-Trichlorophenol	mg/kg	0.20	<0.20	<0.20	<0.20	<0.20	<0.20
2,4-Dinitrophenol	mg/kg	4.0	<4.0	<4.0	<4.0	<4.0	<4.0
4-Nitrophenol	mg/kg	4.0	<4.0	<4.0	<4.0	<4.0	<4.0
2,3,4,5 & 2,3,4,6-Tetrachlorophenol	mg/kg	0.40	<0.40	<0.40	<0.40	<0.40	<0.40
2,3,5,6-Tetrachlorophenol	mg/kg	0.20	<0.20	<0.20	<0.20	<0.20	<0.20
4,6-Dinitro-2-methylphenol	mg/kg	10	<10	<10	<10	<10	<10
Pentachlorophenol	mg/kg	2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Dinoseb	mg/kg	10	<10	<10	<10	<10	<10
2-Cyclohexyl-4,6-Dinitrophenol	mg/kg	20	<20	<20	<20	<20	<20
Surrogate 2-Fluorophenol	%		*97.0*	*97.5*	*94.8*	*97.1*	*95.5*

Speciated Phenols (Sediment)

Envirolab ID	Units	PQL	PEK0250-06	PEK0250-07	PEK0250-08	PEK0250-09	PEK0250-10
Your Reference			EPW6	EPW3	EPW7	EPW7	EPW3
Date Sampled			31/10/2023	31/10/2023	31/10/2023	31/10/2023	31/10/2023
Depth			0.50-1.00	0.50-1.00	0.00-0.50	1.00-1.50	0.00-0.50
Surrogate Phenol-D6	%		*76.0*	*75.2*	*71.7*	*69.5*	*70.5*

Envirolab ID	Units	PQL	PEK0250-11	PEK0250-12	PEK0250-13	PEK0250-14	PEK0250-15
Your Reference			EPW1	EPW8	EPW11	EPW1	EPW11
Date Sampled			31/10/2023	31/10/2023	31/10/2023	31/10/2023	31/10/2023
Depth			0.00-0.50	0.50-1.00	1.00-1.50	0.50-1.00	0.50-1.00
Phenol	mg/kg	0.20	<0.20	<0.20	<0.20	<0.20	<0.20
2-Chlorophenol	mg/kg	0.20	<0.20	<0.20	<0.20	<0.20	<0.20
2-Methylphenol	mg/kg	0.20	<0.20	<0.20	<0.20	<0.20	<0.20
3/4-Methylphenol	mg/kg	0.40	<0.40	<0.40	<0.40	<0.40	<0.40
2-Nitrophenol	mg/kg	0.20	<0.20	<0.20	<0.20	<0.20	<0.20
2,4-Dimethylphenol	mg/kg	0.20	<0.20	<0.20	<0.20	<0.20	<0.20
2,4-Dichlorophenol	mg/kg	0.20	<0.20	<0.20	<0.20	<0.20	<0.20
2,6-Dichlorophenol	mg/kg	0.20	<0.20	<0.20	<0.20	<0.20	<0.20
4-Chloro-3-methylphenol	mg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
2,4,6-Trichlorophenol	mg/kg	0.20	<0.20	<0.20	<0.20	<0.20	<0.20
2,4,5-Trichlorophenol	mg/kg	0.20	<0.20	<0.20	<0.20	<0.20	<0.20
2,4-Dinitrophenol	mg/kg	4.0	<4.0	<4.0	<4.0	<4.0	<4.0
4-Nitrophenol	mg/kg	4.0	<4.0	<4.0	<4.0	<4.0	<4.0
2,3,4,5 & 2,3,4,6-Tetrachlorophenol	mg/kg	0.40	<0.40	<0.40	<0.40	<0.40	<0.40
2,3,5,6-Tetrachlorophenol	mg/kg	0.20	<0.20	<0.20	<0.20	<0.20	<0.20
4,6-Dinitro-2-methylphenol	mg/kg	10	<10	<10	<10	<10	<10
Pentachlorophenol	mg/kg	2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Dinoseb	mg/kg	10	<10	<10	<10	<10	<10
2-Cyclohexyl-4,6-Dinitrophenol	mg/kg	20	<20	<20	<20	<20	<20
Surrogate 2-Fluorophenol	%		*97.1*	*95.3*	*95.9*	*95.7*	*95.6*
Surrogate Phenol-D6	%		*69.1*	*67.2*	*65.6*	*67.9*	*64.1*

Envirolab ID	Units	PQL	PEK0250-16	PEK0250-17	PEK0250-18	PEK0250-19	PEK0250-20
Your Reference			EPW11	EPW2	EPW12	EPW4	EPW8
Date Sampled			31/10/2023	31/10/2023	31/10/2023	31/10/2023	31/10/2023
Depth			0.00-0.50	0.00-0.50	0.00-0.50	0.00-0.50	0.00-0.50
Phenol	mg/kg	0.20	<0.20	<0.20	<0.20	<0.20	<0.20
2-Chlorophenol	mg/kg	0.20	<0.20	<0.20	<0.20	<0.20	<0.20
2-Methylphenol	mg/kg	0.20	<0.20	<0.20	<0.20	<0.20	<0.20
3/4-Methylphenol	mg/kg	0.40	<0.40	<0.40	<0.40	<0.40	<0.40
2-Nitrophenol	mg/kg	0.20	<0.20	<0.20	<0.20	<0.20	<0.20
2,4-Dimethylphenol	mg/kg	0.20	<0.20	<0.20	<0.20	<0.20	<0.20
2,4-Dichlorophenol	mg/kg	0.20	<0.20	<0.20	<0.20	<0.20	<0.20
2,6-Dichlorophenol	mg/kg	0.20	<0.20	<0.20	<0.20	<0.20	<0.20
4-Chloro-3-methylphenol	mg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
2,4,6-Trichlorophenol	mg/kg	0.20	<0.20	<0.20	<0.20	<0.20	<0.20
2,4,5-Trichlorophenol	mg/kg	0.20	<0.20	<0.20	<0.20	<0.20	<0.20
2,4-Dinitrophenol	mg/kg	4.0	<4.0	<4.0	<4.0	<4.0	<4.0
4-Nitrophenol	mg/kg	4.0	<4.0	<4.0	<4.0	<4.0	<4.0
2,3,4,5 & 2,3,4,6-Tetrachlorophenol	mg/kg	0.40	<0.40	<0.40	<0.40	<0.40	<0.40
2,3,5,6-Tetrachlorophenol	mg/kg	0.20	<0.20	<0.20	<0.20	<0.20	<0.20

Speciated Phenols (Sediment)

Envirolab ID	Units	PQL	PEK0250-16	PEK0250-17	PEK0250-18	PEK0250-19	PEK0250-20
Your Reference			EPW11	EPW2	EPW12	EPW4	EPW8
Date Sampled			31/10/2023	31/10/2023	31/10/2023	31/10/2023	31/10/2023
Depth			0.00-0.50	0.00-0.50	0.00-0.50	0.00-0.50	0.00-0.50
4,6-Dinitro-2-methylphenol	mg/kg	10	<10	<10	<10	<10	<10
Pentachlorophenol	mg/kg	2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Dinoseb	mg/kg	10	<10	<10	<10	<10	<10
2-Cyclohexyl-4,6-Dinitrophenol	mg/kg	20	<20	<20	<20	<20	<20
Surrogate 2-Fluorophenol	%		*97.9*	*96.9*	*96.7*	*97.5*	*98.1*
Surrogate Phenol-D6	%		*70.4*	*67.3*	*69.3*	*65.5*	*65.7*

Envirolab ID	Units	PQL	PEK0250-23	PEK0250-24
Your Reference			EPW8A	EPW8A
Date Sampled			31/10/2023	31/10/2023
Depth			0.00-0.50	0.50-1.00
Phenol	mg/kg	0.20	<0.20	<0.20
2-Chlorophenol	mg/kg	0.20	<0.20	<0.20
2-Methylphenol	mg/kg	0.20	<0.20	<0.20
3/4-Methylphenol	mg/kg	0.40	<0.40	<0.40
2-Nitrophenol	mg/kg	0.20	<0.20	<0.20
2,4-Dimethylphenol	mg/kg	0.20	<0.20	<0.20
2,4-Dichlorophenol	mg/kg	0.20	<0.20	<0.20
2,6-Dichlorophenol	mg/kg	0.20	<0.20	<0.20
4-Chloro-3-methylphenol	mg/kg	1.0	<1.0	<1.0
2,4,6-Trichlorophenol	mg/kg	0.20	<0.20	<0.20
2,4,5-Trichlorophenol	mg/kg	0.20	<0.20	<0.20
2,4-Dinitrophenol	mg/kg	4.0	<4.0	<4.0
4-Nitrophenol	mg/kg	4.0	<4.0	<4.0
2,3,4,5 & 2,3,4,6-Tetrachlorophenol	mg/kg	0.40	<0.40	<0.40
2,3,5,6-Tetrachlorophenol	mg/kg	0.20	<0.20	<0.20
4,6-Dinitro-2-methylphenol	mg/kg	10	<10	<10
Pentachlorophenol	mg/kg	2.0	<2.0	<2.0
Dinoseb	mg/kg	10	<10	<10
2-Cyclohexyl-4,6-Dinitrophenol	mg/kg	20	<20	<20
Surrogate 2-Fluorophenol	%		*98.5*	*98.3*
Surrogate Phenol-D6	%		*67.3*	*66.9*

Synthetic Pyrethroids (Sediment)

Envirolab ID	Units	PQL	PEK0250-01	PEK0250-02	PEK0250-03	PEK0250-04	PEK0250-05
Your Reference			EPW6	EPW5	EPW10	EPW10	EPW7
Date Sampled			31/10/2023	31/10/2023	31/10/2023	31/10/2023	31/10/2023
Depth			0.00-0.50	0.00-0.50	0.00-0.50	0.50-1.00	0.50-1.00
Bifenthrin	µg/kg	10	<10	<10	<10	<10	<10
lamda-Cyhalothrin	µg/kg	10	<10	<10	<10	<10	<10
cis-Permethrin	µg/kg	10	<10	<10	<10	<10	<10
trans-Permethrin	µg/kg	10	<10	<10	<10	<10	<10
Cyfluthrin	µg/kg	100	<100	<100	<100	<100	<100
Cypermethrin	µg/kg	100	<100	<100	<100	<100	<100
Esfenvalerate	µg/kg	10	<10	<10	<10	<10	<10
Deltamethrin	µg/kg	10	<10	<10	<10	<10	<10
Surrogate p-Terphenyl-D14	%		*79.9*	*76.5*	*77.5*	*75.7*	*70.9*

Envirolab ID	Units	PQL	PEK0250-06	PEK0250-07	PEK0250-08	PEK0250-09	PEK0250-10
Your Reference			EPW6	EPW3	EPW7	EPW7	EPW3
Date Sampled			31/10/2023	31/10/2023	31/10/2023	31/10/2023	31/10/2023
Depth			0.50-1.00	0.50-1.00	0.00-0.50	1.00-1.50	0.00-0.50
Bifenthrin	µg/kg	10	<10	<10	<10	<10	<10
lamda-Cyhalothrin	µg/kg	10	<10	<10	<10	<10	<10
cis-Permethrin	µg/kg	10	<10	<10	<10	<10	<10
trans-Permethrin	µg/kg	10	<10	<10	<10	<10	<10
Cyfluthrin	µg/kg	100	<100	<100	<100	<100	<100
Cypermethrin	µg/kg	100	<100	<100	<100	<100	<100
Esfenvalerate	µg/kg	10	<10	<10	<10	<10	<10
Deltamethrin	µg/kg	10	<10	<10	<10	<10	<10
Surrogate p-Terphenyl-D14	%		*66.9*	*64.9*	*75.7*	*63.2*	*63.2*

Envirolab ID	Units	PQL	PEK0250-11	PEK0250-12	PEK0250-13	PEK0250-14	PEK0250-15
Your Reference			EPW1	EPW8	EPW11	EPW1	EPW11
Date Sampled			31/10/2023	31/10/2023	31/10/2023	31/10/2023	31/10/2023
Depth			0.00-0.50	0.50-1.00	1.00-1.50	0.50-1.00	0.50-1.00
Bifenthrin	µg/kg	10	<10	<10	<10	<10	<10
lamda-Cyhalothrin	µg/kg	10	<10	<10	<10	<10	<10
cis-Permethrin	µg/kg	10	<10	<10	<10	<10	<10
trans-Permethrin	µg/kg	10	<10	<10	<10	<10	<10
Cyfluthrin	µg/kg	100	<100	<100	<100	<100	<100
Cypermethrin	µg/kg	100	<100	<100	<100	<100	<100
Esfenvalerate	µg/kg	10	<10	<10	<10	<10	<10
Deltamethrin	µg/kg	10	<10	<10	<10	<10	<10
Surrogate p-Terphenyl-D14	%		*72.4*	*71.2*	*67.3*	*74.7*	*66.4*

Envirolab ID	Units	PQL	PEK0250-16	PEK0250-17	PEK0250-18	PEK0250-19	PEK0250-20
Your Reference			EPW11	EPW2	EPW12	EPW4	EPW8
Date Sampled			31/10/2023	31/10/2023	31/10/2023	31/10/2023	31/10/2023
Depth			0.00-0.50	0.00-0.50	0.00-0.50	0.00-0.50	0.00-0.50
Bifenthrin	µg/kg	10	<10	<10	<10	15	<10
lamda-Cyhalothrin	µg/kg	10	<10	<10	<10	14	<10
cis-Permethrin	µg/kg	10	<10	<10	<10	<10	<10
trans-Permethrin	µg/kg	10	<10	<10	<10	<10	<10
Cyfluthrin	µg/kg	100	<100	<100	<100	<100	<100
Cypermethrin	µg/kg	100	<100	<100	<100	<100	<100

Synthetic Pyrethroids (Sediment)

Envirolab ID	Units	PQL	PEK0250-16	PEK0250-17	PEK0250-18	PEK0250-19	PEK0250-20
Your Reference			EPW11	EPW2	EPW12	EPW4	EPW8
Date Sampled			31/10/2023	31/10/2023	31/10/2023	31/10/2023	31/10/2023
Depth			0.00-0.50	0.00-0.50	0.00-0.50	0.00-0.50	0.00-0.50
Esfenvalerate	µg/kg	10	<10	<10	<10	<10	<10
Deltamethrin	µg/kg	10	<10	<10	<10	<10	<10
Surrogate p-Terphenyl-D14	%		*69.1*	*83.0*	*74.6*	*80.2*	*72.6*

Envirolab ID	Units	PQL	PEK0250-23	PEK0250-24
Your Reference			EPW8A	EPW8A
Date Sampled			31/10/2023	31/10/2023
Depth			0.00-0.50	0.50-1.00
Bifenthrin	µg/kg	10	<10	<10
lamda-Cyhalothrin	µg/kg	10	<10	<10
cis-Permethrin	µg/kg	10	<10	<10
trans-Permethrin	µg/kg	10	<10	<10
Cyfluthrin	µg/kg	100	<100	<100
Cypermethrin	µg/kg	100	<100	<100
Esfenvalerate	µg/kg	10	<10	<10
Deltamethrin	µg/kg	10	<10	<10
Surrogate p-Terphenyl-D14	%		*85.8*	*72.8*

Carbamates (Sediment)

Envirolab ID	Units	PQL	PEK0250-01	PEK0250-02	PEK0250-03	PEK0250-04	PEK0250-05
Your Reference			EPW6	EPW5	EPW10	EPW10	EPW7
Date Sampled			31/10/2023	31/10/2023	31/10/2023	31/10/2023	31/10/2023
Depth			0.00-0.50	0.00-0.50	0.00-0.50	0.50-1.00	0.50-1.00
Molinate	µg/kg	10	<10	<10	<10	<10	<10
Carbofuran	µg/kg	10	<10	<10	<10	<10	<10
Carbaryl	µg/kg	10	<10	<10	<10	<10	<10
Surrogate p-Terphenyl-D14	%		*79.9*	*76.5*	*77.5*	*75.7*	*70.9*

Envirolab ID	Units	PQL	PEK0250-06	PEK0250-07	PEK0250-08	PEK0250-09	PEK0250-10
Your Reference			EPW6	EPW3	EPW7	EPW7	EPW3
Date Sampled			31/10/2023	31/10/2023	31/10/2023	31/10/2023	31/10/2023
Depth			0.50-1.00	0.50-1.00	0.00-0.50	1.00-1.50	0.00-0.50
Molinate	µg/kg	10	<10	<10	<10	<10	<10
Carbofuran	µg/kg	10	<10	<10	<10	<10	<10
Carbaryl	µg/kg	10	<10	<10	<10	<10	<10
Surrogate p-Terphenyl-D14	%		*66.9*	*64.9*	*75.7*	*63.2*	*63.2*

Envirolab ID	Units	PQL	PEK0250-11	PEK0250-12	PEK0250-13	PEK0250-14	PEK0250-15
Your Reference			EPW1	EPW8	EPW11	EPW1	EPW11
Date Sampled			31/10/2023	31/10/2023	31/10/2023	31/10/2023	31/10/2023
Depth			0.00-0.50	0.50-1.00	1.00-1.50	0.50-1.00	0.50-1.00
Molinate	µg/kg	10	<10	<10	<10	<10	<10
Carbofuran	µg/kg	10	<10	<10	<10	<10	<10
Carbaryl	µg/kg	10	<10	<10	<10	<10	<10
Surrogate p-Terphenyl-D14	%		*72.4*	*71.2*	*67.3*	*74.7*	*66.4*

Envirolab ID	Units	PQL	PEK0250-16	PEK0250-17	PEK0250-18	PEK0250-19	PEK0250-20
Your Reference			EPW11	EPW2	EPW12	EPW4	EPW8
Date Sampled			31/10/2023	31/10/2023	31/10/2023	31/10/2023	31/10/2023
Depth			0.00-0.50	0.00-0.50	0.00-0.50	0.00-0.50	0.00-0.50
Molinate	µg/kg	10	<10	<10	<10	<10	<10
Carbofuran	µg/kg	10	<10	<10	<10	<10	<10
Carbaryl	µg/kg	10	<10	<10	<10	<10	<10
Surrogate p-Terphenyl-D14	%		*69.1*	*83.0*	*74.6*	*80.2*	*72.6*

Envirolab ID	Units	PQL	PEK0250-23	PEK0250-24
Your Reference			EPW8A	EPW8A
Date Sampled			31/10/2023	31/10/2023
Depth			0.00-0.50	0.50-1.00
Molinate	µg/kg	10	<10	<10
Carbofuran	µg/kg	10	<10	<10
Carbaryl	µg/kg	10	<10	<10
Surrogate p-Terphenyl-D14	%		*85.8*	*72.8*

Certificate of Analysis PEK0250

Triazine Herbicides (Sediment)

Envirolab ID	Units	PQL	PEK0250-01	PEK0250-02	PEK0250-03	PEK0250-04	PEK0250-05
Your Reference			EPW6	EPW5	EPW10	EPW10	EPW7
Date Sampled			31/10/2023	31/10/2023	31/10/2023	31/10/2023	31/10/2023
Depth			0.00-0.50	0.00-0.50	0.00-0.50	0.50-1.00	0.50-1.00
Simazine	µg/kg	10	<10	<10	<10	<10	<10
Atrazine	µg/kg	10	<10	<10	<10	<10	<10
Propazine	µg/kg	10	<10	<10	<10	<10	<10
Terbuthylazine	µg/kg	10	<10	<10	<10	<10	<10
Metribuzin	µg/kg	50	<50	<50	<50	<50	<50
Ametryn	µg/kg	10	<10	<10	<10	<10	<10
Prometryn	µg/kg	10	<10	<10	<10	<10	<10
Terbutryn	µg/kg	10	<10	<10	<10	<10	<10
Cyanazine	µg/kg	10	<10	<10	<10	<10	<10
Irgarol	µg/kg	10	<10	<10	<10	<10	<10
Hexazinone	µg/kg	10	<10	<10	<10	<10	<10
Surrogate p-Terphenyl-D14	%		*79.9*	*76.5*	*77.5*	*75.7*	*70.9*

Envirolab ID	Units	PQL	PEK0250-06	PEK0250-07	PEK0250-08	PEK0250-09	PEK0250-10
Your Reference			EPW6	EPW3	EPW7	EPW7	EPW3
Date Sampled			31/10/2023	31/10/2023	31/10/2023	31/10/2023	31/10/2023
Depth			0.50-1.00	0.50-1.00	0.00-0.50	1.00-1.50	0.00-0.50
Simazine	µg/kg	10	<10	<10	<10	<10	<10
Atrazine	µg/kg	10	<10	<10	<10	<10	<10
Propazine	µg/kg	10	<10	<10	<10	<10	<10
Terbuthylazine	µg/kg	10	<10	<10	<10	<10	<10
Metribuzin	µg/kg	50	<50	<50	<50	<50	<50
Ametryn	µg/kg	10	<10	<10	<10	<10	<10
Prometryn	µg/kg	10	<10	<10	<10	<10	<10
Terbutryn	µg/kg	10	<10	<10	<10	<10	<10
Cyanazine	µg/kg	10	<10	<10	<10	<10	<10
Irgarol	µg/kg	10	<10	<10	<10	<10	<10
Hexazinone	µg/kg	10	<10	<10	<10	<10	<10
Surrogate p-Terphenyl-D14	%		*66.9*	*64.9*	*75.7*	*63.2*	*63.2*

Envirolab ID	Units	PQL	PEK0250-11	PEK0250-12	PEK0250-13	PEK0250-14	PEK0250-15
Your Reference			EPW1	EPW8	EPW11	EPW1	EPW11
Date Sampled			31/10/2023	31/10/2023	31/10/2023	31/10/2023	31/10/2023
Depth			0.00-0.50	0.50-1.00	1.00-1.50	0.50-1.00	0.50-1.00
Simazine	µg/kg	10	<10	<10	<10	<10	<10
Atrazine	µg/kg	10	<10	<10	<10	<10	<10
Propazine	µg/kg	10	<10	<10	<10	<10	<10
Terbuthylazine	µg/kg	10	<10	<10	<10	<10	<10
Metribuzin	µg/kg	50	<50	<50	<50	<50	<50
Ametryn	µg/kg	10	<10	<10	<10	<10	<10
Prometryn	µg/kg	10	<10	<10	<10	<10	<10
Terbutryn	µg/kg	10	<10	<10	<10	<10	<10
Cyanazine	µg/kg	10	<10	<10	<10	<10	<10
Irgarol	µg/kg	10	<10	<10	<10	<10	<10
Hexazinone	µg/kg	10	<10	<10	<10	<10	<10
Surrogate p-Terphenyl-D14	%		*72.4*	*71.2*	*67.3*	*74.7*	*66.4*

Certificate of Analysis PEK0250

Triazine Herbicides (Sediment)

Envirolab ID	Units	PQL	PEK0250-16	PEK0250-17	PEK0250-18	PEK0250-19	PEK0250-20
Your Reference			EPW11	EPW2	EPW12	EPW4	EPW8
Date Sampled			31/10/2023	31/10/2023	31/10/2023	31/10/2023	31/10/2023
Depth			0.00-0.50	0.00-0.50	0.00-0.50	0.00-0.50	0.00-0.50
Simazine	µg/kg	10	<10	<10	<10	<10	<10
Atrazine	µg/kg	10	<10	<10	<10	<10	<10
Propazine	µg/kg	10	<10	<10	<10	<10	<10
Terbuthylazine	µg/kg	10	<10	<10	<10	<10	<10
Metribuzin	µg/kg	50	<50	<50	<50	<50	<50
Ametryn	µg/kg	10	<10	<10	<10	<10	<10
Prometryn	µg/kg	10	<10	<10	<10	<10	<10
Terbutryn	µg/kg	10	<10	<10	<10	<10	<10
Cyanazine	µg/kg	10	<10	<10	<10	<10	<10
Irgarol	µg/kg	10	<10	<10	<10	<10	<10
Hexazinone	µg/kg	10	<10	<10	<10	<10	<10
Surrogate p-Terphenyl-D14	%		*69.1*	*83.0*	*74.6*	*80.2*	*72.6*

Envirolab ID	Units	PQL	PEK0250-23	PEK0250-24
Your Reference			EPW8A	EPW8A
Date Sampled			31/10/2023	31/10/2023
Depth			0.00-0.50	0.50-1.00
Simazine	µg/kg	10	<10	<10
Atrazine	µg/kg	10	<10	<10
Propazine	µg/kg	10	<10	<10
Terbuthylazine	µg/kg	10	<10	<10
Metribuzin	µg/kg	50	<50	<50
Ametryn	µg/kg	10	<10	<10
Prometryn	µg/kg	10	<10	<10
Terbutryn	µg/kg	10	<10	<10
Cyanazine	µg/kg	10	<10	<10
Irgarol	µg/kg	10	<10	<10
Hexazinone	µg/kg	10	<10	<10
Surrogate p-Terphenyl-D14	%		*85.8*	*72.8*

Phenoxy Acid Herbicides (Sediment)

Envirolab ID	Units	PQL	PEK0250-01	PEK0250-02	PEK0250-03	PEK0250-04	PEK0250-05
Your Reference			EPW6	EPW5	EPW10	EPW10	EPW7
Date Sampled			31/10/2023	31/10/2023	31/10/2023	31/10/2023	31/10/2023
Depth			0.00-0.50	0.00-0.50	0.00-0.50	0.50-1.00	0.50-1.00
Clopyralid	µg/kg	50	<50	<50	<50	<50	<50
3,5-Dichlorobenzoic acid	µg/kg	50	<50	<50	<50	<50	<50
2-Chlorophenoxy acetic acid	µg/kg	50	<50	<50	<50	<50	<50
4-Chlorophenoxy acetic acid	µg/kg	50	<50	<50	<50	<50	<50
Dicamba	µg/kg	50	<50	<50	<50	<50	<50
Mecoprop	µg/kg	50	<50	<50	<50	<50	<50
MCPA	µg/kg	50	<50	<50	<50	<50	<50
2,6-D	µg/kg	50	<50	<50	<50	<50	<50
Dichlorprop	µg/kg	50	<50	<50	<50	<50	<50
2,4-D	µg/kg	50	<50	<50	<50	<50	<50
Bromoxynil	µg/kg	50	<50	<50	<50	<50	<50
Triclopyr	µg/kg	50	<50	<50	<50	<50	<50
2,4,6-T	µg/kg	50	<50	<50	<50	<50	<50
2,4,5-TP	µg/kg	50	<50	<50	<50	<50	<50
2,4,5-T	µg/kg	50	<50	<50	<50	<50	<50
MCPB	µg/kg	50	<50	<50	<50	<50	<50
Dinoseb	µg/kg	50	<50	<50	<50	<50	<50
2,4-DB	µg/kg	50	<50	<50	<50	<50	<50
Ioxynil	µg/kg	50	<50	<50	<50	<50	<50
Picloram	µg/kg	50	<50	<50	<50	<50	<50
Chlorthal	µg/kg	50	<50	<50	<50	<50	<50
Acifluorfen	µg/kg	50	<50	<50	<50	<50	<50
Surrogate 2,4-DCPA	%		*71.5*	*78.8*	*62.6*	*70.8*	*94.1*

Envirolab ID	Units	PQL	PEK0250-06	PEK0250-07	PEK0250-08	PEK0250-09	PEK0250-10
Your Reference			EPW6	EPW3	EPW7	EPW7	EPW3
Date Sampled			31/10/2023	31/10/2023	31/10/2023	31/10/2023	31/10/2023
Depth			0.50-1.00	0.50-1.00	0.00-0.50	1.00-1.50	0.00-0.50
Clopyralid	µg/kg	50	<50	<50	<50	<50	<50
3,5-Dichlorobenzoic acid	µg/kg	50	<50	<50	<50	<50	<50
2-Chlorophenoxy acetic acid	µg/kg	50	<50	<50	<50	<50	<50
4-Chlorophenoxy acetic acid	µg/kg	50	<50	<50	<50	<50	<50
Dicamba	µg/kg	50	<50	<50	<50	<50	<50
Mecoprop	µg/kg	50	<50	<50	<50	<50	<50
MCPA	µg/kg	50	<50	<50	<50	<50	<50
2,6-D	µg/kg	50	<50	<50	<50	<50	<50
Dichlorprop	µg/kg	50	<50	<50	<50	<50	<50
2,4-D	µg/kg	50	<50	<50	<50	<50	<50
Bromoxynil	µg/kg	50	<50	<50	<50	<50	<50
Triclopyr	µg/kg	50	<50	<50	<50	<50	<50
2,4,6-T	µg/kg	50	<50	<50	<50	<50	<50
2,4,5-TP	µg/kg	50	<50	<50	<50	<50	<50
2,4,5-T	µg/kg	50	<50	<50	<50	<50	<50
MCPB	µg/kg	50	<50	<50	<50	<50	<50
Dinoseb	µg/kg	50	<50	<50	<50	<50	<50
2,4-DB	µg/kg	50	<50	<50	<50	<50	<50

Certificate of Analysis PEK0250

Phenoxy Acid Herbicides (Sediment)

Envirolab ID	Units	PQL	PEK0250-06	PEK0250-07	PEK0250-08	PEK0250-09	PEK0250-10
Your Reference			EPW6	EPW3	EPW7	EPW7	EPW3
Date Sampled			31/10/2023	31/10/2023	31/10/2023	31/10/2023	31/10/2023
Depth			0.50-1.00	0.50-1.00	0.00-0.50	1.00-1.50	0.00-0.50
Ioxynil	µg/kg	50	<50	<50	<50	<50	<50
Picloram	µg/kg	50	<50	<50	<50	<50	<50
Chlorthal	µg/kg	50	<50	<50	<50	<50	<50
Acifluorfen	µg/kg	50	<50	<50	<50	<50	<50
Surrogate 2,4-DCPA	%		*67.6*	*71.1*	*89.3*	*78.6*	*78.0*

Envirolab ID	Units	PQL	PEK0250-11	PEK0250-12	PEK0250-13	PEK0250-14	PEK0250-15
Your Reference			EPW1	EPW8	EPW11	EPW1	EPW11
Date Sampled			31/10/2023	31/10/2023	31/10/2023	31/10/2023	31/10/2023
Depth			0.00-0.50	0.50-1.00	1.00-1.50	0.50-1.00	0.50-1.00
Clopyralid	µg/kg	50	<50	<50	<50	<50	<50
3,5-Dichlorobenzoic acid	µg/kg	50	<50	<50	<50	<50	<50
2-Chlorophenoxy acetic acid	µg/kg	50	<50	<50	<50	<50	<50
4-Chlorophenoxy acetic acid	µg/kg	50	<50	<50	<50	<50	<50
Dicamba	µg/kg	50	<50	<50	<50	<50	<50
Mecoprop	µg/kg	50	<50	<50	<50	<50	<50
MCPA	µg/kg	50	<50	<50	<50	<50	<50
2,6-D	µg/kg	50	<50	<50	<50	<50	<50
Dichlorprop	µg/kg	50	<50	<50	<50	<50	<50
2,4-D	µg/kg	50	<50	<50	<50	<50	<50
Bromoxynil	µg/kg	50	<50	<50	<50	<50	<50
Triclopyr	µg/kg	50	<50	<50	<50	<50	<50
2,4,6-T	µg/kg	50	<50	<50	<50	<50	<50
2,4,5-TP	µg/kg	50	<50	<50	<50	<50	<50
2,4,5-T	µg/kg	50	<50	<50	<50	<50	<50
MCPB	µg/kg	50	<50	<50	<50	<50	<50
Dinoseb	µg/kg	50	<50	<50	<50	<50	<50
2,4-DB	µg/kg	50	<50	<50	<50	<50	<50
Ioxynil	µg/kg	50	<50	<50	<50	<50	<50
Picloram	µg/kg	50	<50	<50	<50	<50	<50
Chlorthal	µg/kg	50	<50	<50	<50	<50	<50
Acifluorfen	µg/kg	50	<50	<50	<50	<50	<50
Surrogate 2,4-DCPA	%		*72.6*	*65.1*	*76.0*	*86.1*	*79.4*

Envirolab ID	Units	PQL	PEK0250-16	PEK0250-17	PEK0250-18	PEK0250-19	PEK0250-20
Your Reference			EPW11	EPW2	EPW12	EPW4	EPW8
Date Sampled			31/10/2023	31/10/2023	31/10/2023	31/10/2023	31/10/2023
Depth			0.00-0.50	0.00-0.50	0.00-0.50	0.00-0.50	0.00-0.50
Clopyralid	µg/kg	50	<50	<50	<50	<50	<50
3,5-Dichlorobenzoic acid	µg/kg	50	<50	<50	<50	<50	<50
2-Chlorophenoxy acetic acid	µg/kg	50	<50	<50	<50	<50	<50
4-Chlorophenoxy acetic acid	µg/kg	50	<50	<50	<50	<50	<50
Dicamba	µg/kg	50	<50	<50	<50	<50	<50
Mecoprop	µg/kg	50	<50	<50	<50	<50	<50
MCPA	µg/kg	50	<50	<50	<50	<50	<50
2,6-D	µg/kg	50	<50	<50	<50	<50	<50
Dichlorprop	µg/kg	50	<50	<50	<50	<50	<50

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Phenoxy Acid Herbicides (Sediment)

Envirolab ID	Units	PQL	PEK0250-16	PEK0250-17	PEK0250-18	PEK0250-19	PEK0250-20
Your Reference			EPW11	EPW2	EPW12	EPW4	EPW8
Date Sampled			31/10/2023	31/10/2023	31/10/2023	31/10/2023	31/10/2023
Depth			0.00-0.50	0.00-0.50	0.00-0.50	0.00-0.50	0.00-0.50
2,4-D	µg/kg	50	<50	<50	<50	<50	<50
Bromoxynil	µg/kg	50	<50	<50	<50	<50	<50
Triclopyr	µg/kg	50	<50	<50	<50	<50	<50
2,4,6-T	µg/kg	50	<50	<50	<50	<50	<50
2,4,5-TP	µg/kg	50	<50	<50	<50	<50	<50
2,4,5-T	µg/kg	50	<50	<50	<50	<50	<50
MCPB	µg/kg	50	<50	<50	<50	<50	<50
Dinoseb	µg/kg	50	<50	<50	<50	<50	<50
2,4-DB	µg/kg	50	<50	<50	<50	<50	<50
Ioxynil	µg/kg	50	<50	<50	<50	<50	<50
Picloram	µg/kg	50	<50	<50	<50	<50	<50
Chlorthal	µg/kg	50	<50	<50	<50	<50	<50
Acifluorfen	µg/kg	50	<50	<50	<50	<50	<50
Surrogate 2,4-DCPA	%		*75.9*	*73.1*	*76.7*	*76.5*	*71.9*

Envirolab ID	Units	PQL	PEK0250-23	PEK0250-24
Your Reference			EPW8A	EPW8A
Date Sampled			31/10/2023	31/10/2023
Depth			0.00-0.50	0.50-1.00
Clopyralid	µg/kg	50	<50	<50
3,5-Dichlorobenzoic acid	µg/kg	50	<50	<50
2-Chlorophenoxy acetic acid	µg/kg	50	<50	<50
4-Chlorophenoxy acetic acid	µg/kg	50	<50	<50
Dicamba	µg/kg	50	<50	<50
Mecoprop	µg/kg	50	<50	<50
MCPA	µg/kg	50	<50	<50
2,6-D	µg/kg	50	<50	<50
Dichlorprop	µg/kg	50	<50	<50
2,4-D	µg/kg	50	<50	<50
Bromoxynil	µg/kg	50	<50	<50
Triclopyr	µg/kg	50	<50	<50
2,4,6-T	µg/kg	50	<50	<50
2,4,5-TP	µg/kg	50	<50	<50
2,4,5-T	µg/kg	50	<50	<50
MCPB	µg/kg	50	<50	<50
Dinoseb	µg/kg	50	<50	<50
2,4-DB	µg/kg	50	<50	<50
Ioxynil	µg/kg	50	<50	<50
Picloram	µg/kg	50	<50	<50
Chlorthal	µg/kg	50	<50	<50
Acifluorfen	µg/kg	50	<50	<50
Surrogate 2,4-DCPA	%		*73.1*	*65.0*

Organometallics (Rinsate)

Envirolab ID	Units	PQL	PEK0250-21	PEK0250-22
Your Reference			EPW5	EPW12
Date Sampled			31/10/2023	31/10/2023
Tributyltin as Sn	µg/L	0.0020	<0.0020	<0.0020
Surrogate Triphenyltin	%		*109*	*95.8*

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Organometallics (Sediment)

Envirolab ID	Units	PQL	PEK0250-01	PEK0250-02	PEK0250-03	PEK0250-04	PEK0250-05
Your Reference			EPW6	EPW5	EPW10	EPW10	EPW7
Date Sampled			31/10/2023	31/10/2023	31/10/2023	31/10/2023	31/10/2023
Depth			0.00-0.50	0.00-0.50	0.00-0.50	0.50-1.00	0.50-1.00
Tributyltin as Sn	µg/kg	0.50	<2.5 [9]	0.99 [8]	2.5 [8]	<0.50	<2.5 [9]
Surrogate Triphenyltin	%		*71.6*	*75.5*	*74.8*	*74.0*	*74.8*

Envirolab ID	Units	PQL	PEK0250-06	PEK0250-07	PEK0250-08	PEK0250-09	PEK0250-10
Your Reference			EPW6	EPW3	EPW7	EPW7	EPW3
Date Sampled			31/10/2023	31/10/2023	31/10/2023	31/10/2023	31/10/2023
Depth			0.50-1.00	0.50-1.00	0.00-0.50	1.00-1.50	0.00-0.50
Tributyltin as Sn	µg/kg	0.50	<0.50	<0.50	4.0 [8]	<0.50	<0.50
Surrogate Triphenyltin	%		*72.1*	*77.0*	*74.7*	*76.6*	*75.7*

Envirolab ID	Units	PQL	PEK0250-11	PEK0250-12	PEK0250-13	PEK0250-14	PEK0250-15
Your Reference			EPW1	EPW8	EPW11	EPW1	EPW11
Date Sampled			31/10/2023	31/10/2023	31/10/2023	31/10/2023	31/10/2023
Depth			0.00-0.50	0.50-1.00	1.00-1.50	0.50-1.00	0.50-1.00
Tributyltin as Sn	µg/kg	0.50	<4.0 [9]	<0.50	<0.50	<0.50	<0.50
Surrogate Triphenyltin	%		*74.4*	*71.5*	*76.0*	*68.8*	*75.3*

Envirolab ID	Units	PQL	PEK0250-16	PEK0250-17	PEK0250-18	PEK0250-19	PEK0250-20
Your Reference			EPW11	EPW2	EPW12	EPW4	EPW8
Date Sampled			31/10/2023	31/10/2023	31/10/2023	31/10/2023	31/10/2023
Depth			0.00-0.50	0.00-0.50	0.00-0.50	0.00-0.50	0.00-0.50
Tributyltin as Sn	µg/kg	0.50	0.73 [8]	1.7 [8]	<0.50	<0.50	<0.50
Surrogate Triphenyltin	%		*74.5*	*72.1*	*74.8*	*74.1*	*71.2*

Envirolab ID	Units	PQL	PEK0250-23	PEK0250-24
Your Reference			EPW8A	EPW8A
Date Sampled			31/10/2023	31/10/2023
Depth			0.00-0.50	0.50-1.00
Tributyltin as Sn	µg/kg	0.50	<4.0 [9]	<0.50
Surrogate Triphenyltin	%		*79.2*	*78.7*

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Acid Extractable Metals (Sediment)

Envirolab ID	Units	PQL	PEK0250-01	PEK0250-02	PEK0250-03	PEK0250-04	PEK0250-05
Your Reference			EPW6	EPW5	EPW10	EPW10	EPW7
Date Sampled			31/10/2023	31/10/2023	31/10/2023	31/10/2023	31/10/2023
Depth			0.00-0.50	0.00-0.50	0.00-0.50	0.50-1.00	0.50-1.00
Phosphorus	mg/kg	10	340	430	410	410	280

Envirolab ID	Units	PQL	PEK0250-06	PEK0250-07	PEK0250-08	PEK0250-09	PEK0250-10
Your Reference			EPW6	EPW3	EPW7	EPW7	EPW3
Date Sampled			31/10/2023	31/10/2023	31/10/2023	31/10/2023	31/10/2023
Depth			0.50-1.00	0.50-1.00	0.00-0.50	1.00-1.50	0.00-0.50
Phosphorus	mg/kg	10	240	400	320	270	370

Envirolab ID	Units	PQL	PEK0250-11	PEK0250-12	PEK0250-13	PEK0250-14	PEK0250-15
Your Reference			EPW1	EPW8	EPW11	EPW1	EPW11
Date Sampled			31/10/2023	31/10/2023	31/10/2023	31/10/2023	31/10/2023
Depth			0.00-0.50	0.50-1.00	1.00-1.50	0.50-1.00	0.50-1.00
Phosphorus	mg/kg	10	450	340	400	400	600

Envirolab ID	Units	PQL	PEK0250-16	PEK0250-17	PEK0250-18	PEK0250-19	PEK0250-20
Your Reference			EPW11	EPW2	EPW12	EPW4	EPW8
Date Sampled			31/10/2023	31/10/2023	31/10/2023	31/10/2023	31/10/2023
Depth			0.00-0.50	0.00-0.50	0.00-0.50	0.00-0.50	0.00-0.50
Phosphorus	mg/kg	10	420	360	620	300	370

Envirolab ID	Units	PQL	PEK0250-23	PEK0250-24
Your Reference			EPW8A	EPW8A
Date Sampled			31/10/2023	31/10/2023
Depth			0.00-0.50	0.50-1.00
Phosphorus	mg/kg	10	370	370

Acid Extractable Low Level Metals (Rinsate)

Envirolab ID	Units	PQL	PEK0250-21	PEK0250-22
Your Reference			EPW5	EPW12
Date Sampled			31/10/2023	31/10/2023
Silver	µg/L	1.0	<1.0	<1.0
Aluminium	µg/L	10	<10	<10
Arsenic	µg/L	1.0	<1.0	<1.0
Cadmium	µg/L	0.10	<0.10	<0.10
Cobalt	µg/L	1.0	<1.0	<1.0
Chromium	µg/L	1.0	<1.0	<1.0
Copper	µg/L	1.0	<1.0	<1.0
Iron	µg/L	10	<10	<10
Mercury	µg/L	0.050	<0.050	<0.050
Manganese	µg/L	1.0	<1.0	<1.0
Nickel	µg/L	1.0	<1.0	<1.0
Lead	µg/L	1.0	<1.0	<1.0
Antimony	µg/L	1.0	<1.0	<1.0
Selenium	µg/L	1.0	<1.0	<1.0
Vanadium	µg/L	1.0	<1.0	<1.0
Zinc	µg/L	1.0	5.7	<1.0

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NAGD Metals (Sediment)

Envirolab ID	Units	PQL	PEK0250-01	PEK0250-02	PEK0250-03	PEK0250-04	PEK0250-05
Your Reference			EPW6	EPW5	EPW10	EPW10	EPW7
Date Sampled			31/10/2023	31/10/2023	31/10/2023	31/10/2023	31/10/2023
Depth			0.00-0.50	0.00-0.50	0.00-0.50	0.50-1.00	0.50-1.00
Silver	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Aluminium	mg/kg	1.0	86	49	170	240	45
Arsenic	mg/kg	0.50	9.8	15	9.7	13	6.0
Cadmium	mg/kg	0.10	<0.10	<0.10	<0.10	0.12	<0.10
Cobalt	mg/kg	0.50	<0.50	<0.50	0.53	0.65	<0.50
Chromium	mg/kg	0.50	21	33	30	43	15
Copper	mg/kg	0.50	1.8	2.2	4.2	2.4	1.1
Iron	mg/kg	1.0	210	230	290	400	110
Mercury	mg/kg	0.010	0.014	<0.010	0.014	<0.010	<0.010
Manganese	mg/kg	0.50	8.9	14	12	13	10
Nickel	mg/kg	0.50	2.6	1.1	4.8	7.4	1.0
Lead	mg/kg	0.50	1.9	1.5	2.5	2.2	1.0
Antimony	mg/kg	0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Selenium	mg/kg	0.10	0.42	0.25	0.70	0.94	0.18
Vanadium	mg/kg	0.50	16	30	22	35	9.1
Zinc	mg/kg	0.50	4.6	4.3	9.0	3.2	3.2

Envirolab ID	Units	PQL	PEK0250-06	PEK0250-07	PEK0250-08	PEK0250-09	PEK0250-10
Your Reference			EPW6	EPW3	EPW7	EPW7	EPW3
Date Sampled			31/10/2023	31/10/2023	31/10/2023	31/10/2023	31/10/2023
Depth			0.50-1.00	0.50-1.00	0.00-0.50	1.00-1.50	0.00-0.50
Silver	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Aluminium	mg/kg	1.0	64	20	51	42	27
Arsenic	mg/kg	0.50	9.5	6.3	5.3	7.5	6.5
Cadmium	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Cobalt	mg/kg	0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Chromium	mg/kg	0.50	15	17	15	15	20
Copper	mg/kg	0.50	0.79	<0.50	4.3	<0.50	0.63
Iron	mg/kg	1.0	170	77	100	100	100
Mercury	mg/kg	0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Manganese	mg/kg	0.50	8.3	12	11	11	12
Nickel	mg/kg	0.50	2.3	0.71	0.95	0.86	0.59
Lead	mg/kg	0.50	0.92	0.59	1.3	0.70	0.95
Antimony	mg/kg	0.50	0.67	<0.50	<0.50	<0.50	<0.50
Selenium	mg/kg	0.10	0.49	0.26	0.14	0.17	0.13
Vanadium	mg/kg	0.50	15	13	7.7	7.3	15
Zinc	mg/kg	0.50	1.4	0.77	6.3	0.73	1.8

Envirolab ID	Units	PQL	PEK0250-11	PEK0250-12	PEK0250-13	PEK0250-14	PEK0250-15
Your Reference			EPW1	EPW8	EPW11	EPW1	EPW11
Date Sampled			31/10/2023	31/10/2023	31/10/2023	31/10/2023	31/10/2023
Depth			0.00-0.50	0.50-1.00	1.00-1.50	0.50-1.00	0.50-1.00
Silver	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Aluminium	mg/kg	1.0	170	220	39	190	49
Arsenic	mg/kg	0.50	9.9	11	11	12	9.3
Cadmium	mg/kg	0.10	0.10	<0.10	<0.10	0.10	<0.10
Cobalt	mg/kg	0.50	<0.50	0.55	<0.50	<0.50	<0.50

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NAGD Metals (Sediment)

Envirolab ID	Units	PQL	PEK0250-11	PEK0250-12	PEK0250-13	PEK0250-14	PEK0250-15
Your Reference			EPW1	EPW8	EPW11	EPW1	EPW11
Date Sampled			31/10/2023	31/10/2023	31/10/2023	31/10/2023	31/10/2023
Depth			0.00-0.50	0.50-1.00	1.00-1.50	0.50-1.00	0.50-1.00
Chromium	mg/kg	0.50	33	30	19	35	24
Copper	mg/kg	0.50	1.9	2.0	<0.50	1.6	0.50
Iron	mg/kg	1.0	270	330	140	280	180
Mercury	mg/kg	0.010	0.012	<0.010	<0.010	<0.010	<0.010
Manganese	mg/kg	0.50	14	12	12	14	14
Nickel	mg/kg	0.50	4.9	6.5	1.0	5.5	1.1
Lead	mg/kg	0.50	1.6	1.8	0.85	1.6	1.1
Antimony	mg/kg	0.50	<0.50	0.57	<0.50	0.58	<0.50
Selenium	mg/kg	0.10	0.65	0.87	0.23	0.74	0.19
Vanadium	mg/kg	0.50	23	29	12	27	14
Zinc	mg/kg	0.50	3.4	2.7	1.0	2.3	1.4

Envirolab ID	Units	PQL	PEK0250-16	PEK0250-17	PEK0250-18	PEK0250-19	PEK0250-20
Your Reference			EPW11	EPW2	EPW12	EPW4	EPW8
Date Sampled			31/10/2023	31/10/2023	31/10/2023	31/10/2023	31/10/2023
Depth			0.00-0.50	0.00-0.50	0.00-0.50	0.00-0.50	0.00-0.50
Silver	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Aluminium	mg/kg	1.0	55	120	81	130	250
Arsenic	mg/kg	0.50	9.6	5.5	38	8.7	12
Cadmium	mg/kg	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Cobalt	mg/kg	0.50	<0.50	<0.50	<0.50	<0.50	0.61
Chromium	mg/kg	0.50	24	22	52	22	29
Copper	mg/kg	0.50	1.2	4.0	1.4	1.6	2.1
Iron	mg/kg	1.0	170	210	700	230	350
Mercury	mg/kg	0.010	<0.010	0.022	0.026	<0.010	<0.010
Manganese	mg/kg	0.50	14	9.6	9.3	8.4	16
Nickel	mg/kg	0.50	1.3	3.1	1.4	3.7	6.6
Lead	mg/kg	0.50	1.4	2.9	2.4	1.5	2.0
Antimony	mg/kg	0.50	<0.50	<0.50	0.70	<0.50	0.53
Selenium	mg/kg	0.10	0.22	0.36	0.26	0.55	0.84
Vanadium	mg/kg	0.50	14	13	69	18	29
Zinc	mg/kg	0.50	3.8	9.9	5.1	22	3.9

Envirolab ID	Units	PQL	PEK0250-23	PEK0250-24
Your Reference			EPW8A	EPW8A
Date Sampled			31/10/2023	31/10/2023
Depth			0.00-0.50	0.50-1.00
Silver	mg/kg	0.10	<0.10	<0.10
Aluminium	mg/kg	1.0	180	230
Arsenic	mg/kg	0.50	11	11
Cadmium	mg/kg	0.10	<0.10	0.10
Cobalt	mg/kg	0.50	<0.50	0.57
Chromium	mg/kg	0.50	30	36
Copper	mg/kg	0.50	2.2	2.0
Iron	mg/kg	1.0	300	350
Mercury	mg/kg	0.010	<0.010	<0.010
Manganese	mg/kg	0.50	9.8	11

NAGD Metals (Sediment)

Envirolab ID	Units	PQL	PEK0250-23	PEK0250-24
Your Reference			EPW8A	EPW8A
Date Sampled			31/10/2023	31/10/2023
Depth			0.00-0.50	0.50-1.00
Nickel	mg/kg	0.50	5.3	6.5
Lead	mg/kg	0.50	1.8	1.9
Antimony	mg/kg	0.50	0.51	0.54
Selenium	mg/kg	0.10	0.78	0.89
Vanadium	mg/kg	0.50	26	30
Zinc	mg/kg	0.50	3.5	2.7

Inorganics - Carbons, Nitrogen Species, Sulfur Species (Sediment)

Envirolab ID	Units	PQL	PEK0250-01	PEK0250-02	PEK0250-03	PEK0250-04	PEK0250-05
Your Reference			EPW6	EPW5	EPW10	EPW10	EPW7
Date Sampled			31/10/2023	31/10/2023	31/10/2023	31/10/2023	31/10/2023
Depth			0.00-0.50	0.00-0.50	0.00-0.50	0.50-1.00	0.50-1.00
Ammonia as N	mg/kg	0.50	3.1	3.2	2.1	1.7	1.1
Nitrate as N	mg/kg	0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Nitrate as NO3 by calculation	mg/kg	3.0	<3.0	<3.0	<3.0	<3.0	<3.0
Nitrite as N	mg/kg	0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Nitrite as NO2 by calculation*	mg/kg	2.0	<2.0	<2.0	<2.0	<2.0	<2.0
NOx as N	mg/kg	0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Organic Nitrogen by calc	mg/kg	10	<10	<10	<10	<10	<10

Envirolab ID	Units	PQL	PEK0250-06	PEK0250-07	PEK0250-08	PEK0250-09	PEK0250-10
Your Reference			EPW6	EPW3	EPW7	EPW7	EPW3
Date Sampled			31/10/2023	31/10/2023	31/10/2023	31/10/2023	31/10/2023
Depth			0.50-1.00	0.50-1.00	0.00-0.50	1.00-1.50	0.00-0.50
Ammonia as N	mg/kg	0.50	0.53	0.52	2.4	<0.50	2.7
Nitrate as N	mg/kg	0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Nitrate as NO3 by calculation	mg/kg	3.0	<3.0	<3.0	<3.0	<3.0	<3.0
Nitrite as N	mg/kg	0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Nitrite as NO2 by calculation*	mg/kg	2.0	<2.0	<2.0	<2.0	<2.0	<2.0
NOx as N	mg/kg	0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Organic Nitrogen by calc	mg/kg	10	<10	<10	<10	<10	<10

Envirolab ID	Units	PQL	PEK0250-11	PEK0250-12	PEK0250-13	PEK0250-14	PEK0250-15
Your Reference			EPW1	EPW8	EPW11	EPW1	EPW11
Date Sampled			31/10/2023	31/10/2023	31/10/2023	31/10/2023	31/10/2023
Depth			0.00-0.50	0.50-1.00	1.00-1.50	0.50-1.00	0.50-1.00
Ammonia as N	mg/kg	0.50	2.0	1.1	<0.50	1.2	<0.50
Nitrate as N	mg/kg	0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Nitrate as NO3 by calculation	mg/kg	3.0	<3.0	<3.0	<3.0	<3.0	<3.0
Nitrite as N	mg/kg	0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Nitrite as NO2 by calculation*	mg/kg	2.0	<2.0	<2.0	<2.0	<2.0	<2.0
NOx as N	mg/kg	0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Organic Nitrogen by calc	mg/kg	10	<10	<10	<10	<10	<10

Envirolab ID	Units	PQL	PEK0250-16	PEK0250-17	PEK0250-18	PEK0250-19	PEK0250-20
Your Reference			EPW11	EPW2	EPW12	EPW4	EPW8
Date Sampled			31/10/2023	31/10/2023	31/10/2023	31/10/2023	31/10/2023
Depth			0.00-0.50	0.00-0.50	0.00-0.50	0.00-0.50	0.00-0.50
Ammonia as N	mg/kg	0.50	<0.50	5.6	2.6	1.4	1.6
Nitrate as N	mg/kg	0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Nitrate as NO3 by calculation	mg/kg	3.0	<3.0	<3.0	<3.0	<3.0	<3.0
Nitrite as N	mg/kg	0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Nitrite as NO2 by calculation*	mg/kg	2.0	<2.0	<2.0	<2.0	<2.0	<2.0
NOx as N	mg/kg	0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Organic Nitrogen by calc	mg/kg	10	<10	<10	<10	<10	<10

Certificate of Analysis PEK0250

Inorganics - Carbons, Nitrogen Species, Sulfur Species (Sediment)

Envirolab ID	**Units**	**PQL**	PEK0250-23	PEK0250-24
Your Reference			EPW8A	EPW8A
Date Sampled			31/10/2023	31/10/2023
Depth			0.00-0.50	0.50-1.00
Ammonia as N	mg/kg	0.50	1.6	1.4
Nitrate as N	mg/kg	0.50	<0.50	<0.50
Nitrate as NO3 by calculation	mg/kg	3.0	<3.0	<3.0
Nitrite as N	mg/kg	0.50	<0.50	<0.50
Nitrite as NO2 by calculation*	mg/kg	2.0	<2.0	<2.0
NOx as N	mg/kg	0.50	<0.50	<0.50
Organic Nitrogen by calc	mg/kg	10	<10	<10

Certificate of Analysis PEK0250

Inorganics - Carbons, Nitrogen Species, Sulfur Species (Sediment) - Analysed By Envirolab Services Sydney

Envirolab ID	Units	PQL	PEK0250-01	PEK0250-02	PEK0250-03	PEK0250-04	PEK0250-05
Your Reference			EPW6	EPW5	EPW10	EPW10	EPW7
Date Sampled			31/10/2023	31/10/2023	31/10/2023	31/10/2023	31/10/2023
Depth			0.00-0.50	0.00-0.50	0.00-0.50	0.50-1.00	0.50-1.00
Total Organic Carbon	%	0.010	0.67	0.43	1.3	1.7	0.41
Total Nitrogen	mg/kg	10	1300	710	2100	2200	620

Envirolab ID	Units	PQL	PEK0250-06	PEK0250-07	PEK0250-08	PEK0250-09	PEK0250-10
Your Reference			EPW6	EPW3	EPW7	EPW7	EPW3
Date Sampled			31/10/2023	31/10/2023	31/10/2023	31/10/2023	31/10/2023
Depth			0.50-1.00	0.50-1.00	0.00-0.50	1.00-1.50	0.00-0.50
Total Organic Carbon	%	0.010	0.74	0.13	0.97	0.23	0.15
Total Nitrogen	mg/kg	10	1000	450	620	540	610

Envirolab ID	Units	PQL	PEK0250-11	PEK0250-12	PEK0250-13	PEK0250-14	PEK0250-15
Your Reference			EPW1	EPW8	EPW11	EPW1	EPW11
Date Sampled			31/10/2023	31/10/2023	31/10/2023	31/10/2023	31/10/2023
Depth			0.00-0.50	0.50-1.00	1.00-1.50	0.50-1.00	0.50-1.00
Total Organic Carbon	%	0.010	1.1	0.32	0.24	1.2	0.26
Total Nitrogen	mg/kg	10	1500	1900	470	1600	610

Envirolab ID	Units	PQL	PEK0250-16	PEK0250-17	PEK0250-18	PEK0250-19	PEK0250-20
Your Reference			EPW11	EPW2	EPW12	EPW4	EPW8
Date Sampled			31/10/2023	31/10/2023	31/10/2023	31/10/2023	31/10/2023
Depth			0.00-0.50	0.00-0.50	0.00-0.50	0.00-0.50	0.00-0.50
Total Organic Carbon	%	0.010	0.34	0.99	0.60	0.86	1.7
Total Nitrogen	mg/kg	10	680	1800	810	1500	1800

Envirolab ID	Units	PQL	PEK0250-23	PEK0250-24
Your Reference			EPW8A	EPW8A
Date Sampled			31/10/2023	31/10/2023
Depth			0.00-0.50	0.50-1.00
Total Organic Carbon	%	0.010	1.6	1.6
Total Nitrogen	mg/kg	10	2900	2200

Inorganics - Nutrients (Sediment)

Envirolab ID	Units	PQL	PEK0250-01	PEK0250-02	PEK0250-03	PEK0250-04	PEK0250-05
Your Reference			EPW6	EPW5	EPW10	EPW10	EPW7
Date Sampled			31/10/2023	31/10/2023	31/10/2023	31/10/2023	31/10/2023
Depth			0.00-0.50	0.00-0.50	0.00-0.50	0.50-1.00	0.50-1.00
TKN as N by calculation	mg/kg	10	1300	710	2100	2200	620

Envirolab ID	Units	PQL	PEK0250-06	PEK0250-07	PEK0250-08	PEK0250-09	PEK0250-10
Your Reference			EPW6	EPW3	EPW7	EPW7	EPW3
Date Sampled			31/10/2023	31/10/2023	31/10/2023	31/10/2023	31/10/2023
Depth			0.50-1.00	0.50-1.00	0.00-0.50	1.00-1.50	0.00-0.50
TKN as N by calculation	mg/kg	10	1000	450	620	540	610

Envirolab ID	Units	PQL	PEK0250-11	PEK0250-12	PEK0250-13	PEK0250-14	PEK0250-15
Your Reference			EPW1	EPW8	EPW11	EPW1	EPW11
Date Sampled			31/10/2023	31/10/2023	31/10/2023	31/10/2023	31/10/2023
Depth			0.00-0.50	0.50-1.00	1.00-1.50	0.50-1.00	0.50-1.00
TKN as N by calculation	mg/kg	10	1500	1900	470	1600	610

Envirolab ID	Units	PQL	PEK0250-16	PEK0250-17	PEK0250-18	PEK0250-19	PEK0250-20
Your Reference			EPW11	EPW2	EPW12	EPW4	EPW8
Date Sampled			31/10/2023	31/10/2023	31/10/2023	31/10/2023	31/10/2023
Depth			0.00-0.50	0.00-0.50	0.00-0.50	0.00-0.50	0.00-0.50
TKN as N by calculation	mg/kg	10	680	1800	810	1500	1800

Envirolab ID	Units	PQL	PEK0250-23	PEK0250-24
Your Reference			EPW8A	EPW8A
Date Sampled			31/10/2023	31/10/2023
Depth			0.00-0.50	0.50-1.00
TKN as N by calculation	mg/kg	10	2900	2200

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Inorganics - General Chemical Parameters (Sediment)

Envirolab ID	**Units**	**PQL**	PEK0250-01	PEK0250-02	PEK0250-03	PEK0250-04	PEK0250-05
Your Reference			EPW6	EPW5	EPW10	EPW10	EPW7
Date Sampled			31/10/2023	31/10/2023	31/10/2023	31/10/2023	31/10/2023
Depth			0.00-0.50	0.00-0.50	0.00-0.50	0.50-1.00	0.50-1.00
Phosphate as P	mg/kg	0.50	<0.50	<0.50	<0.50	<0.50	<0.50

Envirolab ID	**Units**	**PQL**	PEK0250-06	PEK0250-07	PEK0250-08	PEK0250-09	PEK0250-10
Your Reference			EPW6	EPW3	EPW7	EPW7	EPW3
Date Sampled			31/10/2023	31/10/2023	31/10/2023	31/10/2023	31/10/2023
Depth			0.50-1.00	0.50-1.00	0.00-0.50	1.00-1.50	0.00-0.50
Phosphate as P	mg/kg	0.50	<0.50	<0.50	1.0	<0.50	<0.50

Envirolab ID	**Units**	**PQL**	PEK0250-11	PEK0250-12	PEK0250-13	PEK0250-14	PEK0250-15
Your Reference			EPW1	EPW8	EPW11	EPW1	EPW11
Date Sampled			31/10/2023	31/10/2023	31/10/2023	31/10/2023	31/10/2023
Depth			0.00-0.50	0.50-1.00	1.00-1.50	0.50-1.00	0.50-1.00
Phosphate as P	mg/kg	0.50	<0.50	<0.50	<0.50	<0.50	<0.50

Envirolab ID	**Units**	**PQL**	PEK0250-16	PEK0250-17	PEK0250-18	PEK0250-19	PEK0250-20
Your Reference			EPW11	EPW2	EPW12	EPW4	EPW8
Date Sampled			31/10/2023	31/10/2023	31/10/2023	31/10/2023	31/10/2023
Depth			0.00-0.50	0.00-0.50	0.00-0.50	0.00-0.50	0.00-0.50
Phosphate as P	mg/kg	0.50	<0.50	<0.50	<0.50	<0.50	<0.50

Envirolab ID	**Units**	**PQL**	PEK0250-23	PEK0250-24
Your Reference			EPW8A	EPW8A
Date Sampled			31/10/2023	31/10/2023
Depth			0.00-0.50	0.50-1.00
Phosphate as P	mg/kg	0.50	<0.50	<0.50

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Inorganics - Moisture (Sediment)

Envirolab ID	Units	PQL	PEK0250-01	PEK0250-02	PEK0250-03	PEK0250-04	PEK0250-05
Your Reference			EPW6	EPW5	EPW10	EPW10	EPW7
Date Sampled			31/10/2023	31/10/2023	31/10/2023	31/10/2023	31/10/2023
Depth			0.00-0.50	0.00-0.50	0.00-0.50	0.50-1.00	0.50-1.00
Moisture	%	0.10	31	27	42	43	16

Envirolab ID	Units	PQL	PEK0250-06	PEK0250-07	PEK0250-08	PEK0250-09	PEK0250-10
Your Reference			EPW6	EPW3	EPW7	EPW7	EPW3
Date Sampled			31/10/2023	31/10/2023	31/10/2023	31/10/2023	31/10/2023
Depth			0.50-1.00	0.50-1.00	0.00-0.50	1.00-1.50	0.00-0.50
Moisture	%	0.10	31	27	14	20	23

Envirolab ID	Units	PQL	PEK0250-11	PEK0250-12	PEK0250-13	PEK0250-14	PEK0250-15
Your Reference			EPW1	EPW8	EPW11	EPW1	EPW11
Date Sampled			31/10/2023	31/10/2023	31/10/2023	31/10/2023	31/10/2023
Depth			0.00-0.50	0.50-1.00	1.00-1.50	0.50-1.00	0.50-1.00
Moisture	%	0.10	35	40	20	33	20

Envirolab ID	Units	PQL	PEK0250-16	PEK0250-17	PEK0250-18	PEK0250-19	PEK0250-20
Your Reference			EPW11	EPW2	EPW12	EPW4	EPW8
Date Sampled			31/10/2023	31/10/2023	31/10/2023	31/10/2023	31/10/2023
Depth			0.00-0.50	0.00-0.50	0.00-0.50	0.00-0.50	0.00-0.50
Moisture	%	0.10	23	35	23	34	38

Envirolab ID	Units	PQL	PEK0250-23	PEK0250-24
Your Reference			EPW8A	EPW8A
Date Sampled			31/10/2023	31/10/2023
Depth			0.00-0.50	0.50-1.00
Moisture	%	0.10	43	41

Certificate of Analysis PEK0250

Inorganics - Cyanide Species and Similar (Sediment)

Envirolab ID	Units	PQL	PEK0250-01	PEK0250-02	PEK0250-03	PEK0250-04	PEK0250-05
Your Reference			EPW6	EPW5	EPW10	EPW10	EPW7
Date Sampled			31/10/2023	31/10/2023	31/10/2023	31/10/2023	31/10/2023
Depth			0.00-0.50	0.00-0.50	0.00-0.50	0.50-1.00	0.50-1.00
Total Cyanide	mg/kg	0.25	<0.25	<0.25	<0.25	<0.25	<0.25

Envirolab ID	Units	PQL	PEK0250-06	PEK0250-07	PEK0250-08	PEK0250-09	PEK0250-10
Your Reference			EPW6	EPW3	EPW7	EPW7	EPW3
Date Sampled			31/10/2023	31/10/2023	31/10/2023	31/10/2023	31/10/2023
Depth			0.50-1.00	0.50-1.00	0.00-0.50	1.00-1.50	0.00-0.50
Total Cyanide	mg/kg	0.25	<0.25	<0.25	<0.25	<0.25	<0.25

Envirolab ID	Units	PQL	PEK0250-11	PEK0250-12	PEK0250-13	PEK0250-14	PEK0250-15
Your Reference			EPW1	EPW8	EPW11	EPW1	EPW11
Date Sampled			31/10/2023	31/10/2023	31/10/2023	31/10/2023	31/10/2023
Depth			0.00-0.50	0.50-1.00	1.00-1.50	0.50-1.00	0.50-1.00
Total Cyanide	mg/kg	0.25	<0.25	<0.25	<0.25	<0.25	<0.25

Envirolab ID	Units	PQL	PEK0250-16	PEK0250-17	PEK0250-18	PEK0250-19	PEK0250-20
Your Reference			EPW11	EPW2	EPW12	EPW4	EPW8
Date Sampled			31/10/2023	31/10/2023	31/10/2023	31/10/2023	31/10/2023
Depth			0.00-0.50	0.00-0.50	0.00-0.50	0.00-0.50	0.00-0.50
Total Cyanide	mg/kg	0.25	<0.25	<0.25	<0.25	<0.25	<0.25

Envirolab ID	Units	PQL	PEK0250-23	PEK0250-24
Your Reference			EPW8A	EPW8A
Date Sampled			31/10/2023	31/10/2023
Depth			0.00-0.50	0.50-1.00
Total Cyanide	mg/kg	0.25	<0.25	<0.25

Certificate of Analysis PEK0250

Inorganics - Miscellaneous (Sediment) - Analysed By Envirolab Services Sydney

Envirolab ID	**Units**	**PQL**	PEK0250-01	PEK0250-03	PEK0250-04	PEK0250-06	PEK0250-11
Your Reference			EPW6	EPW10	EPW10	EPW6	EPW1
Date Sampled			31/10/2023	31/10/2023	31/10/2023	31/10/2023	31/10/2023
Depth			0.00-0.50	0.00-0.50	0.50-1.00	0.50-1.00	0.00-0.50
Particle Density*	g/cm3		2.6	2.5	2.5	2.6	2.6

Envirolab ID	**Units**	**PQL**	PEK0250-14	PEK0250-15	PEK0250-17	PEK0250-18	PEK0250-19
Your Reference			EPW1	EPW11	EPW2	EPW12	EPW4
Date Sampled			31/10/2023	31/10/2023	31/10/2023	31/10/2023	31/10/2023
Depth			0.50-1.00	0.50-1.00	0.00-0.50	0.00-0.50	0.00-0.50
Particle Density*	g/cm3		2.5	2.7	2.6	2.7	2.6

Envirolab ID	**Units**	**PQL**	PEK0250-20	PEK0250-23	PEK0250-24
Your Reference			EPW8	EPW8A	EPW8A
Date Sampled			31/10/2023	31/10/2023	31/10/2023
Depth			0.00-0.50	0.00-0.50	0.50-1.00
Particle Density*	g/cm3		2.5	2.5	2.5

Certificate of Analysis PEK0250

Particle Size (Sediment)

Envirolab ID	Units	PQL	PEK0250-01	PEK0250-02	PEK0250-03	PEK0250-04	PEK0250-05
Your Reference			EPW6	EPW5	EPW10	EPW10	EPW7
Date Sampled			31/10/2023	31/10/2023	31/10/2023	31/10/2023	31/10/2023
Depth			0.00-0.50	0.00-0.50	0.00-0.50	0.50-1.00	0.50-1.00
75 mm	% passing	1.0	100	100	100	100	100
37.5 mm	% passing	1.0	100	100	100	100	100
19 mm	% passing	1.0	100	100	100	100	100
9.5 mm	% passing	1.0	99	100	99	100	100
4.75 mm	% passing	1.0	96	98	96	96	100
2.36 mm	% passing	1.0	88	95	90	90	99
1.18 mm	% passing	1.0	78	81	84	83	98
600 µm	% passing	1.0	71	63	78	78	89
425 µm	% passing	1.0	<1.0	41	72	72	77
300 µm	% passing	1.0	46	21	64	64	53
150 µm	% passing	1.0	24	6.0	44	50	16
75 µm	% passing	1.0	16	3.1	30	40	6.6
20 µm	% passing	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
2 µm Clay	% passing	1.0	<1.0	<1.0	<1.0	<1.0	<1.0

Envirolab ID	Units	PQL	PEK0250-06	PEK0250-07	PEK0250-08	PEK0250-09	PEK0250-10
Your Reference			EPW6	EPW3	EPW7	EPW7	EPW3
Date Sampled			31/10/2023	31/10/2023	31/10/2023	31/10/2023	31/10/2023
Depth			0.50-1.00	0.50-1.00	0.00-0.50	1.00-1.50	0.00-0.50
75 mm	% passing	1.0	100	100	100	100	100
37.5 mm	% passing	1.0	100	100	100	100	100
19 mm	% passing	1.0	92	100	100	100	100
9.5 mm	% passing	1.0	81	100	100	100	100
4.75 mm	% passing	1.0	70	97	100	100	99
2.36 mm	% passing	1.0	60	93	100	99	97
1.18 mm	% passing	1.0	51	75	100	98	82
600 µm	% passing	1.0	44	61	90	93	67
425 µm	% passing	1.0	38	52	75	82	54
300 µm	% passing	1.0	30	38	47	57	34
150 µm	% passing	1.0	18	7.2	15	16	4.5
75 µm	% passing	1.0	13	4.5	8.5	8.3	3.0
20 µm	% passing	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
2 µm Clay	% passing	1.0	<1.0	<1.0	<1.0	<1.0	<1.0

Envirolab ID	Units	PQL	PEK0250-11	PEK0250-13	PEK0250-14	PEK0250-15	PEK0250-16
Your Reference			EPW1	EPW11	EPW1	EPW11	EPW11
Date Sampled			31/10/2023	31/10/2023	31/10/2023	31/10/2023	31/10/2023
Depth			0.00-0.50	1.00-1.50	0.50-1.00	0.50-1.00	0.00-0.50
75 mm	% passing	1.0	100	100	100	100	100
37.5 mm	% passing	1.0	100	100	100	100	100
19 mm	% passing	1.0	100	99	100	100	100
9.5 mm	% passing	1.0	100	95	100	100	100
4.75 mm	% passing	1.0	97	86	96	98	100
2.36 mm	% passing	1.0	94	75	96	91	99
1.18 mm	% passing	1.0	90	64	91	84	98
600 µm	% passing	1.0	86	59	88	76	92
425 µm	% passing	1.0	79	52	83	68	82

Particle Size (Sediment)

Envirolab ID	Units	PQL	PEK0250-11	PEK0250-13	PEK0250-14	PEK0250-15	PEK0250-16
Your Reference			EPW1	EPW11	EPW1	EPW11	EPW11
Date Sampled			31/10/2023	31/10/2023	31/10/2023	31/10/2023	31/10/2023
Depth			0.00-0.50	1.00-1.50	0.50-1.00	0.50-1.00	0.00-0.50
300 µm	% passing	1.0	66	40	74	53	64
150 µm	% passing	1.0	33	12	46	20	18
75 µm	% passing	1.0	26	6.8	39	11	9.8
20 µm	% passing	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
2 µm Clay	% passing	1.0	<1.0	<1.0	<1.0	<1.0	<1.0

Envirolab ID	Units	PQL	PEK0250-17	PEK0250-18	PEK0250-19	PEK0250-20	PEK0250-23
Your Reference			EPW2	EPW12	EPW4	EPW8	EPW8A
Date Sampled			31/10/2023	31/10/2023	31/10/2023	31/10/2023	31/10/2023
Depth			0.00-0.50	0.00-0.50	0.00-0.50	0.00-0.50	0.00-0.50
75 mm	% passing	1.0	100	100	100	100	100
37.5 mm	% passing	1.0	100	100	94	100	100
19 mm	% passing	1.0	99	100	91	100	100
9.5 mm	% passing	1.0	95	99	86	100	100
4.75 mm	% passing	1.0	90	96	78	96	95
2.36 mm	% passing	1.0	81	91	71	89	86
1.18 mm	% passing	1.0	71	80	61	84	79
600 µm	% passing	1.0	64	71	55	79	75
425 µm	% passing	1.0	59	62	51	76	73
300 µm	% passing	1.0	52	50	45	72	70
150 µm	% passing	1.0	39	21	34	64	63
75 µm	% passing	1.0	32	11	28	61	58
20 µm	% passing	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
2 µm Clay	% passing	1.0	<1.0	<1.0	<1.0	<1.0	<1.0

Envirolab ID	Units	PQL	PEK0250-24
Your Reference			EPW8A
Date Sampled			31/10/2023
Depth			0.50-1.00
75 mm	% passing	1.0	100
37.5 mm	% passing	1.0	100
19 mm	% passing	1.0	100
9.5 mm	% passing	1.0	100
4.75 mm	% passing	1.0	95
2.36 mm	% passing	1.0	88
1.18 mm	% passing	1.0	83
600 µm	% passing	1.0	80
425 µm	% passing	1.0	77
300 µm	% passing	1.0	74
150 µm	% passing	1.0	68
75 µm	% passing	1.0	65
20 µm	% passing	1.0	<1.0
2 µm Clay	% passing	1.0	<1.0

Certificate of Analysis PEK0250

Subcontracted Organics - Certificate: 23S1637 - Analysed By ChemCentre - WA (Sediment)

Envirolab ID	Units	PQL	PEK0250-01	PEK0250-02	PEK0250-03	PEK0250-04	PEK0250-05
Your Reference			EPW6	EPW5	EPW10	EPW10	EPW7
Date Sampled			31/10/2023	31/10/2023	31/10/2023	31/10/2023	31/10/2023
Depth			0.00-0.50	0.00-0.50	0.00-0.50	0.50-1.00	0.50-1.00
Praziquantel*	µg/kg	5.0	<5 [13]	<5 [13]	<5 [13]	<5 [13]	<5 [13]

Envirolab ID	Units	PQL	PEK0250-06	PEK0250-07	PEK0250-08	PEK0250-09	PEK0250-10
Your Reference			EPW6	EPW3	EPW7	EPW7	EPW3
Date Sampled			31/10/2023	31/10/2023	31/10/2023	31/10/2023	31/10/2023
Depth			0.50-1.00	0.50-1.00	0.00-0.50	1.00-1.50	0.00-0.50
Praziquantel*	µg/kg	5.0	<5 [13]	<5 [13]	<5 [13]	<5 [13]	<5 [13]

Envirolab ID	Units	PQL	PEK0250-11	PEK0250-12	PEK0250-13	PEK0250-14	PEK0250-15
Your Reference			EPW1	EPW8	EPW11	EPW1	EPW11
Date Sampled			31/10/2023	31/10/2023	31/10/2023	31/10/2023	31/10/2023
Depth			0.00-0.50	0.50-1.00	1.00-1.50	0.50-1.00	0.50-1.00
Praziquantel*	µg/kg	5.0	<5 [13]	<5 [13]	<5 [13]	<5 [13]	<5 [13]

Envirolab ID	Units	PQL	PEK0250-16	PEK0250-17	PEK0250-18	PEK0250-19	PEK0250-20
Your Reference			EPW11	EPW2	EPW12	EPW4	EPW8
Date Sampled			31/10/2023	31/10/2023	31/10/2023	31/10/2023	31/10/2023
Depth			0.00-0.50	0.00-0.50	0.00-0.50	0.00-0.50	0.00-0.50
Praziquantel*	µg/kg	5.0	<5 [13]	<5 [13]	<5 [13]	<5 [13]	<5 [13]

Envirolab ID	Units	PQL	PEK0250-23	PEK0250-24
Your Reference			EPW8A	EPW8A
Date Sampled			31/10/2023	31/10/2023
Depth			0.00-0.50	0.50-1.00
Praziquantel*	µg/kg	5.0	<5 [13]	<5 [13]

Result Comments

Identifier	Description
[7]	Surrogate recovery was outside routine acceptance criteria (60-140%) due to sample matrix effects. This may be due to the presence of carbon and/or other artefacts. An acceptable recovery was achieved for the LCS surrogates.
[8]	Samples exhibited low extracted internal standard recovery; results above adjusted PQLs will have a higher measurement uncertainty
[9]	PQL(s) has/have been raised due to matrix interference.
[13]	The sub-contracting laboratory did not provide analysis and/or preparation and/or sample receipt dates. The date(s) the sample(s) was/were received at the sub-contracting laboratory has/have been used to assess holding time(s).

Method Summary

Method ID	Methodology Summary
Calc	Calculation
Calc - TKN	TKN determined by calculation (Total Nitrogen - NOx).
INORG-008	Moisture content determined by heating at 105+/-5 °C for a minimum of 12 hours.
INORG-014	Cyanide - free, total, weak acid dissociable by segmented flow analyser (in line dialysis with colourimetric finish). Solids/Filters and sorbents are extracted in a caustic media prior to analysis. Impingers are pH adjusted as required prior to analysis. Cyanides amenable to Chlorination - samples are analysed untreated and treated with hypochlorite to assess the potential for chlorination of cyanide forms.
INORG-055	Nitrate/Nitrite/NOx/TKN - determined colourimetrically. Waters samples are filtered on receipt prior to analysis. Soils/solids are analysed following a water extraction.
INORG-057	Ammonia - determined colourimetrically. Water samples are filtered on receipt prior to analysis. Soils and OHS media are analysed following a water extraction. Alternatively, Ammonia can be extracted from soil using 1M KCl.
INORG-060	Phosphate - determined colourimetrically using APHA latest edition 4500 P E. Water samples are filtered on receipt prior to analysis. Soils are analysed from a water extract.
INORG-107	Particle Size Distribution using in house method INORG-107 (sieves and hydrometer).
INORG-122	Soil Density using gas pycnometer
INORG-137	Determination of Total Nitrogen, Sulphur and Total Carbon in solids, rock, plant material and vegetation via combustion and NDIR.
METALS-020	Determination of various metals by ICP-OES.
METALS-021	Determination of Mercury by Cold Vapour AAS.
METALS-022	Determination of various metals by ICP-MS. Please note for Bromine and Iodine, any forms of these elements that are present are included together in the one result reported for each of these two elements.
ORG-020	Soil samples are extracted with Dichloromethane/Acetone and waters with Dichloromethane and analysed by GC-FID. F2 = (>C10-C16)-Naphthalene as per NEPM B1 Guideline on Investigation Levels for Soil and Groundwater (HSLs Tables 1A (3, 4)). Note Naphthalene is determined from the VOC analysis. Note, the Total +ve TRH PQL is reflective of the lowest individual PQL and is therefore "Total +ve TRH" is simply a sum of the positive individual TRH fractions (>C10-C40).
ORG-022	Determination of semi-volatile organic compounds (SVOCs) by GC-MS. Water samples are extracted by LLE and soils using DCM/Acetone/Methanol.
ORG-022_OC	Determination of semi-volatile organic compounds (SVOCs) by GC-MS. Water samples are extracted by LLE and soils using DCM/Acetone/Methanol.
ORG-022_PAH	Determination of semi-volatile organic compounds (SVOCs) by GC-MS. Water samples are extracted by LLE and solids using DCM/Acetone/Methanol. For PAHs:- Benzo(a)pyrene TEQ as per NEPM B1 Guideline on Investigation Levels for Soil and Groundwater - 2013. 1. 'TEQ PQL' values are assuming all contributing PAHs reported as <PQL are actually at the PQL. This is the most conservative approach and can give false positive TEQs given that PAHs that contribute to the TEQ calculation may not be present. 2. 'TEQ zero' values are assuming all contributing PAHs reported as <PQL are zero. This is the least conservative approach and is more susceptible to false negative TEQs when PAHs that contribute to the TEQ calculation are present but below PQL. 3. 'TEQ half PQL' values are assuming all contributing PAHs reported as <PQL are half the stipulated PQL. Hence a mid-point between the most and least conservative approaches above. Note, for Total +ve calculations, the PQL is reflective of the lowest individual PQL and therefore, for example, "Total +ve PAHs" is simply a sum of the positive individual PAHs.
ORG-023	Determination of volatile organic compounds (VOCs) by P&T-GC-MS. Water samples are analysed directly by purge and trap GC-MS. Soils are extracted with Methanol, diluted and analysed by purge and trap GC-MS.
ORG-023_F1_TOT	Determination of volatile organic compounds (VOCs) by P&T-GC-MS. Water samples are analysed directly by purge and trap GC-MS. Solids are extracted with Methanol, diluted and analysed by purge and trap GC-MS. F1 = (C6-C10)-BTEX as per NEPM B1 Guideline on Investigation Levels for Soil and Groundwater. Note, the Total +ve Xylene PQL is reflective of the lowest individual PQL and is therefore "Total +ve Xylenes" is simply a sum of the positive individual Xylenes.
ORG-025	Determination of semi-volatile organic compounds (SVOCs) by GC-MS-MS. Water samples are extracted by LLE and soils/solids using DCM/Acetone/Methanol.
ORG-025_TBT_S	Determination of Organometallic Compounds by derivatisation and analysis by GC-MS-MS.
ORG-025_TBT_W	Determination of Organometallic Compounds by derivatisation and analysis by GC-MS-MS.
SUB-007	Subcontracted to Chemcentre - Accreditation number 8

Result Definitions

Identifier	Description
NR	Not reported
NEPM	National Environment Protection Measure
NS	Not specified
LCS	Laboratory Control Sample
RPD	Relative Percent Difference
>	Greater than
<	Less than
PQL	Practical Quantitation Limit
INS	Insufficient sample for this test
NA	Test not required
NT	Not tested
DOL	Samples rejected due to particulate overload (air filters only)
RFD	Samples rejected due to filter damage (air filters only)
RUD	Samples rejected due to uneven deposition (air filters only)
##	Indicates a laboratory acceptance criteria outlier, for further details, see Result Comments and/or QC Comments

Quality Control Definitions

Blank

This is the component of the analytical signal which is not derived from the sample but from reagents, glassware etc, and is determined by processing solvents and reagents in exactly the same manner as for samples.

Surrogate Spike

Surrogates are known additions to each sample, blank, matrix spike and LCS in a batch, of compounds which are similar to the analyte of interest, however are not expected to be found in real samples.

LCS (Laboratory Control Sample)

This comprises either a standard reference material or a control matrix (such as a blank sand or water) fortified with analytes representative of the analyte class. It is simply a check sample.

Matrix Spike

A portion of the sample is spiked with a known concentration of target analyte. The purpose of the matrix spike is to monitor the performance of the analytical method used and to determine whether matrix interferences exist.

Duplicate

This is the complete duplicate analysis of a sample from the process batch. The sample selected should be one where the analyte concentration is easily measurable.

Laboratory Acceptance Criteria

Duplicate sample and matrix spike recoveries may not be reported on smaller jobs, however, were analysed at a frequency to meet or exceed NEPM requirements. All samples are tested in batches of 20. The duplicate sample RPD and matrix spike recoveries for the batch were within the laboratory acceptance criteria. Filters, swabs, wipes, tubes and badges will not have duplicate data as the whole sample is generally extracted during sample extraction. Spikes for Physical and Aggregate Tests are not applicable. For VOCs in water samples, three vials are required for duplicate or spike analysis.

General Acceptance Criteria (GAC) - Analyte specific criteria applies for some analytes and is reflected in QC recovery tables.

Duplicates: >10xPQL - RPD acceptance criteria will vary depending on the analytes and the analytical techniques but is typically in the range 20%-50% - see ELN-P05 QAQC tables for details (available on request); <10xPQL - RPD are higher as the results approach PQL and the estimated measurement uncertainty will statistically increase. Matrix Spikes, LCS and Surrogate recoveries: Generally 70-130% for inorganics/metals; 60-140% for organics (+/-50% surrogates) and 10-140% for labile SVOCs (including labile surrogates), ultra trace organics and speciated phenols is acceptable.

In circumstances where no duplicate and/or sample spike has been reported at 1 in 10 and/or 1 in 20 samples respectively, the sample volume submitted was typically insufficient in order to satisfy laboratory QA/QC protocols.

Miscellaneous Information

When samples are received where certain analytes are outside of recommended technical holding times (THTs), the analysis has proceeded. Where analytes are on the verge of breaching THTs, every effort will be made to analyse within the THT or as soon as practicable.

Where sampling dates are not provided, Envirolab are not in a position to comment on the validity of the analysis where recommended technical holding times may have been breached. We have taken the sampling date as being the date received at the laboratory.

Two significant figures are reported for the majority of tests and with a high degree of confidence, for results <10*PQL, the second significant figure may be in doubt i.e. has a relatively high degree of uncertainty and is provided for information only.

Measurement Uncertainty estimates are available for most tests upon request.

Analysis of aqueous samples typically involves the extraction/digestion and/or analysis of the liquid phase only (i.e. NOT any settled sediment phase but inclusive of suspended particles if present), unless stipulated on the Envirolab COC or by correspondence. Notable exceptions include certain Physical Tests (pH/EC/BOD/COD/Apparent Colour etc.), Solids testing, Total Recoverable metals and PFAS where sediment/solids are included by default.

Urine Analysis - The BEI values listed are taken from the 2022 edition of *TLVs and BEIs Threshold Limits by ACGIH*.

Air volume measurements are not covered by Envirolab's NATA accreditation.

Data Quality Assessment Summary PEK0250

Client Details

Client	BMT Commercial Australia Pty Ltd
Your Reference	SA Water DP
Date Issued	29/11/2023

Recommended Holding Time Compliance

No recommended holding time exceedances

Quality Control and QC Frequency

QC Type	Compliant	Details
Blank	Yes	No Outliers
LCS	No	LCS Outliers Exist - See detailed list below
Duplicates	No	Duplicate Outliers Exist - See detailed list below
Matrix Spike	No	Matrix Spike Outliers Exist - See detailed list below
Surrogates / Extracted Internal Standards	No	Surrogates / Extracted ISTD Outliers Exist - See detailed list below
QC Frequency	No	QC Frequency Outliers Exist - See detailed list below

Surrogates/Extracted Internal Standards, Duplicates and/or Matrix Spikes are not always relevant/applicable to certain analyses and matrices. Therefore, said QC measures are deemed compliant in these situations by default. See Laboratory Acceptance Criteria for more information

Recommended Holding Time Compliance

Analysis	Sample Number(s)	Date Sampled	Date Extracted	Date Analysed	Compliant
VCH NAGD | Soil	16-20, 23-24	31/10/2023	06/11/2023	08/11/2023	Yes
	1-15	31/10/2023	06/11/2023	09/11/2023	Yes
vTRH&MBTEXN | Water	21-22	31/10/2023	07/11/2023	07/11/2023	Yes
vTRH/BTEX - NAGD | Soil	1-15	31/10/2023	06/11/2023	06/11/2023	Yes
	16-20, 23-24	31/10/2023	06/11/2023	08/11/2023	Yes
sTRH | Water	21-22	31/10/2023	06/11/2023	07/11/2023	Yes
sTRH - NAGD | Soil	1-3, 5-20	31/10/2023	06/11/2023	09/11/2023	Yes
	23-24	31/10/2023	06/11/2023	10/11/2023	Yes
	4	31/10/2023	06/11/2023	14/11/2023	Yes
PAH NAGD | Soil	5-7	31/10/2023	06/11/2023	10/11/2023	Yes
	1-4, 8-20, 23-24	31/10/2023	06/11/2023	11/11/2023	Yes
OCP NAGD | Soil	5-7	31/10/2023	06/11/2023	10/11/2023	Yes
	1-4, 8-20, 23-24	31/10/2023	06/11/2023	11/11/2023	Yes
OPP NAGD | Soil	5-7	31/10/2023	06/11/2023	10/11/2023	Yes
	1-4, 8-20, 23-24	31/10/2023	06/11/2023	11/11/2023	Yes
PCB TR | Soil	23-24	31/10/2023	06/11/2023	11/11/2023	Yes
PCB Congeners NAGD | Soil	5-7	31/10/2023	06/11/2023	10/11/2023	Yes
	1-4, 8-20, 23-24	31/10/2023	06/11/2023	11/11/2023	Yes
SVCH NAGD | Soil	5-7	31/10/2023	06/11/2023	10/11/2023	Yes
	1-4, 8-20, 23-24	31/10/2023	06/11/2023	11/11/2023	Yes
Speciated Phenols | Soil	1-20, 23-24	31/10/2023	06/11/2023	08/11/2023	Yes
Syn Pyrethroid NAGD | Soil	1-20, 23-24	31/10/2023	06/11/2023	28/11/2023	Yes
Carbamates NAGD | Soil	5-7	31/10/2023	06/11/2023	10/11/2023	Yes
	1-4, 8-20, 23-24	31/10/2023	06/11/2023	11/11/2023	Yes
Triazines NAGD | Soil	5-7	31/10/2023	06/11/2023	10/11/2023	Yes
	1-4, 8-20, 23-24	31/10/2023	06/11/2023	11/11/2023	Yes
Phenoxy Acid Herbicides | Soil	1-20, 23-24	31/10/2023	06/11/2023	07/11/2023	Yes
Organotins NAGD | Soil	23	31/10/2023	06/11/2023	09/11/2023	Yes
	1-20, 24	31/10/2023	06/11/2023	10/11/2023	Yes
TBT | Water	21-22	31/10/2023	07/11/2023	09/11/2023	Yes
Metals | Soil	1-20, 23-24	31/10/2023	06/11/2023	07/11/2023	Yes
Total Metals (LL) | Water	21-22	31/10/2023	06/11/2023	08/11/2023	Yes
Total Metals (LL)-Hg | Water	21-22	31/10/2023	06/11/2023	07/11/2023	Yes
Metals (NAGD) | Soil	1-20, 23-24	31/10/2023	06/11/2023	08/11/2023	Yes
	1-20, 23-24	31/10/2023	06/11/2023	10/11/2023	Yes
Nitrogen - Ammonia | Soil	1-20, 23-24	31/10/2023	08/11/2023	08/11/2023	Yes
Nitrogen - Nitrate | Soil	1-20, 23-24	31/10/2023	06/11/2023	09/11/2023	Yes
Nitrogen - Nitrite | Soil	1-20, 23-24	31/10/2023	06/11/2023	09/11/2023	Yes
Nitrogen - NOx | Soil	1-20, 23-24	31/10/2023	06/11/2023	09/11/2023	Yes
TOC by Combustion | Soil	1-20, 23-24	31/10/2023	15/11/2023	15/11/2023	Yes

Data Quality Assessment Summary PEK0250

Recommended Holding Time Compliance

Analysis	Sample Number(s)	Date Sampled	Date Extracted	Date Analysed	Compliant
Total Nitrogen | Soil	1-20, 23-24	31/10/2023	14/11/2023	15/11/2023	Yes
TKN as N calc | Soil	1-20, 23-24	31/10/2023	07/11/2023	17/11/2023	Yes
Phosphate as P | Soil	1-18, 20, 23-24	31/10/2023	06/11/2023	09/11/2023	Yes
	19	31/10/2023	06/11/2023	10/11/2023	Yes
Moisture | Soil	1-20, 23-24	31/10/2023	06/11/2023	07/11/2023	Yes
Cyanide - Total | Soil	1-20, 23-24	31/10/2023	06/11/2023	08/11/2023	Yes
Particle Density | Soil	1, 3-4, 6, 11, 14-15, 17-20, 23-24	31/10/2023	17/11/2023	17/11/2023	Yes
PSD Hydrometer | Soil	1-11, 13-20, 23-24	31/10/2023	16/11/2023	17/11/2023	Yes
PSD Sieving | Soil	1-11, 13-20, 23-24	31/10/2023	16/11/2023	17/11/2023	Yes
Praziquantel | Soil	1-20, 23-24	31/10/2023	07/11/2023	16/11/2023	Yes

Outliers: Laboratory Control Samples

ORG-020|Semi-volatile TRH (Water)| Batch BEK0495

Sample ID	Analyte	% Limits	% Recovery
BEK0495-BS1	o-Terphenyl	60 - 140	##

ORG-020|Semi-volatile TRH - NAGD (Soil)| Batch BEK0544

Sample ID	Analyte	% Limits	% Recovery
BEK0544-BS1	o-Terphenyl	60 - 140	##

ORG-020|Semi-volatile TRH - NAGD (Soil)| Batch BEK0545

Sample ID	Analyte	% Limits	% Recovery
BEK0545-BS1	o-Terphenyl	60 - 140	##

Data Quality Assessment Summary PEK0250

Outliers: Duplicates

METALS-022|Acid Extractable Low Level Metals (Water)| Batch BEK0511

Sample ID	Duplicate ID	Analyte	% Limits	RPD
BEK0511-DUP2#	DUP2	Nickel	30.00	200[10]

METALS-022|NAGD Metals (Soil)| Batch BEK0531

Sample ID	Duplicate ID	Analyte	% Limits	RPD
BEK0531-DUP1#	DUP1	Copper	40.00	72.5[11]
BEK0531-DUP1#	DUP1	Selenium	40.00	200[11]
BEK0531-DUP3#	DUP3	Copper	40.00	56.9[11]
BEK0531-DUP3#	DUP3	Selenium	40.00	200[11]

METALS-022|NAGD Metals (Soil)| Batch BEK0532

Sample ID	Duplicate ID	Analyte	% Limits	RPD
PEK0250-16	DUP1	Zinc	40.00	52.6[11]

Data Quality Assessment Summary PEK0250

Outliers: Matrix Spike

INORG-014|Inorganics - Cyanide Species and Similar (Soil)| Batch BEK0530

Sample ID	Analyte	% Limits	% Recovery
PEK0250-24	Total Cyanide	70 - 130	##[3]

INORG-057|Inorganics - Carbons, Nitrogen Species, Sulfur Species (Soil)| Batch BEK0787

Sample ID	Analyte	% Limits	% Recovery
PEK0250-02	Ammonia as N	70 - 130	##[2]

METALS-022|NAGD Metals (Soil)| Batch BEK0531

Sample ID	Analyte	% Limits	% Recovery
BEK0531-MS1#	Aluminium	70 - 130	##[1]
BEK0531-MS1#	Iron	70 - 130	##[1]

METALS-022|NAGD Metals (Soil)| Batch BEK0532

Sample ID	Analyte	% Limits	% Recovery
PEK0250-17	Iron	70 - 130	##[1]

ORG-020|Semi-volatile TRH (Water)| Batch BEK0495

Sample ID	Analyte	% Limits	% Recovery
BEK0495-MS1#	o-Terphenyl	60 - 140	##[6]

ORG-020|Semi-volatile TRH - NAGD (Soil)| Batch BEK0544

Sample ID	Analyte	% Limits	% Recovery
PEK0250-02	o-Terphenyl	60 - 140	##[6]

ORG-020|Semi-volatile TRH - NAGD (Soil)| Batch BEK0545

Sample ID	Analyte	% Limits	% Recovery
PEK0250-24	o-Terphenyl	60 - 140	##[6]

ORG-022|Organophosphorus Pesticides - NAGD (Soil)| Batch BEK0547

Sample ID	Analyte	% Limits	% Recovery

ORG-022_OC|Organochlorine Pesticides - NAGD (Soil)| Batch BEK0547

Sample ID	Analyte	% Limits	% Recovery
PEK0250-02	2-Chlorophenol-D4	60 - 140	57.4[7]
PEK0250-02	Aldrin	60 - 140	46.5[4]

Data Quality Assessment Summary PEK0250

ORG-025|Phenoxy Acid Herbicides (Soil)| Batch BEK0540

Sample ID	Analyte	% Limits	% Recovery
PEK0250-02	2,4-D	60 - 140	45.0[4]
PEK0250-02	MCPA	60 - 140	50.7[4]

ORG-025|Phenoxy Acid Herbicides (Soil)| Batch BEK0541

Sample ID	Analyte	% Limits	% Recovery
PEK0250-24	2,4,5-T	60 - 140	45.6[4]
PEK0250-24	2,4-D	60 - 140	29.6[4]
PEK0250-24	MCPA	60 - 140	33.7[4]

Outliers: Surrogate / Extracted Internal Standards

ORG-022|Organophosphorus Pesticides - NAGD (Matrix)| Batch BEK0547

Sample ID	Analyte	% Limits	% Recovery
PEK0250-01	2-Chlorophenol-D4	60 - 140	53.0% [7]
PEK0250-02	2-Chlorophenol-D4	60 - 140	53.5% [7]
PEK0250-05	2-Chlorophenol-D4	60 - 140	54.5% [7]
PEK0250-06	2-Chlorophenol-D4	60 - 140	55.1% [7]
PEK0250-09	2-Chlorophenol-D4	60 - 140	## [7]
PEK0250-10	2-Chlorophenol-D4	60 - 140	40.7% [7]
PEK0250-12	2-Chlorophenol-D4	60 - 140	45.5% [7]
PEK0250-14	2-Chlorophenol-D4	60 - 140	37.4% [7]
PEK0250-15	2-Chlorophenol-D4	60 - 140	## [7]
PEK0250-16	2-Chlorophenol-D4	60 - 140	45.3% [7]
PEK0250-18	2-Chlorophenol-D4	60 - 140	## [7]
PEK0250-19	2-Chlorophenol-D4	60 - 140	50.5% [7]
PEK0250-20	2-Chlorophenol-D4	60 - 140	48.6% [7]

ORG-022_OC|Organochlorine Pesticides - NAGD (Matrix)| Batch BEK0547

Sample ID	Analyte	% Limits	% Recovery
PEK0250-01	2-Chlorophenol-D4	60 - 140	53.0% [7]
PEK0250-02	2-Chlorophenol-D4	60 - 140	53.5% [7]
PEK0250-05	2-Chlorophenol-D4	60 - 140	54.5% [7]
PEK0250-06	2-Chlorophenol-D4	60 - 140	55.1% [7]
PEK0250-09	2-Chlorophenol-D4	60 - 140	## [7]
PEK0250-10	2-Chlorophenol-D4	60 - 140	40.7% [7]
PEK0250-12	2-Chlorophenol-D4	60 - 140	45.5% [7]
PEK0250-14	2-Chlorophenol-D4	60 - 140	37.4% [7]
PEK0250-15	2-Chlorophenol-D4	60 - 140	## [7]
PEK0250-16	2-Chlorophenol-D4	60 - 140	45.3% [7]
PEK0250-18	2-Chlorophenol-D4	60 - 140	## [7]
PEK0250-20	2-Chlorophenol-D4	60 - 140	48.6% [7]

Outliers: QC Frequency

ORG-023_F1_TOT|Volatile TRH and BTEX (Water)| Batch BEK0759

Analysis	QC Type	Expected	Reported
vTRH&MBTEXN	Matrix Spike	1	0

ORG-023|Volatile Organic Compounds (Soil) | Batch BEK0533

Analyte	Units	PQL	Blank	DUP1 BEK0533-DUP1# Samp | QC | RPD %	DUP2 PEK0250-07 Samp | QC | RPD %	LCS %	Spike % BEK0533-MS2#
Hexachlorocyclopentadiene	mg/kg		<0.10	<0.10 | <0.10 | [NA]	<0.10 | <0.10 | [NA]	[NA]	[NA]
Dichlorodifluoromethane (Freon-12)	mg/kg	1.0	<1.0	<1.0 | <1.0 | [NA]	<1.0 | <1.0 | [NA]	[NA]	[NA]
Chloromethane	mg/kg	1.0	<1.0	<1.0 | <1.0 | [NA]	<1.0 | <1.0 | [NA]	[NA]	[NA]
Vinyl chloride	mg/kg	0.30	<0.30	<0.30 | <0.30 | [NA]	<0.30 | <0.30 | [NA]	[NA]	[NA]
Bromomethane	mg/kg	1.0	<1.0	<1.0 | <1.0 | [NA]	<1.0 | <1.0 | [NA]	[NA]	[NA]
Chloroethane	mg/kg	1.0	<1.0	<1.0 | <1.0 | [NA]	<1.0 | <1.0 | [NA]	[NA]	[NA]
Trichlorofluoromethane (Freon-11)	mg/kg	0.70	<0.70	<0.70 | <0.70 | [NA]	<0.70 | <0.70 | [NA]	[NA]	[NA]
1,1-Dichloroethene	mg/kg	0.10	<0.10	<0.10 | <0.10 | [NA]	<0.10 | <0.10 | [NA]	[NA]	[NA]
trans-1,2-Dichloroethene	mg/kg	0.10	<0.10	<0.10 | <0.10 | [NA]	<0.10 | <0.10 | [NA]	[NA]	[NA]
1,1-Dichloroethane	mg/kg	0.10	<0.10	<0.10 | <0.10 | [NA]	<0.10 | <0.10 | [NA]	113	115
2,2-Dichloropropane	mg/kg	1.0	<1.0	<1.0 | <1.0 | [NA]	<1.0 | <1.0 | [NA]	[NA]	[NA]
cis-1,2-Dichloroethene	mg/kg	0.10	<0.10	<0.10 | <0.10 | [NA]	<0.10 | <0.10 | [NA]	[NA]	[NA]
Bromochloromethane	mg/kg	0.50	<0.50	<0.50 | <0.50 | [NA]	<0.50 | <0.50 | [NA]	[NA]	[NA]
Chloroform	mg/kg	0.10	<0.10	<0.10 | <0.10 | [NA]	<0.10 | <0.10 | [NA]	114	117
1,1,1-Trichloroethane	mg/kg	0.10	<0.10	<0.10 | <0.10 | [NA]	<0.10 | <0.10 | [NA]	117	118
1,1-Dichloropropene	mg/kg	0.10	<0.10	<0.10 | <0.10 | [NA]	<0.10 | <0.10 | [NA]	[NA]	[NA]
Carbon Tetrachloride	mg/kg	0.10	<0.10	<0.10 | <0.10 | [NA]	<0.10 | <0.10 | [NA]	[NA]	[NA]
1,2-Dichloroethane	mg/kg	0.10	<0.10	<0.10 | <0.10 | [NA]	<0.10 | <0.10 | [NA]	113	116
Trichloroethene	mg/kg	0.10	<0.10	<0.10 | <0.10 | [NA]	<0.10 | <0.10 | [NA]	114	118
1,2-Dichloropropane	mg/kg	0.10	<0.10	<0.10 | <0.10 | [NA]	<0.10 | <0.10 | [NA]	[NA]	[NA]
Dibromomethane	mg/kg	0.50	<0.50	<0.50 | <0.50 | [NA]	<0.50 | <0.50 | [NA]	[NA]	[NA]
Bromodichloromethane	mg/kg	0.10	<0.10	<0.10 | <0.10 | [NA]	<0.10 | <0.10 | [NA]	112	114
cis-1,3-Dichloropropene	mg/kg	0.10	<0.10	<0.10 | <0.10 | [NA]	<0.10 | <0.10 | [NA]	[NA]	[NA]
trans-1,3-Dichloropropene	mg/kg	0.10	<0.10	<0.10 | <0.10 | [NA]	<0.10 | <0.10 | [NA]	[NA]	[NA]
1,1,2-Trichloroethane	mg/kg	0.10	<0.10	<0.10 | <0.10 | [NA]	<0.10 | <0.10 | [NA]	[NA]	[NA]
1,3-Dichloropropane	mg/kg	0.10	<0.10	<0.10 | <0.10 | [NA]	<0.10 | <0.10 | [NA]	[NA]	[NA]
Tetrachloroethene	mg/kg	0.10	<0.10	<0.10 | <0.10 | [NA]	<0.10 | <0.10 | [NA]	114	113
Dibromochloromethane	mg/kg	0.10	<0.10	<0.10 | <0.10 | [NA]	<0.10 | <0.10 | [NA]	112	114
1,2-Dibromoethane	mg/kg	0.10	<0.10	<0.10 | <0.10 | [NA]	<0.10 | <0.10 | [NA]	[NA]	[NA]
Chlorobenzene	mg/kg	0.10	<0.10	<0.10 | <0.10 | [NA]	<0.10 | <0.10 | [NA]	[NA]	[NA]
1,1,1,2-Tetrachloroethane	mg/kg	0.10	<0.10	<0.10 | <0.10 | [NA]	<0.10 | <0.10 | [NA]	[NA]	[NA]
Bromoform	mg/kg	0.10	<0.10	<0.10 | <0.10 | [NA]	<0.10 | <0.10 | [NA]	107	111
1,1,2,2-Tetrachloroethane	mg/kg	0.10	<0.10	<0.10 | <0.10 | [NA]	<0.10 | <0.10 | [NA]	[NA]	[NA]
1,2,3-Trichloropropane	mg/kg	0.10	<0.10	<0.10 | <0.10 | [NA]	<0.10 | <0.10 | [NA]	[NA]	[NA]
Bromobenzene	mg/kg	0.10	<0.10	<0.10 | <0.10 | [NA]	<0.10 | <0.10 | [NA]	[NA]	[NA]
2-Chlorotoluene	mg/kg	0.10	<0.10	<0.10 | <0.10 | [NA]	<0.10 | <0.10 | [NA]	[NA]	[NA]
4-Chlorotoluene	mg/kg	0.10	<0.10	<0.10 | <0.10 | [NA]	<0.10 | <0.10 | [NA]	[NA]	[NA]
1,3-Dichlorobenzene	mg/kg	0.10	<0.10	<0.10 | <0.10 | [NA]	<0.10 | <0.10 | [NA]	[NA]	[NA]
1,4-Dichlorobenzene	mg/kg	0.10	<0.10	<0.10 | <0.10 | [NA]	<0.10 | <0.10 | [NA]	107	109
1,2-Dichlorobenzene	mg/kg	0.10	<0.10	<0.10 | <0.10 | [NA]	<0.10 | <0.10 | [NA]	[NA]	[NA]
1,2-Dibromo-3-chloropropane	mg/kg	0.10	<0.10	<0.10 | <0.10 | [NA]	<0.10 | <0.10 | [NA]	[NA]	[NA]
Hexachlorobutadiene	mg/kg	0.10	<0.10	<0.10 | <0.10 | [NA]	<0.10 | <0.10 | [NA]	[NA]	[NA]
1,2,4-Trichlorobenzene	mg/kg	0.10	<0.10	<0.10 | <0.10 | [NA]	<0.10 | <0.10 | [NA]	111	113
1,2,3-Trichlorobenzene	mg/kg	0.10	<0.10	<0.10 | <0.10 | [NA]	<0.10 | <0.10 | [NA]	[NA]	[NA]
Surrogate Dibromofluoromethane	*%*		*99.1*	*101 | 99.5*	*99.1 | 101*	*101*	*101*
Surrogate aaa-Trifluorotoluene	*%*		*115*	*111 | 113*	*113 | 106*	*112*	*112*
Surrogate Toluene-D8	*%*		*102*	*99.4 | 99.5*	*98.0 | 100*	*102*	*102*
Surrogate 4-Bromofluorobenzene	*%*		*102*	*103 | 105*	*99.1 | 99.6*	*97.9*	*98.5*

The QC reported was not specifically part of this workorder but formed part of the QC process batch.

Quality Control PEK0250

ORG-023 | Volatile Organic Compounds (Soil) | Batch BEK0549

Analyte	Units	PQL	Blank	DUP1 PEK0250-16 Samp | QC | RPD %	DUP2 BEK0549-DUP2# Samp | QC | RPD %	LCS %	Spike % PEK0250-17
Hexachlorocyclopentadiene	mg/kg		0.00	0.00 | 0.00 | [NA]	0.00 | 0.00 | [NA]	[NA]	[NA]
Dichlorodifluoromethane (Freon-12)	mg/kg	1.0	<1.0	<1.0 | <1.0 | [NA]	<1.0 | <1.0 | [NA]	[NA]	[NA]
Chloromethane	mg/kg	1.0	<1.0	<1.0 | <1.0 | [NA]	<1.0 | <1.0 | [NA]	[NA]	[NA]
Vinyl chloride	mg/kg	0.30	<0.30	<0.30 | <0.30 | [NA]	<0.30 | <0.30 | [NA]	[NA]	[NA]
Bromomethane	mg/kg	1.0	<1.0	<1.0 | <1.0 | [NA]	<1.0 | <1.0 | [NA]	[NA]	[NA]
Chloroethane	mg/kg	1.0	<1.0	<1.0 | <1.0 | [NA]	<1.0 | <1.0 | [NA]	[NA]	[NA]
Trichlorofluoromethane (Freon-11)	mg/kg	0.70	<0.70	<0.70 | <0.70 | [NA]	<0.70 | <0.70 | [NA]	[NA]	[NA]
1,1-Dichloroethene	mg/kg	0.10	<0.10	<0.10 | <0.10 | [NA]	<0.10 | <0.10 | [NA]	[NA]	[NA]
trans-1,2-Dichloroethene	mg/kg	0.10	<0.10	<0.10 | <0.10 | [NA]	<0.10 | <0.10 | [NA]	[NA]	[NA]
1,1-Dichloroethane	mg/kg	0.10	<0.10	<0.10 | <0.10 | [NA]	<0.10 | <0.10 | [NA]	114	98.6
2,2-Dichloropropane	mg/kg	1.0	<1.0	<1.0 | <1.0 | [NA]	<1.0 | <1.0 | [NA]	[NA]	[NA]
cis-1,2-Dichloroethene	mg/kg	0.10	<0.10	<0.10 | <0.10 | [NA]	<0.10 | <0.10 | [NA]	[NA]	[NA]
Bromochloromethane	mg/kg	0.50	<0.50	<0.50 | <0.50 | [NA]	<0.50 | <0.50 | [NA]	[NA]	[NA]
Chloroform	mg/kg	0.10	<0.10	<0.10 | <0.10 | [NA]	<0.10 | <0.10 | [NA]	116	102
1,1,1-Trichloroethane	mg/kg	0.10	<0.10	<0.10 | <0.10 | [NA]	<0.10 | <0.10 | [NA]	119	102
1,1-Dichloropropene	mg/kg	0.10	<0.10	<0.10 | <0.10 | [NA]	<0.10 | <0.10 | [NA]	[NA]	[NA]
Carbon Tetrachloride	mg/kg	0.10	<0.10	<0.10 | <0.10 | [NA]	<0.10 | <0.10 | [NA]	[NA]	[NA]
1,2-Dichloroethane	mg/kg	0.10	<0.10	<0.10 | <0.10 | [NA]	<0.10 | <0.10 | [NA]	116	101
Trichloroethene	mg/kg	0.10	<0.10	<0.10 | <0.10 | [NA]	<0.10 | <0.10 | [NA]	122	112
1,2-Dichloropropane	mg/kg	0.10	<0.10	<0.10 | <0.10 | [NA]	<0.10 | <0.10 | [NA]	[NA]	[NA]
Dibromomethane	mg/kg	0.50	<0.50	<0.50 | <0.50 | [NA]	<0.50 | <0.50 | [NA]	[NA]	[NA]
Bromodichloromethane	mg/kg	0.10	<0.10	<0.10 | <0.10 | [NA]	<0.10 | <0.10 | [NA]	113	100
cis-1,3-Dichloropropene	mg/kg	0.10	<0.10	<0.10 | <0.10 | [NA]	<0.10 | <0.10 | [NA]	[NA]	[NA]
trans-1,3-Dichloropropene	mg/kg	0.10	<0.10	<0.10 | <0.10 | [NA]	<0.10 | <0.10 | [NA]	[NA]	[NA]
1,1,2-Trichloroethane	mg/kg	0.10	<0.10	<0.10 | <0.10 | [NA]	<0.10 | <0.10 | [NA]	[NA]	[NA]
1,3-Dichloropropane	mg/kg	0.10	<0.10	<0.10 | <0.10 | [NA]	<0.10 | <0.10 | [NA]	[NA]	[NA]
Tetrachloroethene	mg/kg	0.10	<0.10	<0.10 | <0.10 | [NA]	<0.10 | <0.10 | [NA]	109	94.4
Dibromochloromethane	mg/kg	0.10	<0.10	<0.10 | <0.10 | [NA]	<0.10 | <0.10 | [NA]	113	99.0
1,2-Dibromoethane	mg/kg	0.10	<0.10	<0.10 | <0.10 | [NA]	<0.10 | <0.10 | [NA]	[NA]	[NA]
Chlorobenzene	mg/kg	0.10	<0.10	<0.10 | <0.10 | [NA]	<0.10 | <0.10 | [NA]	[NA]	[NA]
1,1,1,2-Tetrachloroethane	mg/kg	0.10	<0.10	<0.10 | <0.10 | [NA]	<0.10 | <0.10 | [NA]	[NA]	[NA]
Bromoform	mg/kg	0.10	<0.10	<0.10 | <0.10 | [NA]	<0.10 | <0.10 | [NA]	107	95.6
1,1,2,2-Tetrachloroethane	mg/kg	0.10	<0.10	<0.10 | <0.10 | [NA]	<0.10 | <0.10 | [NA]	[NA]	[NA]
1,2,3-Trichloropropane	mg/kg	0.10	<0.10	<0.10 | <0.10 | [NA]	<0.10 | <0.10 | [NA]	[NA]	[NA]
Bromobenzene	mg/kg	0.10	<0.10	<0.10 | <0.10 | [NA]	<0.10 | <0.10 | [NA]	[NA]	[NA]
2-Chlorotoluene	mg/kg	0.10	<0.10	<0.10 | <0.10 | [NA]	<0.10 | <0.10 | [NA]	[NA]	[NA]
4-Chlorotoluene	mg/kg	0.10	<0.10	<0.10 | <0.10 | [NA]	<0.10 | <0.10 | [NA]	[NA]	[NA]
1,3-Dichlorobenzene	mg/kg	0.10	<0.10	<0.10 | <0.10 | [NA]	<0.10 | <0.10 | [NA]	[NA]	[NA]
1,4-Dichlorobenzene	mg/kg	0.10	<0.10	<0.10 | <0.10 | [NA]	<0.10 | <0.10 | [NA]	107	95.5
1,2-Dichlorobenzene	mg/kg	0.10	<0.10	<0.10 | <0.10 | [NA]	<0.10 | <0.10 | [NA]	[NA]	[NA]
1,2-Dibromo-3-chloropropane	mg/kg	0.10	<0.10	<0.10 | <0.10 | [NA]	<0.10 | <0.10 | [NA]	[NA]	[NA]
Hexachlorobutadiene	mg/kg	0.10	<0.10	<0.10 | <0.10 | [NA]	<0.10 | <0.10 | [NA]	[NA]	[NA]
1,2,4-Trichlorobenzene	mg/kg	0.10	<0.10	<0.10 | <0.10 | [NA]	<0.10 | <0.10 | [NA]	114	98.7
1,2,3-Trichlorobenzene	mg/kg	0.10	<0.10	<0.10 | <0.10 | [NA]	<0.10 | <0.10 | [NA]	[NA]	[NA]
Surrogate Dibromofluoromethane	*%*		*102*	*102 | 101*	*102 | 102*	*104*	*100*
Surrogate aaa-Trifluorotoluene	*%*		*108*	*106 | 106*	*109 | 110*	*105*	*91.3*
Surrogate Toluene-D8	*%*		*98.9*	*100 | 100*	*98.7 | 99.1*	*102*	*101*
Surrogate 4-Bromofluorobenzene	*%*		*101*	*98.1 | 101*	*100 | 100*	*95.9*	*96.8*

The QC reported was not specifically part of this workorder but formed part of the QC process batch.

Quality Control PEK0250

ORG-023_F1_TOT|Volatile TRH and BTEX (Water) | Batch BEK0759

Analyte	Units	PQL	Blank	DUP1 BEK0759-DUP1# Samp | QC | RPD %	LCS %
TRH C6-C9	µg/L	10	<10	<10 | <10 | [NA]	99.3
TRH C6-C10	µg/L	10	<10	<10 | <10 | [NA]	97.8
TRH C6-C10 less BTEX (F1)	µg/L	10	<10	<10 | <10 | [NA]	[NA]
Methyl tert butyl ether (MTBE)	µg/L	1.0	<1.0		[NA]
Benzene	µg/L	1.0	<1.0	<1.0 | <1.0 | [NA]	105
Toluene	µg/L	1.0	<1.0	<1.0 | <1.0 | [NA]	105
Ethylbenzene	µg/L	1.0	<1.0	<1.0 | <1.0 | [NA]	104
meta+para Xylene	µg/L	2.0	<2.0	<2.0 | <2.0 | [NA]	103
ortho-Xylene	µg/L	1.0	<1.0	<1.0 | <1.0 | [NA]	107
Total Xylene	µg/L	3.0	<3.0	<3.0 | <3.0 | [NA]	[NA]
Naphthalene (value used in F2 calc)	µg/L	1.0	<1.0	<1.0 | <1.0 | [NA]	[NA]
Surrogate Dibromofluoromethane	*%*		*92.6*	*91.5 | 92.2*	*93.7*
Surrogate Toluene-D8	*%*		*97.8*	*97.9 | 99.1*	*100*
Surrogate 4-Bromofluorobenzene	*%*		*100*	*100 | 101*	*97.0*

The QC reported was not specifically part of this workorder but formed part of the QC process batch.

ORG-023_F1_TOT|Volatile TRH and BTEX - NAGD (Soil) | Batch BEK0533

Analyte	Units	PQL	Blank	DUP1 BEK0533-DUP1# Samp | QC | RPD %	DUP2 PEK0250-07 Samp | QC | RPD %	LCS %	Spike % BEK0533-MS1#
TRH C6-C9	mg/kg	25	<25	<25 | <25 | [NA]	<25 | <25 | [NA]	86.3	87.5
TRH C6-C10	mg/kg	25	<25	<25 | <25 | [NA]	<25 | <25 | [NA]	86.1	87.3
Benzene	mg/kg	0.20	<0.20	<0.20 | <0.20 | [NA]	<0.20 | <0.20 | [NA]	105	104
Toluene	mg/kg	0.20	<0.20	<0.20 | <0.20 | [NA]	<0.20 | <0.20 | [NA]	102	104
Ethylbenzene	mg/kg	0.20	<0.20	<0.20 | <0.20 | [NA]	<0.20 | <0.20 | [NA]	104	104
Total Xylene	mg/kg	0.60	<0.60	<0.60 | <0.60 | [NA]	<0.60 | <0.60 | [NA]	[NA]	[NA]
Surrogate aaa-Trifluorotoluene	*%*		*106*	*105 | 107*	*108 | 99.2*	*115*	*113*

The QC reported was not specifically part of this workorder but formed part of the QC process batch.

ORG-023_F1_TOT|Volatile TRH and BTEX - NAGD (Soil) | Batch BEK0549

Analyte	Units	PQL	Blank	DUP1 PEK0250-16 Samp | QC | RPD %	DUP2 BEK0549-DUP2# Samp | QC | RPD %	LCS %	Spike % PEK0250-17
TRH C6-C9	mg/kg	25	<25	<25 | <25 | [NA]	<25 | <25 | [NA]	85.8	69.3
TRH C6-C10	mg/kg	25	<25	<25 | <25 | [NA]	<25 | <25 | [NA]	86.0	69.3
Benzene	mg/kg	0.20	<0.20	<0.20 | <0.20 | [NA]	<0.20 | <0.20 | [NA]	101	82.1
Toluene	mg/kg	0.20	<0.20	<0.20 | <0.20 | [NA]	<0.20 | <0.20 | [NA]	104	84.7
Ethylbenzene	mg/kg	0.20	<0.20	<0.20 | <0.20 | [NA]	<0.20 | <0.20 | [NA]	106	85.1
Total Xylene	mg/kg	0.60	<0.60	<0.60 | <0.60 | [NA]	<0.60 | <0.60 | [NA]	[NA]	[NA]
Surrogate aaa-Trifluorotoluene	*%*		*88.2*	*100 | 97.3*	*104 | 105*	*110*	*87.9*

The QC reported was not specifically part of this workorder but formed part of the QC process batch.

ORG-020|Semi-volatile TRH (Water) | Batch BEK0495

Analyte	Units	PQL	Blank	DUP1 BEK0495-DUP1# Samp | QC | RPD %	DUP2 BEK0495-DUP2# Samp | QC | RPD %	LCS %	Spike % BEK0495-MS1#
TRH C10-C14	µg/L	50	<50	<50 | <50 | [NA]	<50 | <50 | [NA]	94.3	63.8
TRH C15-C28	µg/L	100	<100	<100 | <100 | [NA]	<100 | <100 | [NA]	98.6	91.3
TRH C29-C36	µg/L	100	<100	<100 | <100 | [NA]	<100 | <100 | [NA]	76.2	82.5
TRH >C10-C16	µg/L	50	<50	<50 | <50 | [NA]	<50 | <50 | [NA]	96.3	73.3
TRH >C16-C34 (F3)	µg/L	100	<100	<100 | <100 | [NA]	<100 | <100 | [NA]	96.6	91.9
TRH >C34-C40 (F4)	µg/L	100	<100	<100 | <100 | [NA]	<100 | <100 | [NA]	85.7	78.4
Surrogate o-Terphenyl	*%*		*90.4*	*82.8 | 79.8*	*64.2 | 58.2 [5]*	*##*	*##[6]*

The QC reported was not specifically part of this workorder but formed part of the QC process batch.

Quality Control PEK0250

ORG-020 | Semi-volatile TRH - NAGD (Soil) | Batch BEK0544

<table>
<tr><th>Analyte</th><th>Units</th><th>PQL</th><th>Blank</th><th>DUP1
PEK0250-01
Samp | QC | RPD %</th><th>DUP2
PEK0250-11
Samp | QC | RPD %</th><th>LCS %</th><th>Spike %
PEK0250-02</th></tr>
<tr><td>TRH C10-C14</td><td>mg/kg</td><td>25</td><td><25</td><td><25 | <25 | [NA]</td><td><25 | <25 | [NA]</td><td>101</td><td>91.6</td></tr>
<tr><td>TRH C15-C28</td><td>mg/kg</td><td>25</td><td><25</td><td><25 | <25 | [NA]</td><td><25 | <25 | [NA]</td><td>103</td><td>96.3</td></tr>
<tr><td>TRH C29-C36</td><td>mg/kg</td><td>25</td><td><25</td><td><25 | <25 | [NA] [10]</td><td><25 | <25 | [NA]</td><td>94.1</td><td>82.2</td></tr>
<tr><td>TRH >C10-C16</td><td>mg/kg</td><td>25</td><td><25</td><td><25 | <25 | [NA]</td><td><25 | <25 | [NA]</td><td>102</td><td>94.6</td></tr>
<tr><td>TRH >C16-C34 (F3)</td><td>mg/kg</td><td>25</td><td><25</td><td><25 | <25 | [NA] [10]</td><td><25 | <25 | [NA]</td><td>102</td><td>94.4</td></tr>
<tr><td>TRH >C34-C40 (F4)</td><td>mg/kg</td><td>25</td><td><25</td><td><25 | <25 | [NA]</td><td><25 | <25 | [NA]</td><td>77.6</td><td>83.4</td></tr>
<tr><td>Surrogate o-Terphenyl</td><td>%</td><td></td><td>92.3</td><td>86.9 | 85.7</td><td>80.5 | 82.8</td><td>##</td><td>##[6]</td></tr>
</table>

ORG-020 | Semi-volatile TRH - NAGD (Soil) | Batch BEK0545

<table>
<tr><th>Analyte</th><th>Units</th><th>PQL</th><th>Blank</th><th>DUP1
PEK0250-23
Samp | QC | RPD %</th><th>LCS %</th><th>Spike %
PEK0250-24</th></tr>
<tr><td>TRH C10-C14</td><td>mg/kg</td><td>25</td><td><25</td><td><25 | <25 | [NA]</td><td>92.1</td><td>89.9</td></tr>
<tr><td>TRH C15-C28</td><td>mg/kg</td><td>25</td><td><25</td><td><25 | <25 | [NA]</td><td>97.1</td><td>94.0</td></tr>
<tr><td>TRH C29-C36</td><td>mg/kg</td><td>25</td><td><25</td><td><25 | <25 | [NA]</td><td>70.3</td><td>75.1</td></tr>
<tr><td>TRH >C10-C16</td><td>mg/kg</td><td>25</td><td><25</td><td><25 | <25 | [NA]</td><td>95.3</td><td>91.8</td></tr>
<tr><td>TRH >C16-C34 (F3)</td><td>mg/kg</td><td>25</td><td><25</td><td><25 | <25 | [NA]</td><td>94.6</td><td>91.6</td></tr>
<tr><td>TRH >C34-C40 (F4)</td><td>mg/kg</td><td>25</td><td><25</td><td><25 | <25 | [NA]</td><td>60.4</td><td>85.5</td></tr>
<tr><td>Surrogate o-Terphenyl</td><td>%</td><td></td><td>82.0</td><td>82.1 | 86.3</td><td>##</td><td>##[6]</td></tr>
</table>

ORG-022_PAH | Polycyclic Aromatic Hydrocarbons - NAGD (Soil) | Batch BEK0547

<table>
<tr><th>Analyte</th><th>Units</th><th>PQL</th><th>Blank</th><th>DUP1
PEK0250-01
Samp | QC | RPD %</th><th>DUP2
PEK0250-11
Samp | QC | RPD %</th><th>LCS %</th><th>Spike %
PEK0250-02</th></tr>
<tr><td>Naphthalene</td><td>µg/kg</td><td>5.0</td><td><5.0</td><td><5.0 | <5.0 | [NA]</td><td><5.0 | <5.0 | [NA]</td><td>80.1</td><td>81.7</td></tr>
<tr><td>2-Methylnaphthalene</td><td>µg/kg</td><td>5.0</td><td><5.0</td><td><5.0 | <5.0 | [NA]</td><td><5.0 | <5.0 | [NA]</td><td>[NA]</td><td>[NA]</td></tr>
<tr><td>Acenaphthylene</td><td>µg/kg</td><td>5.0</td><td><5.0</td><td><5.0 | <5.0 | [NA]</td><td><5.0 | <5.0 | [NA]</td><td>[NA]</td><td>[NA]</td></tr>
<tr><td>Acenaphthene</td><td>µg/kg</td><td>5.0</td><td><5.0</td><td><5.0 | <5.0 | [NA]</td><td><5.0 | <5.0 | [NA]</td><td>[NA]</td><td>[NA]</td></tr>
<tr><td>Fluorene</td><td>µg/kg</td><td>5.0</td><td><5.0</td><td><5.0 | <5.0 | [NA]</td><td><5.0 | <5.0 | [NA]</td><td>80.1</td><td>72.7</td></tr>
<tr><td>Phenanthrene</td><td>µg/kg</td><td>5.0</td><td><5.0</td><td><5.0 | <5.0 | [NA]</td><td><5.0 | <5.0 | [NA]</td><td>86.3</td><td>97.1</td></tr>
<tr><td>Anthracene</td><td>µg/kg</td><td>5.0</td><td><5.0</td><td><5.0 | <5.0 | [NA]</td><td><5.0 | <5.0 | [NA]</td><td>[NA]</td><td>[NA]</td></tr>
<tr><td>Fluoranthene</td><td>µg/kg</td><td>5.0</td><td><5.0</td><td><5.0 | <5.0 | [NA]</td><td><5.0 | <5.0 | [NA]</td><td>86.4</td><td>102</td></tr>
<tr><td>Pyrene</td><td>µg/kg</td><td>5.0</td><td><5.0</td><td><5.0 | <5.0 | [NA]</td><td><5.0 | <5.0 | [NA]</td><td>94.9</td><td>118</td></tr>
<tr><td>Benzo(a)anthracene</td><td>µg/kg</td><td>5.0</td><td><5.0</td><td><5.0 | <5.0 | [NA]</td><td><5.0 | <5.0 | [NA]</td><td>[NA]</td><td>[NA]</td></tr>
<tr><td>Chrysene</td><td>µg/kg</td><td>5.0</td><td><5.0</td><td><5.0 | <5.0 | [NA]</td><td><5.0 | <5.0 | [NA]</td><td>102</td><td>102</td></tr>
<tr><td>Benzo(b,j,k)fluoranthene</td><td>µg/kg</td><td>10</td><td><10</td><td><10 | <10 | [NA]</td><td><10 | <10 | [NA]</td><td>[NA]</td><td>[NA]</td></tr>
<tr><td>Benzo(e)pyrene</td><td>µg/kg</td><td>5.0</td><td><5.0</td><td><5.0 | <5.0 | [NA]</td><td><5.0 | <5.0 | [NA]</td><td>[NA]</td><td>[NA]</td></tr>
<tr><td>Benzo(a)pyrene</td><td>µg/kg</td><td>5.0</td><td><5.0</td><td><5.0 | <5.0 | [NA]</td><td><5.0 | <5.0 | [NA]</td><td>117</td><td>116</td></tr>
<tr><td>Perylene</td><td>µg/kg</td><td>5.0</td><td><5.0</td><td><5.0 | <5.0 | [NA]</td><td><5.0 | <5.0 | [NA]</td><td>[NA]</td><td>[NA]</td></tr>
<tr><td>Indeno(1,2,3-c,d)pyrene</td><td>µg/kg</td><td>5.0</td><td><5.0</td><td><5.0 | <5.0 | [NA]</td><td><5.0 | <5.0 | [NA]</td><td>[NA]</td><td>[NA]</td></tr>
<tr><td>Dibenzo(a,h)anthracene</td><td>µg/kg</td><td>5.0</td><td><5.0</td><td><5.0 | <5.0 | [NA]</td><td><5.0 | <5.0 | [NA]</td><td>[NA]</td><td>[NA]</td></tr>
<tr><td>Benzo(g,h,i)perylene</td><td>µg/kg</td><td>5.0</td><td><5.0</td><td><5.0 | <5.0 | [NA]</td><td><5.0 | <5.0 | [NA]</td><td>[NA]</td><td>[NA]</td></tr>
<tr><td>Coronene</td><td>µg/kg</td><td>5.0</td><td><5.0</td><td><5.0 | <5.0 | [NA]</td><td><5.0 | <5.0 | [NA]</td><td>[NA]</td><td>[NA]</td></tr>
<tr><td>Surrogate p-Terphenyl-D14</td><td>%</td><td></td><td>67.1</td><td>79.9 | 86.2</td><td>72.4 | 79.5</td><td>62.4</td><td>78.3</td></tr>
</table>

Quality Control PEK0250

ORG-022_PAH | Polycyclic Aromatic Hydrocarbons - NAGD (Soil) | Batch BEK0548

Analyte	Units	PQL	Blank	DUP1 PEK0250-23 Samp | QC | RPD %	LCS %	Spike % PEK0250-24
Naphthalene	µg/kg	5.0	<5.0	<5.0 | <5.0 | [NA]	79.0	78.8
2-Methylnaphthalene	µg/kg	5.0	<5.0	<5.0 | <5.0 | [NA]	[NA]	[NA]
Acenaphthylene	µg/kg	5.0	<5.0	<5.0 | <5.0 | [NA]	[NA]	[NA]
Acenaphthene	µg/kg	5.0	<5.0	<5.0 | <5.0 | [NA]	[NA]	[NA]
Fluorene	µg/kg	5.0	<5.0	<5.0 | <5.0 | [NA]	84.0	78.2
Phenanthrene	µg/kg	5.0	<5.0	<5.0 | <5.0 | [NA]	83.2	89.1
Anthracene	µg/kg	5.0	<5.0	<5.0 | <5.0 | [NA]	[NA]	[NA]
Fluoranthene	µg/kg	5.0	<5.0	<5.0 | <5.0 | [NA]	86.7	103
Pyrene	µg/kg	5.0	<5.0	<5.0 | <5.0 | [NA]	90.8	106
Benzo(a)anthracene	µg/kg	5.0	<5.0	<5.0 | <5.0 | [NA]	[NA]	[NA]
Chrysene	µg/kg	5.0	<5.0	<5.0 | <5.0 | [NA]	96.9	90.5
Benzo(b,j,k)fluoranthene	µg/kg	10	<10	<10 | <10 | [NA]	[NA]	[NA]
Benzo(e)pyrene	µg/kg	5.0	<5.0	<5.0 | <5.0 | [NA]	[NA]	[NA]
Benzo(a)pyrene	µg/kg	5.0	<5.0	<5.0 | <5.0 | [NA]	112	110
Perylene	µg/kg	5.0	<5.0	<5.0 | <5.0 | [NA]	[NA]	[NA]
Indeno(1,2,3-c,d)pyrene	µg/kg	5.0	<5.0	<5.0 | <5.0 | [NA]	[NA]	[NA]
Dibenzo(a,h)anthracene	µg/kg	5.0	<5.0	<5.0 | <5.0 | [NA]	[NA]	[NA]
Benzo(g,h,i)perylene	µg/kg	5.0	<5.0	<5.0 | <5.0 | [NA]	[NA]	[NA]
Coronene	µg/kg	5.0	<5.0	<5.0 | <5.0 | [NA]	[NA]	[NA]
Surrogate p-Terphenyl-D14	*%*		*83.2*	*85.8 | 90.3*	*85.0*	*92.3*

ORG-022_OC | Organochlorine Pesticides - NAGD (Soil) | Batch BEK0547

Analyte	Units	PQL	Blank	DUP1 PEK0250-01 Samp | QC | RPD %	DUP2 PEK0250-11 Samp | QC | RPD %	LCS %	Spike % PEK0250-02
alpha-BHC	µg/kg	1.0	<1.0	<1.0 | <1.0 | [NA]	<1.0 | <1.0 | [NA]	75.9	71.7
Hexachlorobenzene	µg/kg	1.0	<1.0	<1.0 | <1.0 | [NA]	<1.0 | <1.0 | [NA]	[NA]	[NA]
beta-BHC	µg/kg	1.0	<1.0	<1.0 | <1.0 | [NA]	<1.0 | <1.0 | [NA]	82.7	78.6
gamma-BHC	µg/kg	1.0	<1.0	<1.0 | <1.0 | [NA]	<1.0 | <1.0 | [NA]	[NA]	[NA]
delta-BHC	µg/kg	1.0	<1.0	<1.0 | <1.0 | [NA]	<1.0 | <1.0 | [NA]	[NA]	[NA]
Heptachlor	µg/kg	1.0	<1.0	<1.0 | <1.0 | [NA]	<1.0 | <1.0 | [NA]	90.1	138
Aldrin	µg/kg	1.0	<1.0	<1.0 | <1.0 | [NA]	<1.0 | <1.0 | [NA]	72.3	46.5[4]
Heptachlor epoxide	µg/kg	1.0	<1.0	<1.0 | <1.0 | [NA]	<1.0 | <1.0 | [NA]	66.9	98.4
trans-Chlordane	µg/kg	1.0	<1.0	<1.0 | <1.0 | [NA]	<1.0 | <1.0 | [NA]	[NA]	[NA]
cis-Chlordane	µg/kg	1.0	<1.0	<1.0 | <1.0 | [NA]	<1.0 | <1.0 | [NA]	[NA]	[NA]
Oxychlordane	µg/kg	1.0	<1.0	<1.0 | <1.0 | [NA]	<1.0 | <1.0 | [NA]	[NA]	[NA]
Endosulfan I	µg/kg	1.0	<1.0	<1.0 | <1.0 | [NA]	<1.0 | <1.0 | [NA]	[NA]	[NA]
4,4'-DDE	µg/kg	1.0	<1.0	<1.0 | <1.0 | [NA]	<1.0 | <1.0 | [NA]	76.0	95.8
Dieldrin	µg/kg	1.0	<1.0	<1.0 | <1.0 | [NA]	<1.0 | <1.0 | [NA]	76.0	102
Endrin	µg/kg	1.0	<1.0	<1.0 | <1.0 | [NA]	<1.0 | <1.0 | [NA]	104	125
4,4'-DDD	µg/kg	1.0	<1.0	<1.0 | <1.0 | [NA]	<1.0 | <1.0 | [NA]	84.2	105
Endosulfan II	µg/kg	1.0	<1.0	<1.0 | <1.0 | [NA]	<1.0 | <1.0 | [NA]	[NA]	[NA]
4,4'-DDT	µg/kg	1.0	<1.0	<1.0 | <1.0 | [NA]	<1.0 | <1.0 | [NA]	[NA]	[NA]
Endosulfan sulfate	µg/kg	1.0	<1.0	<1.0 | <1.0 | [NA]	<1.0 | <1.0 | [NA]	84.6	95.6
Methoxychlor	µg/kg	1.0	<1.0	<1.0 | <1.0 | [NA]	<1.0 | <1.0 | [NA]	[NA]	[NA]
Surrogate 2-Chlorophenol-D4	*%*		*71.8*	*53.0 | 52.0 [7]*	*70.6 | 71.1*	*76.1*	*57.4[7]*

Quality Control PEK0250

ORG-022_OC|Organochlorine Pesticides - NAGD (Soil) | Batch BEK0548

Analyte	Units	PQL	Blank	DUP1 PEK0250-23 Samp | QC | RPD %	LCS %	Spike % PEK0250-24
alpha-BHC	µg/kg	1.0	<1.0	<1.0 | <1.0 | [NA]	87.5	74.7
Hexachlorobenzene	µg/kg	1.0	<1.0	<1.0 | <1.0 | [NA]	[NA]	[NA]
beta-BHC	µg/kg	1.0	<1.0	<1.0 | <1.0 | [NA]	93.5	84.9
gamma-BHC	µg/kg	1.0	<1.0	<1.0 | <1.0 | [NA]	[NA]	[NA]
delta-BHC	µg/kg	1.0	<1.0	<1.0 | <1.0 | [NA]	[NA]	[NA]
Heptachlor	µg/kg	1.0	<1.0	<1.0 | <1.0 | [NA]	120	115
Aldrin	µg/kg	1.0	<1.0	<1.0 | <1.0 | [NA]	83.9	85.7
Heptachlor epoxide	µg/kg	1.0	<1.0	<1.0 | <1.0 | [NA]	91.4	93.3
trans-Chlordane	µg/kg	1.0	<1.0	<1.0 | <1.0 | [NA]	[NA]	[NA]
cis-Chlordane	µg/kg	1.0	<1.0	<1.0 | <1.0 | [NA]	[NA]	[NA]
Oxychlordane	µg/kg	1.0	<1.0	<1.0 | <1.0 | [NA]	[NA]	[NA]
Endosulfan I	µg/kg	1.0	<1.0	<1.0 | <1.0 | [NA]	[NA]	[NA]
4,4'-DDE	µg/kg	1.0	<1.0	<1.0 | <1.0 | [NA]	90.3	92.8
Dieldrin	µg/kg	1.0	<1.0	<1.0 | <1.0 | [NA]	89.7	96.3
Endrin	µg/kg	1.0	<1.0	<1.0 | <1.0 | [NA]	121	122
4,4'-DDD	µg/kg	1.0	<1.0	<1.0 | <1.0 | [NA]	97.6	105
Endosulfan II	µg/kg	1.0	<1.0	<1.0 | <1.0 | [NA]	[NA]	[NA]
4,4'-DDT	µg/kg	1.0	<1.0	<1.0 | <1.0 | [NA]	[NA]	[NA]
Endosulfan sulfate	µg/kg	1.0	<1.0	<1.0 | <1.0 | [NA]	99.1	107
Methoxychlor	µg/kg	1.0	<1.0	<1.0 | <1.0 | [NA]	[NA]	[NA]
Surrogate 2-Chlorophenol-D4	*%*		*61.2*	*64.8 | 63.0*	*64.2*	*61.0*

ORG-022|Organophosphorus Pesticides - NAGD (Soil) | Batch BEK0547

Analyte	Units	PQL	Blank	DUP1 PEK0250-01 Samp | QC | RPD %	DUP2 PEK0250-11 Samp | QC | RPD %	LCS %	Spike % PEK0250-02
Dichlorvos	µg/kg	50	<50	<50 | <50 | [NA]	<50 | <50 | [NA]	[NA]	[NA]
Dimethoate	µg/kg	50	<50	<50 | <50 | [NA]	<50 | <50 | [NA]	[NA]	[NA]
Diazinon	µg/kg	50	<50	<50 | <50 | [NA]	<50 | <50 | [NA]	[NA]	[NA]
Chlorpyrifos-methyl	µg/kg	50	<50	<50 | <50 | [NA]	<50 | <50 | [NA]	75.8	106
Ronnel	µg/kg	50	<50	<50 | <50 | [NA]	<50 | <50 | [NA]	[NA]	[NA]
Fenitrothion	µg/kg	50	<50	<50 | <50 | [NA]	<50 | <50 | [NA]	77.6	120
Malathion	µg/kg	50	<50	<50 | <50 | [NA]	<50 | <50 | [NA]	[NA]	[NA]
Chlorpyrifos	µg/kg	50	<50	<50 | <50 | [NA]	<50 | <50 | [NA]	84.0	104
Parathion	µg/kg	50	<50	<50 | <50 | [NA]	<50 | <50 | [NA]	[NA]	[NA]
Bromophos-ethyl	µg/kg	50	<50	<50 | <50 | [NA]	<50 | <50 | [NA]	[NA]	[NA]
Ethion	µg/kg	50	<50	<50 | <50 | [NA]	<50 | <50 | [NA]	120	123
Azinphos-methyl	µg/kg	50	<50	<50 | <50 | [NA]	<50 | <50 | [NA]	[NA]	[NA]
Surrogate 2-Chlorophenol-D4	*%*		*71.8*	*53.0 | 52.0 [7]*	*70.6 | 71.1*	*76.1*	*57.4[7]*

ORG-022|Organophosphorus Pesticides - NAGD (Soil) | Batch BEK0548

Analyte	Units	PQL	Blank	DUP1 PEK0250-23 Samp | QC | RPD %	LCS %	Spike % PEK0250-24
Dichlorvos	µg/kg	50	<50	<50 | <50 | [NA]	[NA]	[NA]
Dimethoate	µg/kg	50	<50	<50 | <50 | [NA]	[NA]	[NA]
Diazinon	µg/kg	50	<50	<50 | <50 | [NA]	[NA]	[NA]
Chlorpyrifos-methyl	µg/kg	50	<50	<50 | <50 | [NA]	101	100
Ronnel	µg/kg	50	<50	<50 | <50 | [NA]	[NA]	[NA]
Fenitrothion	µg/kg	50	<50	<50 | <50 | [NA]	108	117
Malathion	µg/kg	50	<50	<50 | <50 | [NA]	[NA]	[NA]
Chlorpyrifos	µg/kg	50	<50	<50 | <50 | [NA]	110	101
Parathion	µg/kg	50	<50	<50 | <50 | [NA]	[NA]	[NA]
Bromophos-ethyl	µg/kg	50	<50	<50 | <50 | [NA]	[NA]	[NA]
Ethion	µg/kg	50	<50	<50 | <50 | [NA]	117	121
Azinphos-methyl	µg/kg	50	<50	<50 | <50 | [NA]	[NA]	[NA]
Surrogate 2-Chlorophenol-D4	*%*		*61.2*	*64.8 | 63.0*	*64.2*	*61.0*

Quality Control PEK0250

ORG-025 | Polychlorinated Biphenyls - Trace Level (Soil) | Batch BEK0548

Analyte	Units	PQL	Blank	DUP1 PEK0250-23 Samp | QC | RPD %	LCS %	Spike % PEK0250-24
Aroclor 1016	µg/kg	5.0	<5.0	<5.0 | <5.0 | [NA]	[NA]	[NA]
Aroclor 1221	µg/kg	5.0	<5.0	<5.0 | <5.0 | [NA]	[NA]	[NA]
Aroclor 1232	µg/kg	5.0	<5.0	<5.0 | <5.0 | [NA]	[NA]	[NA]
Aroclor 1242	µg/kg	5.0	<5.0	<5.0 | <5.0 | [NA]	[NA]	[NA]
Aroclor 1248	µg/kg	5.0	<5.0	<5.0 | <5.0 | [NA]	[NA]	[NA]
Aroclor 1254	µg/kg	5.0	<5.0	<5.0 | <5.0 | [NA]	[NA]	[NA]
Aroclor 1260	µg/kg	5.0	<5.0	<5.0 | <5.0 | [NA]	[NA]	[NA]
PCB C103	µg/kg		0.00	0.00 | 0.00 | [NA]	112	111
Surrogate 2-Fluorobiphenyl	*%*		*61.3*	*62.0 | 64.8*	*67.7*	*62.9*

ORG-025 | Polychlorinated Biphenyls - NAGD (Soil) | Batch BEK0547

Analyte	Units	PQL	Blank	DUP1 PEK0250-01 Samp | QC | RPD %	DUP2 PEK0250-11 Samp | QC | RPD %	LCS %	Spike % PEK0250-02
PCB C103	µg/kg			0.00 | 0.00 | [NA]	0.00 | 0.00 | [NA]	70.5	96.3
Total PCBs	µg/kg	5.0	<5.0	<5.0 | <5.0 | [NA]	<5.0 | <5.0 | [NA]	[NA]	[NA]
Surrogate 2-Fluorobiphenyl	*%*		*60.0*	*61.5 | 68.0*	*65.3 | 72.0*	*66.6*	*64.6*

ORG-025 | Polychlorinated Biphenyls - NAGD (Soil) | Batch BEK0548

Analyte	Units	PQL	Blank	DUP1 PEK0250-23 Samp | QC | RPD %	LCS %	Spike % PEK0250-24
PCB C103	µg/kg			0.00 | 0.00 | [NA]	112	111
Total PCBs	µg/kg	5.0	<5.0	<5.0 | <5.0 | [NA]	[NA]	[NA]
Surrogate 2-Fluorobiphenyl	*%*		*61.3*	*62.0 | 64.8*	*67.7*	*62.9*

ORG-022 | Semi Volatile Organic Compounds (Soil) | Batch BEK0547

Analyte	Units	PQL	Blank	DUP1 PEK0250-01 Samp | QC | RPD %	DUP2 PEK0250-11 Samp | QC | RPD %	LCS %	Spike % PEK0250-02
Pentachloroethane	µg/kg	10	<10	<10 | <10 | [NA]	<10 | <10 | [NA]	[NA]	[NA]
1,3-Dichlorobenzene	µg/kg	10	<10	<10 | <10 | [NA]	<10 | <10 | [NA]	[NA]	[NA]
1,4-Dichlorobenzene	µg/kg	10	<10	<10 | <10 | [NA]	<10 | <10 | [NA]	81.2	81.1
1,2-Dichlorobenzene	µg/kg	10	<10	<10 | <10 | [NA]	<10 | <10 | [NA]	[NA]	[NA]
Hexachloroethane	µg/kg	10	<10	<10 | <10 | [NA]	<10 | <10 | [NA]	[NA]	[NA]
1,3,5-Trichlorobenzene	µg/kg	10	<10	<10 | <10 | [NA]	<10 | <10 | [NA]	[NA]	[NA]
1,2,4-Trichlorobenzene	µg/kg	10	<10	<10 | <10 | [NA]	<10 | <10 | [NA]	80.4	83.4
Hexachloropropene	µg/kg	10	<10	<10 | <10 | [NA]	<10 | <10 | [NA]	[NA]	[NA]
Hexachlorobutadiene	µg/kg	10	<10	<10 | <10 | [NA]	<10 | <10 | [NA]	[NA]	[NA]
1,2,3-Trichlorobenzene	µg/kg	10	<10	<10 | <10 | [NA]	<10 | <10 | [NA]	[NA]	[NA]
Hexachlorocyclopentadiene	µg/kg	100	<100	<100 | <100 | [NA]	<100 | <100 | [NA]	[NA]	[NA]
1,2,3,5-Tetrachlorobenzene	µg/kg	10	<10	<10 | <10 | [NA]	<10 | <10 | [NA]	[NA]	[NA]
1,2,4,5-Tetrachlorobenzene	µg/kg	10	<10	<10 | <10 | [NA]	<10 | <10 | [NA]	[NA]	[NA]
1,2,3,4-Tetrachlorobenzene	µg/kg	10	<10	<10 | <10 | [NA]	<10 | <10 | [NA]	[NA]	[NA]
Pentachlorobenzene	µg/kg	10	<10	<10 | <10 | [NA]	<10 | <10 | [NA]	[NA]	[NA]
Hexachlorobenzene	µg/kg	10	<10	<10 | <10 | [NA]	<10 | <10 | [NA]	[NA]	[NA]
Surrogate p-Terphenyl-D14	*%*		*67.1*	*79.9 | 86.2*	*72.4 | 79.5*	*62.4*	*78.3*

Quality Control PEK0250

ORG-022|Semi Volatile Organic Compounds (Soil) | Batch BEK0548

Analyte	Units	PQL	Blank	DUP1 PEK0250-23 Samp	DUP1 QC	DUP1 RPD %	LCS %	Spike % PEK0250-24
Pentachloroethane	µg/kg	10	<10	<10	<10	[NA]	[NA]	[NA]
1,3-Dichlorobenzene	µg/kg	10	<10	<10	<10	[NA]	[NA]	[NA]
1,4-Dichlorobenzene	µg/kg	10	<10	<10	<10	[NA]	79.2	75.4
1,2-Dichlorobenzene	µg/kg	10	<10	<10	<10	[NA]	[NA]	[NA]
Hexachloroethane	µg/kg	10	<10	<10	<10	[NA]	[NA]	[NA]
1,3,5-Trichlorobenzene	µg/kg	10	<10	<10	<10	[NA]	[NA]	[NA]
1,2,4-Trichlorobenzene	µg/kg	10	<10	<10	<10	[NA]	91.0	84.6
Hexachloropropene	µg/kg	10	<10	<10	<10	[NA]	[NA]	[NA]
Hexachlorobutadiene	µg/kg	10	<10	<10	<10	[NA]	[NA]	[NA]
1,2,3-Trichlorobenzene	µg/kg	10	<10	<10	<10	[NA]	[NA]	[NA]
Hexachlorocyclopentadiene	µg/kg	100	<100	<100	<100	[NA]	[NA]	[NA]
1,2,3,5-Tetrachlorobenzene	µg/kg	10	<10	<10	<10	[NA]	[NA]	[NA]
1,2,4,5-Tetrachlorobenzene	µg/kg	10	<10	<10	<10	[NA]	[NA]	[NA]
1,2,3,4-Tetrachlorobenzene	µg/kg	10	<10	<10	<10	[NA]	[NA]	[NA]
Pentachlorobenzene	µg/kg	10	<10	<10	<10	[NA]	[NA]	[NA]
Hexachlorobenzene	µg/kg	10	<10	<10	<10	[NA]	[NA]	[NA]
Surrogate p-Terphenyl-D14	*%*		*83.2*	*85.8*	*90.3*		*85.0*	*92.3*

ORG-022|Speciated Phenols (Soil) | Batch BEK0536

Analyte	Units	PQL	Blank	DUP1 BEK0536-DUP1# Samp	DUP1 QC	DUP1 RPD %	DUP2 PEK0250-07 Samp	DUP2 QC	DUP2 RPD %	LCS %	Spike % BEK0536-MS2#
Phenol	mg/kg	0.20	<0.20	<0.20	<0.20	[NA]	<0.20	<0.20	[NA]	89.2	93.0
2-Chlorophenol	mg/kg	0.20	<0.20	<0.20	<0.20	[NA]	<0.20	<0.20	[NA]	93.7	97.0
2-Methylphenol	mg/kg	0.20	<0.20	<0.20	<0.20	[NA]	<0.20	<0.20	[NA]	94.4	100
3/4-Methylphenol	mg/kg	0.40	<0.40	<0.40	<0.40	[NA]	<0.40	<0.40	[NA]	[NA]	[NA]
2-Nitrophenol	mg/kg	0.20	<0.20	<0.20	<0.20	[NA]	<0.20	<0.20	[NA]	[NA]	[NA]
2,4-Dimethylphenol	mg/kg	0.20	<0.20	<0.20	<0.20	[NA]	<0.20	<0.20	[NA]	[NA]	[NA]
2,4-Dichlorophenol	mg/kg	0.20	<0.20	<0.20	<0.20	[NA]	<0.20	<0.20	[NA]	[NA]	[NA]
2,6-Dichlorophenol	mg/kg	0.20	<0.20	<0.20	<0.20	[NA]	<0.20	<0.20	[NA]	89.2	91.3
4-Chloro-3-methylphenol	mg/kg	1.0	<1.0	<1.0	<1.0	[NA]	<1.0	<1.0	[NA]	[NA]	[NA]
2,4,6-Trichlorophenol	mg/kg	0.20	<0.20	<0.20	<0.20	[NA]	<0.20	<0.20	[NA]	[NA]	[NA]
2,4,5-Trichlorophenol	mg/kg	0.20	<0.20	<0.20	<0.20	[NA]	<0.20	<0.20	[NA]	[NA]	[NA]
2,4-Dinitrophenol	mg/kg	4.0	<4.0	<4.0	<4.0	[NA]	<4.0	<4.0	[NA]	[NA]	[NA]
4-Nitrophenol	mg/kg	4.0	<4.0	<4.0	<4.0	[NA]	<4.0	<4.0	[NA]	[NA]	[NA]
2,3,4,5 & 2,3,4,6-Tetrachlorophenol	mg/kg	0.40	<0.40	<0.40	<0.40	[NA]	<0.40	<0.40	[NA]	[NA]	[NA]
2,3,5,6-Tetrachlorophenol	mg/kg	0.20	<0.20	<0.20	<0.20	[NA]	<0.20	<0.20	[NA]	[NA]	[NA]
4,6-Dinitro-2-methylphenol	mg/kg	10	<10	<10	<10	[NA]	<10	<10	[NA]	[NA]	[NA]
Pentachlorophenol	mg/kg	2.0	<2.0	<2.0	<2.0	[NA]	<2.0	<2.0	[NA]	[NA]	[NA]
Dinoseb	mg/kg	10	<10	<10	<10	[NA]	<10	<10	[NA]	[NA]	[NA]
2-Cyclohexyl-4,6-Dinitrophenol	mg/kg	20	<20	<20	<20	[NA]	<20	<20	[NA]	[NA]	[NA]
Surrogate 2-Fluorophenol	*%*		*101*	*33.2*	*37.5 [7]*		*97.5*	*102*		*100*	*97.4*
Surrogate Phenol-D6	*%*		*89.5*	*60.4*	*66.0*		*75.2*	*72.9*		*88.5*	*88.8*

The QC reported was not specifically part of this workorder but formed part of the QC process batch.

Quality Control PEK0250

ORG-022|Speciated Phenols (Soil) | Batch BEK0537

Analyte	Units	PQL	Blank	DUP1 PEK0250-16			DUP2 BEK0537-DUP2#			LCS %	Spike % PEK0250-17
				Samp	QC	RPD %	Samp	QC	RPD %		
Phenol	mg/kg	0.20	<0.20	<0.20	<0.20	[NA]	<0.20	<0.20	[NA]	86.5	74.7
2-Chlorophenol	mg/kg	0.20	<0.20	<0.20	<0.20	[NA]	<0.20	<0.20	[NA]	98.3	84.2
2-Methylphenol	mg/kg	0.20	<0.20	<0.20	<0.20	[NA]	<0.20	<0.20	[NA]	93.2	71.1
3/4-Methylphenol	mg/kg	0.40	<0.40	<0.40	<0.40	[NA]	<0.40	<0.40	[NA]	[NA]	[NA]
2-Nitrophenol	mg/kg	0.20	<0.20	<0.20	<0.20	[NA]	<0.20	<0.20	[NA]	[NA]	[NA]
2,4-Dimethylphenol	mg/kg	0.20	<0.20	<0.20	<0.20	[NA]	<0.20	<0.20	[NA]	[NA]	[NA]
2,4-Dichlorophenol	mg/kg	0.20	<0.20	<0.20	<0.20	[NA]	<0.20	<0.20	[NA]	[NA]	[NA]
2,6-Dichlorophenol	mg/kg	0.20	<0.20	<0.20	<0.20	[NA]	<0.20	<0.20	[NA]	96.6	84.9
4-Chloro-3-methylphenol	mg/kg	1.0	<1.0	<1.0	<1.0	[NA]	<1.0	<1.0	[NA]	[NA]	[NA]
2,4,6-Trichlorophenol	mg/kg	0.20	<0.20	<0.20	<0.20	[NA]	<0.20	<0.20	[NA]	[NA]	[NA]
2,4,5-Trichlorophenol	mg/kg	0.20	<0.20	<0.20	<0.20	[NA]	<0.20	<0.20	[NA]	[NA]	[NA]
2,4-Dinitrophenol	mg/kg	4.0	<4.0	<4.0	<4.0	[NA]	<4.0	<4.0	[NA]	[NA]	[NA]
4-Nitrophenol	mg/kg	4.0	<4.0	<4.0	<4.0	[NA]	<4.0	<4.0	[NA]	[NA]	[NA]
2,3,4,5 & 2,3,4,6-Tetrachlorophenol	mg/kg	0.40	<0.40	<0.40	<0.40	[NA]	<0.40	<0.40	[NA]	[NA]	[NA]
2,3,5,6-Tetrachlorophenol	mg/kg	0.20	<0.20	<0.20	<0.20	[NA]	<0.20	<0.20	[NA]	[NA]	[NA]
4,6-Dinitro-2-methylphenol	mg/kg	10	<10	<10	<10	[NA]	<10	<10	[NA]	[NA]	[NA]
Pentachlorophenol	mg/kg	2.0	<2.0	<2.0	<2.0	[NA]	<2.0	<2.0	[NA]	[NA]	[NA]
Dinoseb	mg/kg	10	<10	<10	<10	[NA]	<10	<10	[NA]	[NA]	[NA]
2-Cyclohexyl-4,6-Dinitrophenol	mg/kg	20	<20	<20	<20	[NA]	<20	<20	[NA]	[NA]	[NA]
Surrogate 2-Fluorophenol	*%*		*99.7*	*97.9*	*98.4*		*97.6*	*93.4*		*101*	*95.3*
Surrogate Phenol-D6	*%*		*78.3*	*70.4*	*68.8*		*65.0*	*63.8*		*76.3*	*74.2*

The QC reported was not specifically part of this workorder but formed part of the QC process batch.

ORG-022|Synthetic Pyrethroids (Soil) | Batch BEK0547

Analyte	Units	PQL	Blank	DUP1 PEK0250-01			DUP2 PEK0250-11			LCS %	Spike % PEK0250-02
				Samp	QC	RPD %	Samp	QC	RPD %		
Bifenthrin	µg/kg	10	<10	<10	<10	[NA]	<10	<10	[NA]	113	119
lamda-Cyhalothrin	µg/kg	10	<10	<10	<10	[NA]	<10	<10	[NA]	124	121
cis-Permethrin	µg/kg	10	<10	<10	<10	[NA]	<10	<10	[NA]	[NA]	[NA]
trans-Permethrin	µg/kg	10	<10	<10	<10	[NA]	<10	<10	[NA]	[NA]	[NA]
Cyfluthrin	µg/kg	100	<100	<100	<100	[NA]	<100	<100	[NA]	[NA]	[NA]
Cypermethrin	µg/kg	100	<100	<100	<100	[NA]	<100	<100	[NA]	[NA]	[NA]
Esfenvalerate	µg/kg	10	<10	<10	<10	[NA]	<10	<10	[NA]	[NA]	[NA]
Deltamethrin	µg/kg	10	<10	<10	<10	[NA]	<10	<10	[NA]	[NA]	[NA]
Surrogate p-Terphenyl-D14	*%*		*67.1*	*79.9*	*86.2*		*72.4*	*79.5*		*62.4*	*78.3*

ORG-022|Synthetic Pyrethroids (Soil) | Batch BEK0548

Analyte	Units	PQL	Blank	DUP1 PEK0250-23			LCS %	Spike % PEK0250-24
				Samp	QC	RPD %		
Bifenthrin	µg/kg	10	<10	<10	<10	[NA]	113	106
lamda-Cyhalothrin	µg/kg	10	<10	<10	<10	[NA]	114	112
cis-Permethrin	µg/kg	10	<10	<10	<10	[NA]	[NA]	[NA]
trans-Permethrin	µg/kg	10	<10	<10	<10	[NA]	[NA]	[NA]
Cyfluthrin	µg/kg	100	<100	<100	<100	[NA]	[NA]	[NA]
Cypermethrin	µg/kg	100	<100	<100	<100	[NA]	[NA]	[NA]
Esfenvalerate	µg/kg	10	<10	<10	<10	[NA]	[NA]	[NA]
Deltamethrin	µg/kg	10	<10	<10	<10	[NA]	[NA]	[NA]
Surrogate p-Terphenyl-D14	*%*		*83.2*	*85.8*	*90.3*		*85.0*	*92.3*

Quality Control PEK0250

ORG-025 | Carbamates (Soil) | Batch BEK0547

Analyte	Units	PQL	Blank	DUP1 PEK0250-01 Samp | QC | RPD %	DUP2 PEK0250-11 Samp | QC | RPD %	LCS %	Spike % PEK0250-02
Molinate	µg/kg	10	<10	<10 | <10 | [NA]	<10 | <10 | [NA]	[NA]	[NA]
Carbofuran	µg/kg	10	<10	<10 | <10 | [NA]	<10 | <10 | [NA]	84.8	124
Carbaryl	µg/kg	10	<10	<10 | <10 | [NA]	<10 | <10 | [NA]	[NA]	[NA]
Surrogate p-Terphenyl-D14	*%*		*67.1*	*79.9 | 86.2*	*72.4 | 79.5*	*62.4*	*78.3*

ORG-025 | Carbamates (Soil) | Batch BEK0548

Analyte	Units	PQL	Blank	DUP1 PEK0250-23 Samp | QC | RPD %	LCS %	Spike % PEK0250-24
Molinate	µg/kg	10	<10	<10 | <10 | [NA]	[NA]	[NA]
Carbofuran	µg/kg	10	<10	<10 | <10 | [NA]	119	121
Carbaryl	µg/kg	10	<10	<10 | <10 | [NA]	[NA]	[NA]
Surrogate p-Terphenyl-D14	*%*		*83.2*	*85.8 | 90.3*	*85.0*	*92.3*

ORG-025 | Triazine Herbicides (Soil) | Batch BEK0547

Analyte	Units	PQL	Blank	DUP1 PEK0250-01 Samp | QC | RPD %	DUP2 PEK0250-11 Samp | QC | RPD %	LCS %	Spike % PEK0250-02
Simazine	µg/kg	10	<10	<10 | <10 | [NA]	<10 | <10 | [NA]	[NA]	[NA]
Atrazine	µg/kg	10	<10	<10 | <10 | [NA]	<10 | <10 | [NA]	97.2	105
Propazine	µg/kg	10	<10	<10 | <10 | [NA]	<10 | <10 | [NA]	88.6	90.5
Terbuthylazine	µg/kg	10	<10	<10 | <10 | [NA]	<10 | <10 | [NA]	[NA]	[NA]
Metribuzin	µg/kg	50	<50	<50 | <50 | [NA]	<50 | <50 | [NA]	[NA]	[NA]
Ametryn	µg/kg	10	<10	<10 | <10 | [NA]	<10 | <10 | [NA]	[NA]	[NA]
Prometryn	µg/kg	10	<10	<10 | <10 | [NA]	<10 | <10 | [NA]	90.8	118
Terbutryn	µg/kg	10	<10	<10 | <10 | [NA]	<10 | <10 | [NA]	[NA]	[NA]
Cyanazine	µg/kg	10	<10	<10 | <10 | [NA]	<10 | <10 | [NA]	[NA]	[NA]
Irgarol	µg/kg	10	<10	<10 | <10 | [NA]	<10 | <10 | [NA]	[NA]	[NA]
Hexazinone	µg/kg	10	<10	<10 | <10 | [NA]	<10 | <10 | [NA]	[NA]	[NA]
Surrogate p-Terphenyl-D14	*%*		*67.1*	*79.9 | 86.2*	*72.4 | 79.5*	*62.4*	*78.3*

ORG-025 | Triazine Herbicides (Soil) | Batch BEK0548

Analyte	Units	PQL	Blank	DUP1 PEK0250-23 Samp | QC | RPD %	LCS %	Spike % PEK0250-24
Simazine	µg/kg	10	<10	<10 | <10 | [NA]	[NA]	[NA]
Atrazine	µg/kg	10	<10	<10 | <10 | [NA]	120	109
Propazine	µg/kg	10	<10	<10 | <10 | [NA]	111	105
Terbuthylazine	µg/kg	10	<10	<10 | <10 | [NA]	[NA]	[NA]
Metribuzin	µg/kg	50	<50	<50 | <50 | [NA]	[NA]	[NA]
Ametryn	µg/kg	10	<10	<10 | <10 | [NA]	[NA]	[NA]
Prometryn	µg/kg	10	<10	<10 | <10 | [NA]	116	118
Terbutryn	µg/kg	10	<10	<10 | <10 | [NA]	[NA]	[NA]
Cyanazine	µg/kg	10	<10	<10 | <10 | [NA]	[NA]	[NA]
Irgarol	µg/kg	10	<10	<10 | <10 | [NA]	[NA]	[NA]
Hexazinone	µg/kg	10	<10	<10 | <10 | [NA]	[NA]	[NA]
Surrogate p-Terphenyl-D14	*%*		*83.2*	*85.8 | 90.3*	*85.0*	*92.3*

Quality Control PEK0250

ORG-025 | Phenoxy Acid Herbicides (Soil) | Batch BEK0540

Analyte	Units	PQL	Blank	DUP1 PEK0250-01 Samp | QC | RPD %	DUP2 PEK0250-11 Samp | QC | RPD %	LCS %	Spike % PEK0250-02
Clopyralid	µg/kg	50	<50	<50 | <50 | [NA]	<50 | <50 | [NA]	[NA]	[NA]
3,5-Dichlorobenzoic acid	µg/kg	50	<50	<50 | <50 | [NA]	<50 | <50 | [NA]	[NA]	[NA]
2-Chlorophenoxy acetic acid	µg/kg	50	<50	<50 | <50 | [NA]	<50 | <50 | [NA]	[NA]	[NA]
4-Chlorophenoxy acetic acid	µg/kg	50	<50	<50 | <50 | [NA]	<50 | <50 | [NA]	[NA]	[NA]
Dicamba	µg/kg	50	<50	<50 | <50 | [NA]	<50 | <50 | [NA]	113	##[4]
Mecoprop	µg/kg	50	<50	<50 | <50 | [NA]	<50 | <50 | [NA]	107	78.0
MCPA	µg/kg	50	<50	<50 | <50 | [NA]	<50 | <50 | [NA]	109	50.7[4]
2,6-D	µg/kg	50	<50	<50 | <50 | [NA]	<50 | <50 | [NA]	[NA]	[NA]
Dichlorprop	µg/kg	50	<50	<50 | <50 | [NA]	<50 | <50 | [NA]	[NA]	[NA]
2,4-D	µg/kg	50	<50	<50 | <50 | [NA]	<50 | <50 | [NA]	111	45.0[4]
Bromoxynil	µg/kg	50	<50	<50 | <50 | [NA]	<50 | <50 | [NA]	[NA]	[NA]
Triclopyr	µg/kg	50	<50	<50 | <50 | [NA]	<50 | <50 | [NA]	[NA]	[NA]
2,4,6-T	µg/kg	50	<50	<50 | <50 | [NA]	<50 | <50 | [NA]	[NA]	[NA]
2,4,5-TP	µg/kg	50	<50	<50 | <50 | [NA]	<50 | <50 | [NA]	[NA]	[NA]
2,4,5-T	µg/kg	50	<50	<50 | <50 | [NA]	<50 | <50 | [NA]	117	71.9
MCPB	µg/kg	50	<50	<50 | <50 | [NA]	<50 | <50 | [NA]	[NA]	[NA]
Dinoseb	µg/kg	50	<50	<50 | <50 | [NA]	<50 | <50 | [NA]	[NA]	[NA]
2,4-DB	µg/kg	50	<50	<50 | <50 | [NA]	<50 | <50 | [NA]	[NA]	[NA]
Ioxynil	µg/kg	50	<50	<50 | <50 | [NA]	<50 | <50 | [NA]	[NA]	[NA]
Picloram	µg/kg	50	<50	<50 | <50 | [NA]	<50 | <50 | [NA]	[NA]	[NA]
Chlorthal	µg/kg	50	<50	<50 | <50 | [NA]	<50 | <50 | [NA]	[NA]	[NA]
Acifluorfen	µg/kg	50	<50	<50 | <50 | [NA]	<50 | <50 | [NA]	[NA]	[NA]
Surrogate 2,4-DCPA	*%*		*103*	*71.5 | 70.5*	*72.6 | 79.5*	*102*	*81.4*

ORG-025 | Phenoxy Acid Herbicides (Soil) | Batch BEK0541

Analyte	Units	PQL	Blank	DUP1 PEK0250-23 Samp | QC | RPD %	LCS %	Spike % PEK0250-24
Clopyralid	µg/kg	50	<50	<50 | <50 | [NA]	[NA]	[NA]
3,5-Dichlorobenzoic acid	µg/kg	50	<50	<50 | <50 | [NA]	[NA]	[NA]
2-Chlorophenoxy acetic acid	µg/kg	50	<50	<50 | <50 | [NA]	[NA]	[NA]
4-Chlorophenoxy acetic acid	µg/kg	50	<50	<50 | <50 | [NA]	[NA]	[NA]
Dicamba	µg/kg	50	<50	<50 | <50 | [NA]	108	##[4]
Mecoprop	µg/kg	50	<50	<50 | <50 | [NA]	103	64.1
MCPA	µg/kg	50	<50	<50 | <50 | [NA]	106	33.7[4]
2,6-D	µg/kg	50	<50	<50 | <50 | [NA]	[NA]	[NA]
Dichlorprop	µg/kg	50	<50	<50 | <50 | [NA]	[NA]	[NA]
2,4-D	µg/kg	50	<50	<50 | <50 | [NA]	102	29.6[4]
Bromoxynil	µg/kg	50	<50	<50 | <50 | [NA]	[NA]	[NA]
Triclopyr	µg/kg	50	<50	<50 | <50 | [NA]	[NA]	[NA]
2,4,6-T	µg/kg	50	<50	<50 | <50 | [NA]	[NA]	[NA]
2,4,5-TP	µg/kg	50	<50	<50 | <50 | [NA]	[NA]	[NA]
2,4,5-T	µg/kg	50	<50	<50 | <50 | [NA]	112	45.6[4]
MCPB	µg/kg	50	<50	<50 | <50 | [NA]	[NA]	[NA]
Dinoseb	µg/kg	50	<50	<50 | <50 | [NA]	[NA]	[NA]
2,4-DB	µg/kg	50	<50	<50 | <50 | [NA]	[NA]	[NA]
Ioxynil	µg/kg	50	<50	<50 | <50 | [NA]	[NA]	[NA]
Picloram	µg/kg	50	<50	<50 | <50 | [NA]	[NA]	[NA]
Chlorthal	µg/kg	50	<50	<50 | <50 | [NA]	[NA]	[NA]
Acifluorfen	µg/kg	50	<50	<50 | <50 | [NA]	[NA]	[NA]
Surrogate 2,4-DCPA	*%*		*67.7*	*73.1 | 61.5*	*89.9*	*68.7*

Quality Control PEK0250

ORG-025_TBT_S | Organometallics (Soil) | Batch BEK0542

Analyte	Units	PQL	Blank	DUP1 PEK0250-01 Samp | QC | RPD %	DUP2 PEK0250-11 Samp | QC | RPD %	LCS %	Spike % PEK0250-02
Tributyltin	µg/kg	0.5		<2.5 | <2.5 | [NA] [9]	<4.0 | <4.0 | [NA] [9]	106	103
Tributyltin as Sn	µg/kg	0.50	<0.50	<2.5 | <2.5 | [NA] [9]	<4.0 | <4.0 | [NA] [9]	[NA]	[NA]
Surrogate Triphenyltin	*%*		*76.7*	*71.6 | 72.8*	*74.4 | 71.1*	*75.7*	*75.6*

ORG-025_TBT_S | Organometallics (Soil) | Batch BEK0543

Analyte	Units	PQL	Blank	DUP1 PEK0250-23 Samp | QC | RPD %	LCS %	Spike % PEK0250-24
Tributyltin	µg/kg	0.5		<4.0 | <4.0 | [NA] [9]	96.6	114
Tributyltin as Sn	µg/kg	0.50	<0.50	<4.0 | <4.0 | [NA] [9]	[NA]	[NA]
Surrogate Triphenyltin	*%*		*86.7*	*79.2 | 78.3*	*86.9*	*80.9*

ORG-025_TBT_W | Organometallics (Water) | Batch BEK0657

Analyte	Units	PQL	Blank	DUP1 PEK0250-21 Samp | QC | RPD %	LCS %	Spike % PEK0250-22
Tributyltin	µg/L	0.002		<0.0020 | <0.0020 | [NA]	102	111
Tributyltin as Sn	µg/L	0.0020	<0.0020	<0.0020 | <0.0020 | [NA]	[NA]	[NA]
Surrogate Triphenyltin	*%*		*106*	*109 | 99.1*	*114*	*98.3*

METALS-020 | Acid Extractable Metals (Soil) | Batch BEK0531

Analyte	Units	PQL	Blank	DUP1 BEK0531-DUP1# Samp | QC | RPD %	DUP2 PEK0250-07 Samp | QC | RPD %	LCS %	Spike % BEK0531-MS1#
Phosphorus	mg/kg	10	<10	88.6 | 80.4 | 9.81	396 | 410 | 3.52	93.3	103

Analyte	Units	PQL	Blank	DUP3 BEK0531-DUP3# Samp | QC | RPD %	DUP4 PEK0250-07 Samp | QC | RPD %	LCS %
Phosphorus	mg/kg	10		88.6 | 79.1 | 11.4	396 | 381 | 3.88	[NA]

The QC reported was not specifically part of this workorder but formed part of the QC process batch.

METALS-020 | Acid Extractable Metals (Soil) | Batch BEK0532

Analyte	Units	PQL	Blank	DUP1 PEK0250-16 Samp | QC | RPD %	DUP2 PEK0250-16 Samp | QC | RPD %	LCS %	Spike % PEK0250-17
Phosphorus	mg/kg	10	<10	424 | 439 | 3.57	424 | 599 | 34.4	94.6	77.1

Quality Control PEK0250

METALS-022 | Acid Extractable Low Level Metals (Water) | Batch BEK0511

Analyte	Units	PQL	Blank	DUP1 BEK0511-DUP1# Samp | QC | RPD %	DUP2 BEK0511-DUP2# Samp | QC | RPD %	LCS %	Spike % BEK0511-MS1#
Aluminium	µg/L	10	<10	11.5 | 12.0 | 4.63	21.6 | 19.4 | 10.7	112	112
Antimony	µg/L	1.0	<1.0	<1.0 | <1.0 | [NA]	<1.0 | <1.0 | [NA]	109	108
Arsenic	µg/L	1.0	<1.0	<1.0 | <1.0 | [NA]	1.73 | 1.72 | 0.348	113	111
Cadmium	µg/L	0.10	<0.10	<0.10 | <0.10 | [NA]	<0.10 | <0.10 | [NA]	107	101
Chromium	µg/L	1.0	<1.0	<1.0 | <1.0 | [NA]	<1.0 | <1.0 | [NA]	114	109
Cobalt	µg/L	1.0	<1.0	<1.0 | <1.0 | [NA]	<1.0 | <1.0 | [NA]	114	109
Copper	µg/L	1.0	<1.0	4.50 | 4.68 | 3.81	2.78 | 2.88 | 3.56	112	102
Iron	µg/L	10	<10	1350 | 1390 | 2.82	24.5 | 24.8 | 1.18	117	123
Lead	µg/L	1.0	<1.0	<1.0 | <1.0 | [NA]	1.10 | 1.14 | 3.04	108	104
Manganese	µg/L	1.0	<1.0	8.72 | 8.45 | 3.12	<1.0 | <1.0 | [NA]	108	104
Nickel	µg/L	1.0	<1.0	<1.0 | <1.0 | [NA]	<1.0 | 1.08 | 200 [10]	111	105
Selenium	µg/L	1.0	<1.0	<1.0 | <1.0 | [NA]	<1.0 | <1.0 | [NA]	120	111
Silver	µg/L	1.0	<1.0	<1.0 | <1.0 | [NA]	<1.0 | <1.0 | [NA]	100	96.7
Vanadium	µg/L	1.0	<1.0	<1.0 | <1.0 | [NA]	2.89 | 2.97 | 2.73	114	110
Zinc	µg/L	1.0	<1.0	45.1 | 45.1 | 0.102	95.0 | 97.7 | 2.72	111	102

The QC reported was not specifically part of this workorder but formed part of the QC process batch.

METALS-021 | Acid Extractable Low Level Metals (Water) | Batch BEK0571

Analyte	Units	PQL	Blank	DUP1 BEK0571-DUP1# Samp | QC | RPD %	DUP2 BEK0571-DUP2# Samp | QC | RPD %	LCS %	Spike % BEK0571-MS1#
Mercury	µg/L	0.050	<0.050	<0.050 | <0.050 | [NA]	<0.050 | <0.050 | [NA]	99.2	72.6

The QC reported was not specifically part of this workorder but formed part of the QC process batch.

Quality Control PEK0250

METALS-022|NAGD Metals (Soil) | Batch BEK0531

Analyte	Units	PQL	Blank	DUP1 BEK0531-DUP1# Samp | QC | RPD %	DUP2 PEK0250-07 Samp | QC | RPD %	LCS %	Spike % BEK0531-MS1#
Aluminium	mg/kg	1.0	<1.0	5680 | 4670 | 19.4	20.0 | 25.6 | 24.6	111	##[1]
Antimony	mg/kg	0.50	<0.50	<0.50 | <0.50 | [NA]	<0.50 | <0.50 | [NA] [11]	111	97.7
Arsenic	mg/kg	0.50	<0.50	1.70 | 1.64 | 3.70	6.28 | 6.97 | 10.3	121	107
Cadmium	mg/kg	0.10	<0.10	<0.10 | <0.10 | [NA]	<0.10 | <0.10 | [NA]	125	110
Chromium	mg/kg	0.50	<0.50	12.8 | 9.33 | 31.4	16.7 | 19.3 | 14.3	117	114
Cobalt	mg/kg	0.50	<0.50	1.18 | 0.858 | 31.9	<0.50 | <0.50 | [NA]	119	114
Copper	mg/kg	0.50	<0.50	21.1 | 9.85 | 72.5 [11]	<0.50 | <0.50 | [NA]	115	106
Iron	mg/kg	1.0	<1.0	5270 | 4160 | 23.5	76.7 | 94.4 | 20.7	115	##[1]
Lead	mg/kg	0.50	<0.50	11.0 | 11.4 | 3.76	0.588 | 0.648 | 9.77	109	110
Manganese	mg/kg	0.50	<0.50	73.2 | 58.1 | 23.1	11.5 | 13.5 | 15.5	109	102
Mercury	mg/kg	0.010	<0.010	0.0252 | 0.0241 | 4.27	<0.010 | <0.010 | [NA]	104	104
Nickel	mg/kg	0.50	<0.50	2.74 | 2.11 | 26.0	0.705 | 0.773 | 9.25	117	109
Selenium	mg/kg	0.10	<0.10	0.111 | <0.10 | 200 [11]	0.257 | 0.310 | 18.7	122	111
Silver	mg/kg	0.10	<0.10	<0.10 | <0.10 | [NA]	<0.10 | <0.10 | [NA]	103	102
Vanadium	mg/kg	0.50	<0.50	11.8 | 9.26 | 24.2	12.6 | 15.3 | 19.5	120	111
Zinc	mg/kg	0.50	<0.50	22.7 | 17.2 | 27.4	0.768 | 0.782 | 1.79	125	106

Analyte	Units	PQL	Blank	DUP3 BEK0531-DUP3# Samp | QC | RPD %	DUP4 PEK0250-07 Samp | QC | RPD %	LCS %
Aluminium	mg/kg	10		5680 | 4900 | 14.7	20.0 | 25.9 | 25.5	[NA]
Antimony	mg/kg	0.5		<0.50 | <0.50 | [NA]	<0.50 | <0.50 | [NA]	[NA]
Arsenic	mg/kg	0.5		1.70 | 1.73 | 1.75	6.28 | 7.34 | 15.6	[NA]
Cadmium	mg/kg	0.1		<0.10 | <0.10 | [NA]	<0.10 | <0.10 | [NA]	[NA]
Chromium	mg/kg	0.5		12.8 | 10.0 | 24.2	16.7 | 20.1 | 18.6	[NA]
Cobalt	mg/kg	0.5		1.18 | 1.02 | 14.7	<0.50 | <0.50 | [NA]	[NA]
Copper	mg/kg	0.5		21.1 | 11.7 | 56.9 [11]	<0.50 | <0.50 | [NA]	[NA]
Iron	mg/kg	10		5270 | 5340 | 1.48	76.7 | 91.5 | 17.5	[NA]
Lead	mg/kg	0.5		11.0 | 10.7 | 2.97	0.588 | 0.639 | 8.38	[NA]
Manganese	mg/kg	0.5		73.2 | 57.5 | 24.2	11.5 | 13.8 | 18.0	[NA]
Mercury	mg/kg	0.01		0.0252 | 0.0278 | 9.81	<0.010 | <0.010 | [NA]	[NA]
Nickel	mg/kg	0.5		2.74 | 2.19 | 22.4	0.705 | 0.865 | 20.4	[NA]
Selenium	mg/kg	0.1		0.111 | <0.10 | 200 [11]	0.257 | 0.284 | 9.82	[NA]
Silver	mg/kg	0.1		<0.10 | <0.10 | [NA]	<0.10 | <0.10 | [NA]	[NA]
Vanadium	mg/kg	0.5		11.8 | 12.5 | 5.82	12.6 | 16.6 | 27.6	[NA]
Zinc	mg/kg	0.5		22.7 | 21.4 | 6.12	0.768 | 0.750 | 2.35	[NA]

The QC reported was not specifically part of this workorder but formed part of the QC process batch.

Quality Control PEK0250

METALS-022 | NAGD Metals (Soil) | Batch BEK0532

<table>
<tr><th>Analyte</th><th>Units</th><th>PQL</th><th>Blank</th><th>DUP1
PEK0250-16
Samp | QC | RPD %</th><th>DUP2
PEK0250-16
Samp | QC | RPD %</th><th>LCS %</th><th>Spike %
PEK0250-17</th></tr>
<tr><td>Aluminium</td><td>mg/kg</td><td>1.0</td><td><1.0</td><td>54.8 | 59.2 | 7.80</td><td>54.8 | 52.0 | 5.24</td><td>101</td><td>104</td></tr>
<tr><td>Antimony</td><td>mg/kg</td><td>0.50</td><td><0.50</td><td><0.50 | <0.50 | [NA]</td><td><0.50 | <0.50 | [NA]</td><td>108</td><td>97.6</td></tr>
<tr><td>Arsenic</td><td>mg/kg</td><td>0.50</td><td><0.50</td><td>9.62 | 10.2 | 5.34</td><td>9.62 | 9.70 | 0.834</td><td>112</td><td>105</td></tr>
<tr><td>Cadmium</td><td>mg/kg</td><td>0.10</td><td><0.10</td><td><0.10 | <0.10 | [NA]</td><td><0.10 | <0.10 | [NA]</td><td>116</td><td>99.4</td></tr>
<tr><td>Chromium</td><td>mg/kg</td><td>0.50</td><td><0.50</td><td>24.0 | 25.3 | 5.15</td><td>24.0 | 23.7 | 1.19</td><td>106</td><td>102</td></tr>
<tr><td>Cobalt</td><td>mg/kg</td><td>0.50</td><td><0.50</td><td><0.50 | <0.50 | [NA]</td><td><0.50 | <0.50 | [NA]</td><td>110</td><td>107</td></tr>
<tr><td>Copper</td><td>mg/kg</td><td>0.50</td><td><0.50</td><td>1.18 | 1.18 | 0.404</td><td>1.18 | 0.871 | 29.8</td><td>105</td><td>94.8</td></tr>
<tr><td>Iron</td><td>mg/kg</td><td>1.0</td><td><1.0</td><td>175 | 181 | 3.46</td><td>175 | 170 | 2.53</td><td>112</td><td>##[1]</td></tr>
<tr><td>Lead</td><td>mg/kg</td><td>0.50</td><td><0.50</td><td>1.35 | 1.40 | 3.43</td><td>1.35 | 1.31 | 3.66</td><td>107</td><td>101</td></tr>
<tr><td>Manganese</td><td>mg/kg</td><td>0.50</td><td><0.50</td><td>14.1 | 14.9 | 5.55</td><td>14.1 | 14.4 | 1.94</td><td>102</td><td>101</td></tr>
<tr><td>Mercury</td><td>mg/kg</td><td>0.010</td><td><0.010</td><td><0.010 | <0.010 | [NA]</td><td><0.010 | <0.010 | [NA]</td><td>103</td><td>89.0</td></tr>
<tr><td>Nickel</td><td>mg/kg</td><td>0.50</td><td><0.50</td><td>1.26 | 1.26 | 0.546</td><td>1.26 | 1.20 | 4.35</td><td>107</td><td>97.5</td></tr>
<tr><td>Selenium</td><td>mg/kg</td><td>0.10</td><td><0.10</td><td>0.225 | 0.220 | 1.98</td><td>0.225 | 0.211 | 6.04</td><td>120</td><td>101</td></tr>
<tr><td>Silver</td><td>mg/kg</td><td>0.10</td><td><0.10</td><td><0.10 | <0.10 | [NA]</td><td><0.10 | <0.10 | [NA]</td><td>103</td><td>91.3</td></tr>
<tr><td>Vanadium</td><td>mg/kg</td><td>0.50</td><td><0.50</td><td>13.7 | 14.7 | 7.10</td><td>13.7 | 13.2 | 3.13</td><td>111</td><td>108</td></tr>
<tr><td>Zinc</td><td>mg/kg</td><td>0.50</td><td><0.50</td><td>3.79 | 6.50 | 52.6 [11]</td><td>3.79 | 2.75 | 31.8</td><td>109</td><td>91.3</td></tr>
</table>

INORG-055 | Inorganics - Carbons, Nitrogen Species, Sulfur Species (Soil) | Batch BEK0785

<table>
<tr><th>Analyte</th><th>Units</th><th>PQL</th><th>Blank</th><th>DUP1
PEK0250-01
Samp | QC | RPD %</th><th>DUP2
PEK0250-11
Samp | QC | RPD %</th><th>LCS %</th><th>Spike %
PEK0250-02</th></tr>
<tr><td>Nitrate as N</td><td>mg/kg</td><td>0.50</td><td><0.50</td><td><0.50 | <0.50 | [NA]</td><td><0.50 | <0.50 | [NA]</td><td>99.6</td><td>114</td></tr>
<tr><td>Nitrate as NO3 by calculation</td><td>mg/kg</td><td>3.0</td><td><3.0</td><td></td><td></td><td>[NA]</td><td>[NA]</td></tr>
<tr><td>Nitrite as N</td><td>mg/kg</td><td>0.50</td><td><0.50</td><td><0.50 | <0.50 | [NA]</td><td><0.50 | <0.50 | [NA]</td><td>[NA]</td><td>[NA]</td></tr>
<tr><td>Nitrite as NO2 by calculation</td><td>mg/kg</td><td>2.0</td><td><2.0</td><td></td><td></td><td>[NA]</td><td>[NA]</td></tr>
<tr><td>NOx as N</td><td>mg/kg</td><td>0.50</td><td><0.50</td><td><0.50 | <0.50 | [NA]</td><td><0.50 | <0.50 | [NA]</td><td>99.6</td><td>114</td></tr>
</table>

Analyte	Units	PQL	Blank	LCS %	Spike % PEK0250-02
Nitrite as N	mg/kg	0.5		101	110

INORG-055 | Inorganics - Carbons, Nitrogen Species, Sulfur Species (Soil) | Batch BEK0786

<table>
<tr><th>Analyte</th><th>Units</th><th>PQL</th><th>Blank</th><th>DUP1
PEK0250-23
Samp | QC | RPD %</th><th>LCS %</th><th>Spike %
PEK0250-24</th></tr>
<tr><td>Nitrate as N</td><td>mg/kg</td><td>0.50</td><td><0.50</td><td><0.50 | <0.50 | [NA]</td><td>99.5</td><td>114</td></tr>
<tr><td>Nitrate as NO3 by calculation</td><td>mg/kg</td><td>3.0</td><td><3.0</td><td></td><td>[NA]</td><td>[NA]</td></tr>
<tr><td>Nitrite as N</td><td>mg/kg</td><td>0.50</td><td><0.50</td><td><0.50 | <0.50 | [NA]</td><td>[NA]</td><td>[NA]</td></tr>
<tr><td>Nitrite as NO2 by calculation</td><td>mg/kg</td><td>2.0</td><td><2.0</td><td></td><td>[NA]</td><td>[NA]</td></tr>
<tr><td>NOx as N</td><td>mg/kg</td><td>0.50</td><td><0.50</td><td><0.50 | <0.50 | [NA]</td><td>99.5</td><td>114</td></tr>
</table>

Analyte	Units	PQL	Blank	LCS %	Spike % PEK0250-24
Nitrite as N	mg/kg	0.5		101	110

INORG-057 | Inorganics - Carbons, Nitrogen Species, Sulfur Species (Soil) | Batch BEK0787

<table>
<tr><th>Analyte</th><th>Units</th><th>PQL</th><th>Blank</th><th>DUP1
PEK0250-01
Samp | QC | RPD %</th><th>DUP2
PEK0250-11
Samp | QC | RPD %</th><th>LCS %</th><th>Spike %
PEK0250-02</th></tr>
<tr><td>Ammonia as N</td><td>mg/kg</td><td>0.50</td><td><0.50</td><td>3.10 | 3.06 | 1.39</td><td>1.97 | 1.78 | 10.6</td><td>92.1</td><td>##[2]</td></tr>
</table>

Quality Control PEK0250

INORG-057 | Inorganics - Carbons, Nitrogen Species, Sulfur Species (Soil) | Batch BEK0788

Analyte	Units	PQL	Blank	DUP1 PEK0250-23 Samp | QC | RPD %	LCS %	Spike % PEK0250-24
Ammonia as N	mg/kg	0.50	<0.50	1.61 | 1.75 | 8.83	91.9	78.8

INORG-137 | Inorganics - Carbons, Nitrogen Species, Sulfur Species (Soil) | Batch BEK2085

Analyte	Units	PQL	Blank	DUP1 PEK0250-01 Samp | QC | RPD %	DUP2 PEK0250-11 Samp | QC | RPD %	LCS %
Total Nitrogen	mg/kg	10	<10	1320 | 1290 | 2.36	1470 | 1550 | 5.25	115

INORG-137 | Inorganics - Carbons, Nitrogen Species, Sulfur Species (Soil) | Batch BEK2086

Analyte	Units	PQL	Blank	DUP1 PEK0250-23 Samp | QC | RPD %	LCS %
Total Nitrogen	mg/kg	10	<10	2900 | 2270 | 24.1	116

INORG-137 | Inorganics - Carbons, Nitrogen Species, Sulfur Species (Soil) | Batch BEK2128

Analyte	Units	PQL	Blank	DUP1 PEK0250-01 Samp | QC | RPD %	DUP2 PEK0250-11 Samp | QC | RPD %	LCS %
Total Organic Carbon	%	0.010	<0.010	0.670 | 0.720 | 7.19	1.10 | 1.30 | 16.7	101

Analyte	Units	PQL	Blank	DUP3 PEK0250-23 Samp | QC | RPD %	LCS %
Total Organic Carbon	%	0.010	<0.010	1.60 | 1.60 | 0.00	98.0

INORG-060 | Inorganics - General Chemical Parameters (Soil) | Batch BEK0785

Analyte	Units	PQL	Blank	DUP1 PEK0250-01 Samp | QC | RPD %	DUP2 PEK0250-11 Samp | QC | RPD %	LCS %	Spike % PEK0250-02
Phosphate as P	mg/kg	0.50	<0.50	<0.50 | <0.50 | [NA]	<0.50 | <0.50 | [NA]	91.3	105

INORG-060 | Inorganics - General Chemical Parameters (Soil) | Batch BEK0786

Analyte	Units	PQL	Blank	DUP1 PEK0250-23 Samp | QC | RPD %	LCS %	Spike % PEK0250-24
Phosphate as P	mg/kg	0.50	<0.50	<0.50 | <0.50 | [NA]	91.0	103

INORG-008 | Inorganics - Moisture (Soil) | Batch BEK0522

Analyte	Units	PQL	Blank	DUP1 BEK0522-DUP1# Samp | QC | RPD %	DUP2 PEK0250-07 Samp | QC | RPD %	LCS %
Moisture	%	0.1		5.44 | 5.71 | 4.84	27.3 | 25.1 | 8.24	[NA]

The QC reported was not specifically part of this workorder but formed part of the QC process batch.

INORG-008 | Inorganics - Moisture (Soil) | Batch BEK0523

Analyte	Units	PQL	Blank	DUP1 PEK0250-16 Samp | QC | RPD %	DUP2 BEK0523-DUP2# Samp | QC | RPD %	LCS %
Moisture	%	0.1		22.7 | 23.3 | 2.65	3.54 | 3.58 | 1.12	[NA]

The QC reported was not specifically part of this workorder but formed part of the QC process batch.

Quality Control PEK0250

INORG-014 | Inorganics - Cyanide Species and Similar (Soil) | Batch BEK0529

Analyte	Units	PQL	Blank	DUP1 PEK0250-01 Samp | QC | RPD %	DUP2 PEK0250-11 Samp | QC | RPD %	LCS %	Spike % PEK0250-02
Total Cyanide	mg/kg	0.25	<0.25	<0.25 | <0.25 | [NA]	<0.25 | <0.25 | [NA]	98.0	75.0

INORG-014 | Inorganics - Cyanide Species and Similar (Soil) | Batch BEK0530

Analyte	Units	PQL	Blank	DUP1 PEK0250-23 Samp | QC | RPD %	LCS %	Spike % PEK0250-24
Total Cyanide	mg/kg	0.25	<0.25	<0.25 | <0.25 | [NA]	86.0	##[3]

QC Comments

Identifier	Description
[1]	Spike recovery is not applicable due to the relatively high analyte background in the sample (>3* spike level). However, the LCS recovery is within acceptance criteria.
[2]	Spike recovery is outside routine acceptance criteria (70-130%), this may be due to suspected non-homogeneity and/or matrix interference effects. However, an acceptable recovery was achieved for the LCS.
[3]	Spike recovery is outside routine acceptance criteria (70-130%). Where recoveries of <20% and >200% are attributable to matrix interference effects, there will be a high uncertainty associated with the parent result.
[4]	Spike recovery is outside routine acceptance criteria (60-140%). Where recoveries of <20% and >200% are attributable to matrix interference effects, there will be a high uncertainty associated with the parent result.
[5]	Surrogate recovery was low due to sample(s) emulsifying during liquid liquid extraction.
[6]	Surrogate recovery is outside routine acceptance criteria (60-140%) as a result of the high concentration of analyte(s) in the sample.
[7]	Surrogate recovery was outside routine acceptance criteria (60-140%) due to sample matrix effects. This may be due to the presence of carbon and/or other artefacts. An acceptable recovery was achieved for the LCS surrogates.
[9]	PQL(s) has/have been raised due to matrix interference.
[10]	Duplicate %RPD may be flagged as an outlier to routine laboratory acceptance, however, where one or both results are <10*PQL, the RPD acceptance criteria increases exponentially.
[11]	The laboratory duplicate RPD acceptance criteria has been exceeded. Sample heterogeneity suspected. 3 sets of data have been provided to help demonstrate the degree of non-homogeneity within the sample as well as assessing the analytical precision.

C.2 ALS

CERTIFICATE OF ANALYSIS

Work Order	: **EP2315578**	Page	: 1 of 22
Client	: **BMT COMMERCIAL AUSTRALIA PTY LTD**	Laboratory	: Environmental Division Perth
Contact	: Kathryn Wheatley	Contact	: Customer Services EP
Address	: Level 4 20 Parkland Road Osborne Park 6017	Address	: 26 Rigali Way Wangara WA Australia 6065
Telephone	: ----	Telephone	: +61-8-9406 1301
Project	: SA Water DP	Date Samples Received	: 03-Nov-2023 16:50
Order number	: ----	Date Analysis Commenced	: 14-Nov-2023
C-O-C number	: ----	Issue Date	: 22-Nov-2023 13:45
Sampler	: Jessica Priess, Kathryn Wheatley		
Site	: ----		
Quote number	: EN/333 FOR TRIPLICATE SAMPLES		
No. of samples received	: 1		
No. of samples analysed	: 1		

NATA
Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted, unless the sampling was conducted by ALS. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results
- Surrogate Control Limits

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Ankit Joshi	Senior Chemist - Inorganics	Sydney Inorganics, Smithfield, NSW
Canhuang Ke	Inorganics Supervisor	Perth Inorganics, Wangara, WA
Chris Lemaitre	Laboratory Manager - Environmental	Brisbane Organics, Stafford, QLD
Chris Lemaitre	Laboratory Manager (Perth)	Perth Inorganics, Wangara, WA
David Viner	SENIOR LAB TECH	Perth Organics, Wangara, WA
Edwandy Fadjar	Organic Coordinator	Sydney Organics, Smithfield, NSW
Efua Wilson	Metals Chemist	Perth Inorganics, Wangara, WA
Franco Lentini	LCMS Coordinator	Sydney Organics, Smithfield, NSW
Kim McCabe	Senior Inorganic Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Matt Frost	Assistant Laboratory Manager	Brisbane Organics, Stafford, QLD

General Comments

The analytical procedures used by ALS have been developed from established internationally recognised procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are fully validated and are often at the client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contract for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- Benzo(a)pyrene Toxicity Equivalent Quotient (TEQ) per the NEPM (2013) is the sum total of the concentration of the eight carcinogenic PAHs multiplied by their Toxicity Equivalence Factor (TEF) relative to Benzo(a)pyrene. TEF values are provided in brackets as follows: Benz(a)anthracene (0.1), Chrysene (0.01), Benzo(b+j) & Benzo(k)fluoranthene (0.1), Benzo(a)pyrene (1.0), Indeno(1.2.3.cd)pyrene (0.1), Dibenz(a.h)anthracene (1.0), Benzo(g.h.i)perylene (0.01). Less than LOR results for 'TEQ Zero' are treated as zero, for 'TEQ 1/2LOR' are treated as half the reported LOR, and for 'TEQ LOR' are treated as being equal to the reported LOR. Note: TEQ 1/2LOR and TEQ LOR will calculate as 0.6mg/Kg and 1.2mg/Kg respectively for samples with non-detects for all of the eight TEQ PAHs.
- EP068: Where reported, Total Chlordane (sum) is the sum of the reported concentrations of cis-Chlordane and trans-Chlordane at or above the LOR.
- EP068: Where reported, Total OCP is the sum of the reported concentrations of all Organochlorine Pesticides at or above LOR.
- EP080-SD: Where reported, Total Xylenes is the sum of the reported concentrations of m&p-Xylene and o-Xylene at or above the LOR.
- EP131A: Where reported, Total Chlordane (sum) is the sum of the reported concentrations of cis-Chlordane and trans-Chlordane at or above the LOR.
- EP074: Where reported, Total Trihalomethanes is the sum of the reported concentrations of all Trihalomethanes at or above the LOR.
- EP074: Where reported, Total Xylenes is the sum of the reported concentrations of m&p-Xylene and o-Xylene at or above the LOR.
- EP074: Where reported, Sum of chlorinated hydrocarbons includes carbon tetrachloride, chlorobenzene, chloroform, 1,2-dichlorobenzene, 1,4-dichlorobenzene, 1,2-dichloroethane, 1,1-dichloroethene, cis-1,2-dichlorothene, trans-1,2-dichlorothene, 1,1,1,2-tetrachloroethane, 1,1,2,2-tetrachloroethane, 1,2,4-trichlorobenzene, 1,1,1-trichloroethane, 1,1,2-trichloroethane, trichloroethene, vinyl chloride, hexachlorobutadiene and methylene chloride.
- EP074: Where reported, Total Trimethylbenzenes is the sum of the reported concentrations of 1.2.3-Trimethylbenzene, 1.2.4-Trimethylbenzene and 1.3.5-Trimethylbenzene at or above the LOR.
- EP075(SIM): Where reported, Total Cresol is the sum of the reported concentrations of 2-Methylphenol and 3- & 4-Methylphenol at or above the LOR.
- EP074: High failing LCS deemed acceptable as all associated analyte results are less than LOR.
- EK026SF: Poor Total Cyanide matrix spike recovery for sample EP2315990-001 due to possible sample matrix interference. Confirmed by re-preparation and re-analysis.
- EG035: Positive Hg result for sample EP2315578 -001 has been confirmed by re-extraction and re-analysis.
- EP075: Where reported, 'Sum of PAH' is the sum of the USEPA 16 priority PAHs
- Benzo(a)pyrene Toxicity Equivalent Quotient (TEQ) is the sum total of the concentration of the eight carcinogenic PAHs multiplied by their Toxicity Equivalence Factor (TEF) relative to Benzo(a)pyrene. TEF values are provided in brackets as follows: Benz(a)anthracene (0.1), Chrysene (0.01), Benzo(b+j) & Benzo(k)fluoranthene (0.1), Benzo(a)pyrene (1.0), Indeno(1.2.3.cd)pyrene (0.1), Dibenz(a.h)anthracene (1.0), Benzo(g.h.i)perylene (0.01). Less than LOR results for 'TEQ Zero' are treated as zero, for 'TEQ 1/2LOR' are treated as half the reported LOR, and for 'TEQ LOR' are treated as being equal to the reported LOR. Note: TEQ 1/2LOR and TEQ LOR will calculate as 0.6mg/Kg and 1.2mg/Kg respectively for samples with non-detects for all of the eight TEQ PAHs.

Analytical Results

Sub-Matrix: SEDIMENT (Matrix: SOIL)			Sample ID	EPW7A 0.0-0.5	----	----	----	----
			Sampling date / time	31-Oct-2023 00:00	----	----	----	----
Compound	CAS Number	LOR	Unit	EP2315578-001	--------	--------	--------	--------
				Result	----	----	----	----
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	1.0	%	**14.7**	----	----	----	----
EG005(ED093)-SD: Total Metals in Sediments by ICP-AES								
Aluminium	7429-90-5	50	mg/kg	**980**	----	----	----	----
Iron	7439-89-6	50	mg/kg	**1870**	----	----	----	----
EG020-SD: Total Metals in Sediments by ICPMS								
Antimony	7440-36-0	0.50	mg/kg	<0.50	----	----	----	----
Arsenic	7440-38-2	1.00	mg/kg	**5.57**	----	----	----	----
Cadmium	7440-43-9	0.1	mg/kg	<0.1	----	----	----	----
Chromium	7440-47-3	1.0	mg/kg	**16.0**	----	----	----	----
Copper	7440-50-8	1.0	mg/kg	**5.2**	----	----	----	----
Cobalt	7440-48-4	0.5	mg/kg	<0.5	----	----	----	----
Lead	7439-92-1	1.0	mg/kg	**1.6**	----	----	----	----
Manganese	7439-96-5	10	mg/kg	**11**	----	----	----	----
Nickel	7440-02-0	1.0	mg/kg	**1.2**	----	----	----	----
Selenium	7782-49-2	0.1	mg/kg	**0.2**	----	----	----	----
Silver	7440-22-4	0.1	mg/kg	<0.1	----	----	----	----
Vanadium	7440-62-2	2.0	mg/kg	**8.4**	----	----	----	----
Zinc	7440-66-6	1.0	mg/kg	**8.1**	----	----	----	----
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.01	mg/kg	**0.01**	----	----	----	----
EK026SF: Total CN by Segmented Flow Analyser								
Total Cyanide	57-12-5	1	mg/kg	<1	----	----	----	----
EK055: Ammonia as N								
Ammonia as N	7664-41-7	20	mg/kg	<20	----	----	----	----
EK057G: Nitrite as N by Discrete Analyser								
Nitrite as N (Sol.)	14797-65-0	0.1	mg/kg	<0.1	----	----	----	----
EK058G: Nitrate as N by Discrete Analyser								

Analytical Results

Sub-Matrix: SEDIMENT
(Matrix: SOIL)

				Sample ID	EPW7A 0.0-0.5	----	----	----	----
				Sampling date / time	31-Oct-2023 00:00	----	----	----	----
	Compound	CAS Number	LOR	Unit	EP2315578-001	--------	--------	--------	--------
					Result	----	----	----	----
EK058G: Nitrate as N by Discrete Analyser - Continued									
	Nitrate as N (Sol.)	14797-55-8	0.1	mg/kg	<0.1	----	----	----	----
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
	Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg	<0.1	----	----	----	----
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser									
	Total Kjeldahl Nitrogen as N	----	20	mg/kg	**420**	----	----	----	----
EK062: Total Nitrogen as N (TKN + NOx)									
^	Total Nitrogen as N	----	20	mg/kg	**420**	----	----	----	----
EK067G: Total Phosphorus as P by Discrete Analyser									
	Total Phosphorus as P	----	2	mg/kg	**290**	----	----	----	----
EK071G: Reactive Phosphorus as P by discrete analyser									
	Reactive Phosphorus as P	14265-44-2	0.1	mg/kg	**0.4**	----	----	----	----
EK255A SD: Ammonium in Sediment									
	Ammonium as N	14798-03-9_N	0.2	mg/kg	<0.2	----	----	----	----
	Ammonium as NH4	----	0.2	mg/kg	<0.2	----	----	----	----
EP003: Total Organic Carbon (TOC) in Soil									
	Total Organic Carbon	----	0.02	%	**0.50**	----	----	----	----
EP068C: Triazines									
	Atrazine	1912-24-9	0.05	mg/kg	<0.05	----	----	----	----
	Simazine	122-34-9	0.05	mg/kg	<0.05	----	----	----	----
EP074A: Monocyclic Aromatic Hydrocarbons									
	Benzene	71-43-2	0.2	mg/kg	<0.2	----	----	----	----
	Toluene	108-88-3	0.5	mg/kg	<0.5	----	----	----	----
	Ethylbenzene	100-41-4	0.5	mg/kg	<0.5	----	----	----	----
	meta- & para-Xylene	108-38-3 106-42-3	0.5	mg/kg	<0.5	----	----	----	----
	Styrene	100-42-5	0.5	mg/kg	<0.5	----	----	----	----
	ortho-Xylene	95-47-6	0.5	mg/kg	<0.5	----	----	----	----
	Isopropylbenzene	98-82-8	0.5	mg/kg	<0.5	----	----	----	----
	n-Propylbenzene	103-65-1	0.5	mg/kg	<0.5	----	----	----	----

Analytical Results

Sub-Matrix: SEDIMENT (Matrix: SOIL)			Sample ID	EPW7A 0.0-0.5	----	----	----	----
			Sampling date / time	31-Oct-2023 00:00	----	----	----	----
Compound	CAS Number	LOR	Unit	EP2315578-001	--------	--------	--------	--------
				Result	----	----	----	----
EP074A: Monocyclic Aromatic Hydrocarbons - Continued								
1.3.5-Trimethylbenzene	108-67-8	0.5	mg/kg	<0.5	----	----	----	----
sec-Butylbenzene	135-98-8	0.5	mg/kg	<0.5	----	----	----	----
1.2.4-Trimethylbenzene	95-63-6	0.5	mg/kg	<0.5	----	----	----	----
tert-Butylbenzene	98-06-6	0.5	mg/kg	<0.5	----	----	----	----
p-Isopropyltoluene	99-87-6	0.5	mg/kg	<0.5	----	----	----	----
n-Butylbenzene	104-51-8	0.5	mg/kg	<0.5	----	----	----	----
EP074B: Oxygenated Compounds								
Vinyl Acetate	108-05-4	5	mg/kg	<5	----	----	----	----
2-Butanone (MEK)	78-93-3	5	mg/kg	<5	----	----	----	----
4-Methyl-2-pentanone (MIBK)	108-10-1	5	mg/kg	<5	----	----	----	----
2-Hexanone (MBK)	591-78-6	5	mg/kg	<5	----	----	----	----
EP074C: Sulfonated Compounds								
Carbon disulfide	75-15-0	0.5	mg/kg	<0.5	----	----	----	----
EP074D: Fumigants								
2.2-Dichloropropane	594-20-7	0.5	mg/kg	<0.5	----	----	----	----
1.2-Dichloropropane	78-87-5	0.5	mg/kg	<0.5	----	----	----	----
cis-1.3-Dichloropropylene	10061-01-5	0.5	mg/kg	<0.5	----	----	----	----
trans-1.3-Dichloropropylene	10061-02-6	0.5	mg/kg	<0.5	----	----	----	----
1.2-Dibromoethane (EDB)	106-93-4	0.5	mg/kg	<0.5	----	----	----	----
EP074E: Halogenated Aliphatic Compounds								
Dichlorodifluoromethane	75-71-8	5	mg/kg	<5	----	----	----	----
Chloromethane	74-87-3	5	mg/kg	<5	----	----	----	----
Vinyl chloride	75-01-4	5	mg/kg	<5	----	----	----	----
Bromomethane	74-83-9	5	mg/kg	<5	----	----	----	----
Chloroethane	75-00-3	5	mg/kg	<5	----	----	----	----
Trichlorofluoromethane	75-69-4	5	mg/kg	<5	----	----	----	----
1.1-Dichloroethene	75-35-4	0.5	mg/kg	<0.5	----	----	----	----

Analytical Results

Sub-Matrix: SEDIMENT (Matrix: SOIL)			Sample ID	EPW7A 0.0-0.5	----	----	----	----
			Sampling date / time	31-Oct-2023 00:00	----	----	----	----
Compound	CAS Number	LOR	Unit	EP2315578-001	--------	--------	--------	--------
				Result	----	----	----	----
EP074E: Halogenated Aliphatic Compounds - Continued								
Iodomethane	74-88-4	0.5	mg/kg	<0.5	----	----	----	----
trans-1.2-Dichloroethene	156-60-5	0.5	mg/kg	<0.5	----	----	----	----
1.1-Dichloroethane	75-34-3	0.5	mg/kg	<0.5	----	----	----	----
cis-1.2-Dichloroethene	156-59-2	0.5	mg/kg	<0.5	----	----	----	----
1.1.1-Trichloroethane	71-55-6	0.5	mg/kg	<0.5	----	----	----	----
1.1-Dichloropropylene	563-58-6	0.5	mg/kg	<0.5	----	----	----	----
Carbon Tetrachloride	56-23-5	0.5	mg/kg	<0.5	----	----	----	----
1.2-Dichloroethane	107-06-2	0.5	mg/kg	<0.5	----	----	----	----
Trichloroethene	79-01-6	0.5	mg/kg	<0.5	----	----	----	----
Dibromomethane	74-95-3	0.5	mg/kg	<0.5	----	----	----	----
1.1.2-Trichloroethane	79-00-5	0.5	mg/kg	<0.5	----	----	----	----
1.3-Dichloropropane	142-28-9	0.5	mg/kg	<0.5	----	----	----	----
Tetrachloroethene	127-18-4	0.5	mg/kg	<0.5	----	----	----	----
1.1.1.2-Tetrachloroethane	630-20-6	0.5	mg/kg	<0.5	----	----	----	----
trans-1.4-Dichloro-2-butene	110-57-6	0.5	mg/kg	<0.5	----	----	----	----
cis-1.4-Dichloro-2-butene	1476-11-5	0.5	mg/kg	<0.5	----	----	----	----
1.1.2.2-Tetrachloroethane	79-34-5	0.5	mg/kg	<0.5	----	----	----	----
1.2.3-Trichloropropane	96-18-4	0.5	mg/kg	<0.5	----	----	----	----
Pentachloroethane	76-01-7	0.5	mg/kg	<0.5	----	----	----	----
1.2-Dibromo-3-chloropropane	96-12-8	0.5	mg/kg	<0.5	----	----	----	----
Hexachlorobutadiene	87-68-3	0.5	mg/kg	<0.5	----	----	----	----
EP074F: Halogenated Aromatic Compounds								
Chlorobenzene	108-90-7	0.5	mg/kg	<0.5	----	----	----	----
Bromobenzene	108-86-1	0.5	mg/kg	<0.5	----	----	----	----
2-Chlorotoluene	95-49-8	0.5	mg/kg	<0.5	----	----	----	----
4-Chlorotoluene	106-43-4	0.5	mg/kg	<0.5	----	----	----	----
1.3-Dichlorobenzene	541-73-1	0.5	mg/kg	<0.5	----	----	----	----

Analytical Results

Sub-Matrix: SEDIMENT (Matrix: SOIL)			Sample ID	EPW7A 0.0-0.5	----	----	----	----
			Sampling date / time	31-Oct-2023 00:00	----	----	----	----
Compound	CAS Number	LOR	Unit	EP2315578-001	--------	--------	--------	--------
				Result	----	----	----	----
EP074F: Halogenated Aromatic Compounds - Continued								
1.4-Dichlorobenzene	106-46-7	0.5	mg/kg	<0.5	----	----	----	----
1.2-Dichlorobenzene	95-50-1	0.5	mg/kg	<0.5	----	----	----	----
1.2.4-Trichlorobenzene	120-82-1	0.5	mg/kg	<0.5	----	----	----	----
1.2.3-Trichlorobenzene	87-61-6	0.5	mg/kg	<0.5	----	----	----	----
EP074G: Trihalomethanes								
Chloroform	67-66-3	0.5	mg/kg	<0.5	----	----	----	----
Bromodichloromethane	75-27-4	0.5	mg/kg	<0.5	----	----	----	----
Dibromochloromethane	124-48-1	0.5	mg/kg	<0.5	----	----	----	----
Bromoform	75-25-2	0.5	mg/kg	<0.5	----	----	----	----
EP074H: Naphthalene								
Naphthalene	91-20-3	1	mg/kg	<1	----	----	----	----
EP075(SIM)A: Phenolic Compounds								
Phenol	108-95-2	0.5	mg/kg	<0.5	----	----	----	----
2-Chlorophenol	95-57-8	0.5	mg/kg	<0.5	----	----	----	----
2-Methylphenol	95-48-7	0.5	mg/kg	<0.5	----	----	----	----
3- & 4-Methylphenol	1319-77-3	1	mg/kg	<1	----	----	----	----
2-Nitrophenol	88-75-5	0.5	mg/kg	<0.5	----	----	----	----
2.4-Dimethylphenol	105-67-9	0.5	mg/kg	<0.5	----	----	----	----
2.4-Dichlorophenol	120-83-2	0.5	mg/kg	<0.5	----	----	----	----
2.6-Dichlorophenol	87-65-0	0.5	mg/kg	<0.5	----	----	----	----
4-Chloro-3-methylphenol	59-50-7	0.5	mg/kg	<0.5	----	----	----	----
2.4.6-Trichlorophenol	88-06-2	0.5	mg/kg	<0.5	----	----	----	----
2.4.5-Trichlorophenol	95-95-4	0.5	mg/kg	<0.5	----	----	----	----
Pentachlorophenol	87-86-5	2	mg/kg	<2	----	----	----	----
EP075A: Phenolic Compounds								
Phenol	108-95-2	0.5	mg/kg	<0.5	----	----	----	----
2-Chlorophenol	95-57-8	0.5	mg/kg	<0.5	----	----	----	----

Analytical Results

Sub-Matrix: SEDIMENT (Matrix: SOIL)			Sample ID	EPW7A 0.0-0.5	----	----	----	----
			Sampling date / time	31-Oct-2023 00:00	----	----	----	----
Compound	CAS Number	LOR	Unit	EP2315578-001	--------	--------	--------	--------
				Result	----	----	----	----
EP075A: Phenolic Compounds - Continued								
2-Methylphenol	95-48-7	0.5	mg/kg	<0.5	----	----	----	----
3- & 4-Methylphenol	1319-77-3	0.5	mg/kg	<0.5	----	----	----	----
2-Nitrophenol	88-75-5	0.5	mg/kg	<0.5	----	----	----	----
2.4-Dimethylphenol	105-67-9	0.5	mg/kg	<0.5	----	----	----	----
2.4-Dichlorophenol	120-83-2	0.5	mg/kg	<0.5	----	----	----	----
2.6-Dichlorophenol	87-65-0	0.5	mg/kg	<0.5	----	----	----	----
4-Chloro-3-methylphenol	59-50-7	0.5	mg/kg	<0.5	----	----	----	----
2.4.6-Trichlorophenol	88-06-2	0.5	mg/kg	<0.5	----	----	----	----
2.4.5-Trichlorophenol	95-95-4	0.5	mg/kg	<0.5	----	----	----	----
Pentachlorophenol	87-86-5	1	mg/kg	<1	----	----	----	----
EP075B: Polynuclear Aromatic Hydrocarbons								
Naphthalene	91-20-3	0.5	mg/kg	<0.5	----	----	----	----
2-Methylnaphthalene	91-57-6	0.5	mg/kg	<0.5	----	----	----	----
2-Chloronaphthalene	91-58-7	0.5	mg/kg	<0.5	----	----	----	----
Acenaphthylene	208-96-8	0.5	mg/kg	<0.5	----	----	----	----
Acenaphthene	83-32-9	0.5	mg/kg	<0.5	----	----	----	----
Fluorene	86-73-7	0.5	mg/kg	<0.5	----	----	----	----
Phenanthrene	85-01-8	0.5	mg/kg	<0.5	----	----	----	----
Anthracene	120-12-7	0.5	mg/kg	<0.5	----	----	----	----
Fluoranthene	206-44-0	0.5	mg/kg	<0.5	----	----	----	----
Pyrene	129-00-0	0.5	mg/kg	<0.5	----	----	----	----
N-2-Fluorenyl Acetamide	53-96-3	0.5	mg/kg	<0.5	----	----	----	----
Benz(a)anthracene	56-55-3	0.5	mg/kg	<0.5	----	----	----	----
Chrysene	218-01-9	0.5	mg/kg	<0.5	----	----	----	----
Benzo(b+j) & Benzo(k)fluoranthene	205-99-2 207-08-9	1	mg/kg	<1	----	----	----	----
7.12-Dimethylbenz(a)anthracene	57-97-6	0.5	mg/kg	<0.5	----	----	----	----

Analytical Results

Sub-Matrix: SEDIMENT (Matrix: SOIL)			Sample ID	EPW7A 0.0-0.5	----	----	----	----
			Sampling date / time	31-Oct-2023 00:00	----	----	----	----
Compound	CAS Number	LOR	Unit	EP2315578-001	--------	--------	--------	--------
				Result	----	----	----	----
EP075B: Polynuclear Aromatic Hydrocarbons - Continued								
Benzo(a)pyrene	50-32-8	0.5	mg/kg	<0.5	----	----	----	----
3-Methylcholanthrene	56-49-5	0.5	mg/kg	<0.5	----	----	----	----
Indeno(1.2.3.cd)pyrene	193-39-5	0.5	mg/kg	<0.5	----	----	----	----
Dibenz(a.h)anthracene	53-70-3	0.5	mg/kg	<0.5	----	----	----	----
Benzo(g.h.i)perylene	191-24-2	0.5	mg/kg	<0.5	----	----	----	----
^ **Sum of PAHs**	----	0.5	mg/kg	<0.5	----	----	----	----
^ **Benzo(a)pyrene TEQ (zero)**	----	0.5	mg/kg	<0.5	----	----	----	----
^ **Benzo(a)pyrene TEQ (half LOR)**	----	0.5	mg/kg	**0.6**	----	----	----	----
^ **Benzo(a)pyrene TEQ (LOR)**	----	0.5	mg/kg	**1.2**	----	----	----	----
EP075C: Phthalate Esters								
Dimethyl phthalate	131-11-3	0.5	mg/kg	<0.5	----	----	----	----
Diethyl phthalate	84-66-2	0.5	mg/kg	<0.5	----	----	----	----
Di-n-butyl phthalate	84-74-2	0.5	mg/kg	<0.5	----	----	----	----
Butyl benzyl phthalate	85-68-7	0.5	mg/kg	<0.5	----	----	----	----
bis(2-ethylhexyl) phthalate	117-81-7	5.0	mg/kg	<5.0	----	----	----	----
Di-n-octylphthalate	117-84-0	0.5	mg/kg	<0.5	----	----	----	----
EP075D: Nitrosamines								
N-Nitrosomethylethylamine	10595-95-6	0.5	mg/kg	<0.5	----	----	----	----
N-Nitrosodiethylamine	55-18-5	0.5	mg/kg	<0.5	----	----	----	----
N-Nitrosopyrrolidine	930-55-2	1.0	mg/kg	<1.0	----	----	----	----
N-Nitrosomorpholine	59-89-2	0.5	mg/kg	<0.5	----	----	----	----
N-Nitrosodi-n-propylamine	621-64-7	0.5	mg/kg	<0.5	----	----	----	----
N-Nitrosopiperidine	100-75-4	0.5	mg/kg	<0.5	----	----	----	----
N-Nitrosodibutylamine	924-16-3	0.5	mg/kg	<0.5	----	----	----	----
N-Nitrosodiphenyl & Diphenylamine	86-30-6 122-39-4	1.0	mg/kg	<1.0	----	----	----	----
Methapyrilene	91-80-5	0.5	mg/kg	<0.5	----	----	----	----

Analytical Results

Sub-Matrix: SEDIMENT (Matrix: SOIL)			Sample ID	EPW7A 0.0-0.5	----	----	----	----
			Sampling date / time	31-Oct-2023 00:00	----	----	----	----
Compound	CAS Number	LOR	Unit	EP2315578-001	--------	--------	--------	--------
				Result	----	----	----	----
EP075E: Nitroaromatics and Ketones								
2-Picoline	109-06-8	0.5	mg/kg	<0.5	----	----	----	----
Acetophenone	98-86-2	0.5	mg/kg	<0.5	----	----	----	----
Nitrobenzene	98-95-3	0.5	mg/kg	<0.5	----	----	----	----
Isophorone	78-59-1	0.5	mg/kg	<0.5	----	----	----	----
2.6-Dinitrotoluene	606-20-2	1.0	mg/kg	<1.0	----	----	----	----
2.4-Dinitrotoluene	121-14-2	1.0	mg/kg	<1.0	----	----	----	----
1-Naphthylamine	134-32-7	0.5	mg/kg	<0.5	----	----	----	----
4-Nitroquinoline-N-oxide	56-57-5	0.5	mg/kg	<0.5	----	----	----	----
5-Nitro-o-toluidine	99-55-8	0.5	mg/kg	<0.5	----	----	----	----
Azobenzene	103-33-3	1	mg/kg	<1	----	----	----	----
1.3.5-Trinitrobenzene	99-35-4	0.5	mg/kg	<0.5	----	----	----	----
Phenacetin	62-44-2	0.5	mg/kg	<0.5	----	----	----	----
4-Aminobiphenyl	92-67-1	0.5	mg/kg	<0.5	----	----	----	----
Pentachloronitrobenzene	82-68-8	0.5	mg/kg	<0.5	----	----	----	----
Pronamide	23950-58-5	0.5	mg/kg	<0.5	----	----	----	----
Dimethylaminoazobenzene	60-11-7	0.5	mg/kg	<0.5	----	----	----	----
Chlorobenzilate	510-15-6	0.5	mg/kg	<0.5	----	----	----	----
EP075F: Haloethers								
Bis(2-chloroethyl) ether	111-44-4	0.5	mg/kg	<0.5	----	----	----	----
Bis(2-chloroethoxy) methane	111-91-1	0.5	mg/kg	<0.5	----	----	----	----
4-Chlorophenyl phenyl ether	7005-72-3	0.5	mg/kg	<0.5	----	----	----	----
4-Bromophenyl phenyl ether	101-55-3	0.5	mg/kg	<0.5	----	----	----	----
EP075G: Chlorinated Hydrocarbons								
1.3-Dichlorobenzene	541-73-1	0.5	mg/kg	<0.5	----	----	----	----
1.4-Dichlorobenzene	106-46-7	0.5	mg/kg	<0.5	----	----	----	----
1.2-Dichlorobenzene	95-50-1	0.5	mg/kg	<0.5	----	----	----	----
Hexachloroethane	67-72-1	0.5	mg/kg	<0.5	----	----	----	----

Analytical Results

Sub-Matrix: SEDIMENT (Matrix: SOIL)			Sample ID	EPW7A 0.0-0.5	----	----	----	----
			Sampling date / time	31-Oct-2023 00:00	----	----	----	----
Compound	CAS Number	LOR	Unit	EP2315578-001	--------	--------	--------	--------
				Result	----	----	----	----
EP075G: Chlorinated Hydrocarbons - Continued								
1.2.4-Trichlorobenzene	120-82-1	0.5	mg/kg	<0.5	----	----	----	----
Hexachloropropylene	1888-71-7	0.5	mg/kg	<0.5	----	----	----	----
Hexachlorobutadiene	87-68-3	0.5	mg/kg	<0.5	----	----	----	----
Hexachlorocyclopentadiene	77-47-4	2.5	mg/kg	<2.5	----	----	----	----
Pentachlorobenzene	608-93-5	0.5	mg/kg	<0.5	----	----	----	----
Hexachlorobenzene (HCB)	118-74-1	1.0	mg/kg	<1.0	----	----	----	----
EP075H: Anilines and Benzidines								
Aniline	62-53-3	0.5	mg/kg	<0.5	----	----	----	----
4-Chloroaniline	106-47-8	0.5	mg/kg	<0.5	----	----	----	----
2-Nitroaniline	88-74-4	1.0	mg/kg	<1.0	----	----	----	----
3-Nitroaniline	99-09-2	1.0	mg/kg	<1.0	----	----	----	----
Dibenzofuran	132-64-9	0.5	mg/kg	<0.5	----	----	----	----
4-Nitroaniline	100-01-6	0.5	mg/kg	<0.5	----	----	----	----
Carbazole	86-74-8	0.5	mg/kg	<0.5	----	----	----	----
3.3`-Dichlorobenzidine	91-94-1	0.5	mg/kg	<0.5	----	----	----	----
EP075I: Organochlorine Pesticides								
alpha-BHC	319-84-6	0.5	mg/kg	<0.5	----	----	----	----
beta-BHC	319-85-7	0.5	mg/kg	<0.5	----	----	----	----
gamma-BHC	58-89-9	0.5	mg/kg	<0.5	----	----	----	----
delta-BHC	319-86-8	0.5	mg/kg	<0.5	----	----	----	----
Heptachlor	76-44-8	0.5	mg/kg	<0.5	----	----	----	----
Aldrin	309-00-2	0.5	mg/kg	<0.5	----	----	----	----
Heptachlor epoxide	1024-57-3	0.5	mg/kg	<0.5	----	----	----	----
alpha-Endosulfan	959-98-8	0.5	mg/kg	<0.5	----	----	----	----
4.4`-DDE	72-55-9	0.5	mg/kg	<0.5	----	----	----	----
Dieldrin	60-57-1	0.5	mg/kg	<0.5	----	----	----	----
Endrin	72-20-8	0.5	mg/kg	<0.5	----	----	----	----

Analytical Results

Sub-Matrix: SEDIMENT
(Matrix: SOIL)

	Compound	CAS Number	LOR	Unit	EPW7A 0.0-0.5	----	----	----	----
				Sampling date / time	31-Oct-2023 00:00	----	----	----	----
					EP2315578-001	--------	--------	--------	--------
					Result	----	----	----	----
	EP075I: Organochlorine Pesticides - Continued								
	beta-Endosulfan	33213-65-9	0.5	mg/kg	<0.5	----	----	----	----
	4.4`-DDD	72-54-8	0.5	mg/kg	<0.5	----	----	----	----
	Endosulfan sulfate	1031-07-8	0.5	mg/kg	<0.5	----	----	----	----
	4.4`-DDT	50-29-3	1.0	mg/kg	<1.0	----	----	----	----
^	**Sum of DDD + DDE + DDT**	72-54-8/72-55-9/50-2	0.5	mg/kg	<0.5	----	----	----	----
^	**Sum of Aldrin + Dieldrin**	309-00-2/60-57-1	0.5	mg/kg	<0.5	----	----	----	----
	EP075J: Organophosphorus Pesticides								
	Dichlorvos	62-73-7	0.5	mg/kg	<0.5	----	----	----	----
	Dimethoate	60-51-5	0.5	mg/kg	<0.5	----	----	----	----
	Diazinon	333-41-5	0.5	mg/kg	<0.5	----	----	----	----
	Chlorpyrifos-methyl	5598-13-0	0.5	mg/kg	<0.5	----	----	----	----
	Malathion	121-75-5	0.5	mg/kg	<0.5	----	----	----	----
	Fenthion	55-38-9	0.5	mg/kg	<0.5	----	----	----	----
	Chlorpyrifos	2921-88-2	0.5	mg/kg	<0.5	----	----	----	----
	Pirimphos-ethyl	23505-41-1	0.5	mg/kg	<0.5	----	----	----	----
	Chlorfenvinphos	470-90-6	0.5	mg/kg	<0.5	----	----	----	----
	Prothiofos	34643-46-4	0.5	mg/kg	<0.5	----	----	----	----
	Ethion	563-12-2	0.5	mg/kg	<0.5	----	----	----	----
	EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions								
	>C10 - C16 Fraction	----	3	mg/kg	<3	----	----	----	----
	>C16 - C34 Fraction	----	3	mg/kg	**8**	----	----	----	----
	>C34 - C40 Fraction	----	5	mg/kg	<5	----	----	----	----
	>C10 - C40 Fraction (sum)	----	3	mg/kg	**8**	----	----	----	----
	>C10 - C16 Fraction minus Naphthalene (F2)	----	3	mg/kg	<3	----	----	----	----
	EP080-SD / EP071-SD: Total Petroleum Hydrocarbons								
	C6 - C9 Fraction	----	3	mg/kg	<3	----	----	----	----

Analytical Results

Sub-Matrix: SEDIMENT (Matrix: SOIL)			Sample ID	EPW7A 0.0-0.5	----	----	----	----
			Sampling date / time	31-Oct-2023 00:00	----	----	----	----
Compound	CAS Number	LOR	Unit	EP2315578-001	--------	--------	--------	--------
				Result	----	----	----	----
EP080-SD / EP071-SD: Total Petroleum Hydrocarbons - Continued								
C10 - C14 Fraction	----	3	mg/kg	<3	----	----	----	----
C15 - C28 Fraction	----	3	mg/kg	**4**	----	----	----	----
C29 - C36 Fraction	----	5	mg/kg	**5**	----	----	----	----
^ C10 - C36 Fraction (sum)	----	3	mg/kg	**9**	----	----	----	----
EP080-SD / EP071-SD: Total Recoverable Hydrocarbons								
C6 - C10 Fraction	C6_C10	3	mg/kg	<3	----	----	----	----
C6 - C10 Fraction minus BTEX (F1)	C6_C10-BTEX	3.0	mg/kg	<3.0	----	----	----	----
EP080-SD: BTEXN								
Benzene	71-43-2	0.2	mg/kg	<0.2	----	----	----	----
Toluene	108-88-3	0.2	mg/kg	<0.2	----	----	----	----
Ethylbenzene	100-41-4	0.2	mg/kg	<0.2	----	----	----	----
meta- & para-Xylene	108-38-3 106-42-3	0.2	mg/kg	<0.2	----	----	----	----
ortho-Xylene	95-47-6	0.2	mg/kg	<0.2	----	----	----	----
^ Total Xylenes	----	0.5	mg/kg	<0.5	----	----	----	----
^ Sum of BTEX	----	0.2	mg/kg	<0.2	----	----	----	----
Naphthalene	91-20-3	0.2	mg/kg	<0.2	----	----	----	----
EP090: Organotin Compounds								
Monobutyltin	78763-54-9	1	µgSn/kg	**2**	----	----	----	----
Dibutyltin	1002-53-5	1	µgSn/kg	<1	----	----	----	----
Tributyltin	56573-85-4	0.5	µgSn/kg	**2.9**	----	----	----	----
EP094A: Synthetic Pyrethroids								
Bioresmethrin	28434-01-07	0.05	mg/kg	<0.05	----	----	----	----
Bifenthrin	82657-04-3	0.05	mg/kg	<0.05	----	----	----	----
Phenothrin	26002-80-2	0.05	mg/kg	<0.05	----	----	----	----
Lambda-cyhalothrin	68085-85-8	0.05	mg/kg	<0.05	----	----	----	----
Permethrin	52645-53-1	0.05	mg/kg	<0.05	----	----	----	----
Cyfluthrin	68359-37-5	0.05	mg/kg	<0.05	----	----	----	----

Analytical Results

Sub-Matrix: SEDIMENT (Matrix: SOIL)			Sample ID	EPW7A 0.0-0.5	----	----	----	----
			Sampling date / time	31-Oct-2023 00:00	----	----	----	----
Compound	CAS Number	LOR	Unit	EP2315578-001	--------	--------	--------	--------
				Result	----	----	----	----
EP094A: Synthetic Pyrethroids - Continued								
Cypermethrin	52315-07-8	0.05	mg/kg	<0.05	----	----	----	----
Fenvalerate & Esfenvalerate	51630-58-1/66230-04-	0.05	mg/kg	<0.05	----	----	----	----
Deltamethrin & Tralomethrin	62229-77-0/66841-25-	0.05	mg/kg	<0.05	----	----	----	----
Allethrin	584-79-2	0.05	mg/kg	<0.05	----	----	----	----
Transfluthrin	118712-89-3	0.05	mg/kg	<0.05	----	----	----	----
Tetramethrin	7696-12-0	0.05	mg/kg	<0.05	----	----	----	----
Tau-fluvalinate	102851-06-9	0.05	mg/kg	<0.05	----	----	----	----
EP094B: Synergist								
Piperonyl Butoxide	63993-73-7	0.05	mg/kg	<0.05	----	----	----	----
EP130A: Organophosphorus Pesticides (Ultra-trace)								
Bromophos-ethyl	4824-78-6	10	µg/kg	<10	----	----	----	----
Carbophenothion	786-19-6	10	µg/kg	<10	----	----	----	----
Chlorfenvinphos (E)	18708-86-6	10.0	µg/kg	<10.0	----	----	----	----
Chlorfenvinphos (Z)	18708-87-7	10	µg/kg	<10	----	----	----	----
Chlorpyrifos	2921-88-2	10	µg/kg	<10	----	----	----	----
Chlorpyrifos-methyl	5598-13-0	10	µg/kg	<10	----	----	----	----
Demeton-S-methyl	919-86-8	10	µg/kg	<10	----	----	----	----
Diazinon	333-41-5	10	µg/kg	<10	----	----	----	----
Dichlorvos	62-73-7	10	µg/kg	<10	----	----	----	----
Dimethoate	60-51-5	10	µg/kg	<10	----	----	----	----
Ethion	563-12-2	10	µg/kg	<10	----	----	----	----
Fenamiphos	22224-92-6	10	µg/kg	<10	----	----	----	----
Fenthion	55-38-9	10	µg/kg	<10	----	----	----	----
Malathion	121-75-5	10	µg/kg	<10	----	----	----	----
Azinphos Methyl	86-50-0	10	µg/kg	<10	----	----	----	----
Monocrotophos	6923-22-4	10	µg/kg	<10	----	----	----	----

Analytical Results

Sub-Matrix: SEDIMENT (Matrix: SOIL)			Sample ID	EPW7A 0.0-0.5	----	----	----	----
			Sampling date / time	31-Oct-2023 00:00	----	----	----	----
Compound	CAS Number	LOR	Unit	EP2315578-001	--------	--------	--------	--------
				Result	----	----	----	----
EP130A: Organophosphorus Pesticides (Ultra-trace) - Continued								
Parathion	56-38-2	10	µg/kg	<10	----	----	----	----
Parathion-methyl	298-00-0	10	µg/kg	<10	----	----	----	----
Pirimphos-ethyl	23505-41-1	10	µg/kg	<10	----	----	----	----
Prothiofos	34643-46-4	10	µg/kg	<10	----	----	----	----
EP131A: Organochlorine Pesticides								
Aldrin	309-00-2	0.50	µg/kg	<0.50	----	----	----	----
alpha-BHC	319-84-6	0.50	µg/kg	<0.50	----	----	----	----
beta-BHC	319-85-7	0.50	µg/kg	<0.50	----	----	----	----
delta-BHC	319-86-8	0.50	µg/kg	<0.50	----	----	----	----
4.4`-DDD	72-54-8	0.50	µg/kg	<0.50	----	----	----	----
4.4`-DDE	72-55-9	0.50	µg/kg	<0.50	----	----	----	----
4.4`-DDT	50-29-3	0.50	µg/kg	<0.50	----	----	----	----
^ **Sum of DDD + DDE + DDT**	72-54-8/72-55-9/50-2	0.50	µg/kg	<0.50	----	----	----	----
Dieldrin	60-57-1	0.50	µg/kg	<0.50	----	----	----	----
alpha-Endosulfan	959-98-8	0.50	µg/kg	<0.50	----	----	----	----
beta-Endosulfan	33213-65-9	0.50	µg/kg	<0.50	----	----	----	----
Endosulfan sulfate	1031-07-8	0.50	µg/kg	<0.50	----	----	----	----
^ **Endosulfan (sum)**	115-29-7	0.50	µg/kg	<0.50	----	----	----	----
Endrin	72-20-8	0.50	µg/kg	<0.50	----	----	----	----
Endrin aldehyde	7421-93-4	0.50	µg/kg	<0.50	----	----	----	----
Endrin ketone	53494-70-5	0.50	µg/kg	<0.50	----	----	----	----
Heptachlor	76-44-8	0.50	µg/kg	<0.50	----	----	----	----
Heptachlor epoxide	1024-57-3	0.50	µg/kg	<0.50	----	----	----	----
Hexachlorobenzene (HCB)	118-74-1	0.50	µg/kg	<0.50	----	----	----	----
gamma-BHC	58-89-9	0.25	µg/kg	<0.25	----	----	----	----
Methoxychlor	72-43-5	0.50	µg/kg	<0.50	----	----	----	----

Analytical Results

Sub-Matrix: SEDIMENT (Matrix: SOIL)			Sample ID	EPW7A 0.0-0.5	----	----	----	----
			Sampling date / time	31-Oct-2023 00:00	----	----	----	----
Compound	CAS Number	LOR	Unit	EP2315578-001	--------	--------	--------	--------
				Result	----	----	----	----
EP131A: Organochlorine Pesticides - Continued								
cis-Chlordane	5103-71-9	0.25	µg/kg	<0.25	----	----	----	----
trans-Chlordane	5103-74-2	0.25	µg/kg	<0.25	----	----	----	----
^ Total Chlordane (sum)	----	0.25	µg/kg	<0.25	----	----	----	----
Oxychlordane	27304-13-8	0.50	µg/kg	<0.50	----	----	----	----
EP131B: Polychlorinated Biphenyls (as Aroclors)								
^ Total Polychlorinated biphenyls	----	5.0	µg/kg	<5.0	----	----	----	----
Aroclor 1016	12674-11-2	5.0	µg/kg	<5.0	----	----	----	----
Aroclor 1221	11104-28-2	5.0	µg/kg	<5.0	----	----	----	----
Aroclor 1232	11141-16-5	5.0	µg/kg	<5.0	----	----	----	----
Aroclor 1242	53469-21-9	5.0	µg/kg	<5.0	----	----	----	----
Aroclor 1248	12672-29-6	5.0	µg/kg	<5.0	----	----	----	----
Aroclor 1254	11097-69-1	5.0	µg/kg	<5.0	----	----	----	----
Aroclor 1260	11096-82-5	5.0	µg/kg	<5.0	----	----	----	----
EP132B: Polynuclear Aromatic Hydrocarbons								
Naphthalene	91-20-3	5	µg/kg	<5	----	----	----	----
2-Methylnaphthalene	91-57-6	5	µg/kg	<5	----	----	----	----
Acenaphthylene	208-96-8	4	µg/kg	<4	----	----	----	----
Acenaphthene	83-32-9	4	µg/kg	<4	----	----	----	----
Fluorene	86-73-7	4	µg/kg	<4	----	----	----	----
Phenanthrene	85-01-8	4	µg/kg	<4	----	----	----	----
Anthracene	120-12-7	4	µg/kg	<4	----	----	----	----
Fluoranthene	206-44-0	4	µg/kg	<4	----	----	----	----
Pyrene	129-00-0	4	µg/kg	<4	----	----	----	----
Benz(a)anthracene	56-55-3	4	µg/kg	<4	----	----	----	----
Chrysene	218-01-9	4	µg/kg	<4	----	----	----	----
Benzo(b+j)fluoranthene	205-99-2 205-82-3	4	µg/kg	<4	----	----	----	----
Benzo(k)fluoranthene	207-08-9	4	µg/kg	<4	----	----	----	----

Analytical Results

Sub-Matrix: SEDIMENT (Matrix: SOIL)			Sample ID	EPW7A 0.0-0.5	----	----	----	----
			Sampling date / time	31-Oct-2023 00:00	----	----	----	----
Compound	CAS Number	LOR	Unit	EP2315578-001	--------	--------	--------	--------
				Result	----	----	----	----
EP132B: Polynuclear Aromatic Hydrocarbons - Continued								
Benzo(e)pyrene	192-97-2	4	µg/kg	<4	----	----	----	----
Benzo(a)pyrene	50-32-8	4	µg/kg	<4	----	----	----	----
Perylene	198-55-0	4	µg/kg	<4	----	----	----	----
Benzo(g.h.i)perylene	191-24-2	4	µg/kg	<4	----	----	----	----
Dibenz(a.h)anthracene	53-70-3	4	µg/kg	<4	----	----	----	----
Indeno(1.2.3.cd)pyrene	193-39-5	4	µg/kg	<4	----	----	----	----
Coronene	191-07-1	5	µg/kg	<5	----	----	----	----
^ Sum of PAHs	----	4	µg/kg	<4	----	----	----	----
^ Benzo(a)pyrene TEQ (zero)	----	4	µg/kg	<4	----	----	----	----
^ Benzo(a)pyrene TEQ (half LOR)	----	4	µg/kg	**5**	----	----	----	----
^ Benzo(a)pyrene TEQ (LOR)	----	4	µg/kg	**10**	----	----	----	----
EP201: Carbamate Pesticides by LCMS								
Oxamyl	23135-22-0	0.02	mg/kg	<0.02	----	----	----	----
Methomyl	16752-77-5	0.02	mg/kg	<0.02	----	----	----	----
3-Hydroxy Carbofuran	16655-82-6	0.02	mg/kg	<0.02	----	----	----	----
Aldicarb	116-06-3	0.02	mg/kg	<0.02	----	----	----	----
Bendiocarb	22781-23-3	0.02	mg/kg	<0.02	----	----	----	----
Thiodicarb	59669-26-0	0.02	mg/kg	<0.02	----	----	----	----
Carbofuran	1563-66-2	0.02	mg/kg	<0.02	----	----	----	----
Carbaryl	63-25-2	0.02	mg/kg	<0.02	----	----	----	----
Methiocarb	2032-65-7	0.02	mg/kg	<0.02	----	----	----	----
EP202A: Phenoxyacetic Acid Herbicides by LCMS								
4-Chlorophenoxy acetic acid	122-88-3	0.02	mg/kg	<0.02	----	----	----	----
2.4-DB	94-82-6	0.02	mg/kg	<0.02	----	----	----	----
Dicamba	1918-00-9	0.02	mg/kg	<0.02	----	----	----	----
Mecoprop	93-65-2	0.02	mg/kg	<0.02	----	----	----	----
MCPA	94-74-6	0.02	mg/kg	<0.02	----	----	----	----

Analytical Results

Sub-Matrix: SEDIMENT (Matrix: SOIL)			Sample ID	EPW7A 0.0-0.5	----	----	----	----
			Sampling date / time	31-Oct-2023 00:00	----	----	----	----
Compound	CAS Number	LOR	Unit	EP2315578-001	--------	--------	--------	--------
				Result	----	----	----	----
EP202A: Phenoxyacetic Acid Herbicides by LCMS - Continued								
2.4-DP	120-36-5	0.02	mg/kg	<0.02	----	----	----	----
2.4-D	94-75-7	0.02	mg/kg	<0.02	----	----	----	----
Triclopyr	55335-06-3	0.02	mg/kg	<0.02	----	----	----	----
2.4.5-TP (Silvex)	93-72-1	0.02	mg/kg	<0.02	----	----	----	----
2.4.5-T	93-76-5	0.02	mg/kg	<0.02	----	----	----	----
MCPB	94-81-5	0.02	mg/kg	<0.02	----	----	----	----
Picloram	1918-02-1	0.02	mg/kg	<0.02	----	----	----	----
Clopyralid	1702-17-6	0.02	mg/kg	<0.02	----	----	----	----
Fluroxypyr	69377-81-7	0.02	mg/kg	<0.02	----	----	----	----
EP068S: Organochlorine Pesticide Surrogate								
Dibromo-DDE	21655-73-2	0.05	%	88.0	----	----	----	----
EP068T: Organophosphorus Pesticide Surrogate								
DEF	78-48-8	0.05	%	96.7	----	----	----	----
EP074S: VOC Surrogates								
1.2-Dichloroethane-D4	17060-07-0	0.5	%	82.7	----	----	----	----
Toluene-D8	2037-26-5	0.5	%	82.1	----	----	----	----
4-Bromofluorobenzene	460-00-4	0.5	%	87.0	----	----	----	----
EP075(SIM)S: Phenolic Compound Surrogates								
Phenol-d6	13127-88-3	0.5	%	94.7	----	----	----	----
2-Chlorophenol-D4	93951-73-6	0.5	%	80.8	----	----	----	----
2.4.6-Tribromophenol	118-79-6	0.5	%	94.5	----	----	----	----
EP075(SIM)T: PAH Surrogates								
2-Fluorobiphenyl	321-60-8	0.5	%	110	----	----	----	----
Anthracene-d10	1719-06-8	0.5	%	85.6	----	----	----	----
4-Terphenyl-d14	1718-51-0	0.5	%	110	----	----	----	----
EP075S: Acid Extractable Surrogates								
2-Fluorophenol	367-12-4	0.5	%	93.3	----	----	----	----

Analytical Results

Sub-Matrix: SEDIMENT (Matrix: SOIL)			Sample ID	EPW7A 0.0-0.5	----	----	----	----
			Sampling date / time	31-Oct-2023 00:00	----	----	----	----
Compound	CAS Number	LOR	Unit	EP2315578-001	--------	--------	--------	--------
				Result	----	----	----	----
EP075S: Acid Extractable Surrogates - Continued								
Phenol-d6	13127-88-3	0.5	%	78.5	----	----	----	----
2-Chlorophenol-D4	93951-73-6	0.5	%	84.4	----	----	----	----
2.4.6-Tribromophenol	118-79-6	0.5	%	44.0	----	----	----	----
EP075T: Base/Neutral Extractable Surrogates								
Nitrobenzene-D5	4165-60-0	0.5	%	82.5	----	----	----	----
1.2-Dichlorobenzene-D4	2199-69-1	0.5	%	80.8	----	----	----	----
2-Fluorobiphenyl	321-60-8	0.5	%	78.5	----	----	----	----
Anthracene-d10	1719-06-8	0.5	%	96.9	----	----	----	----
4-Terphenyl-d14	1718-51-0	0.5	%	60.6	----	----	----	----
EP080-SD: TPH(V)/BTEX Surrogates								
1.2-Dichloroethane-D4	17060-07-0	0.2	%	122	----	----	----	----
Toluene-D8	2037-26-5	0.2	%	104	----	----	----	----
4-Bromofluorobenzene	460-00-4	0.2	%	123	----	----	----	----
EP090S: Organotin Surrogate								
Tripropyltin	----	0.5	%	53.3	----	----	----	----
EP094S: Pesticide Surrogate								
DEF	78-48-8	0.05	%	107	----	----	----	----
EP130S: Organophosphorus Pesticide Surrogate								
DEF	78-48-8	10	%	83.3	----	----	----	----
EP131S: OC Pesticide Surrogate								
Dibromo-DDE	21655-73-2	0.50	%	44.7	----	----	----	----
EP131T: PCB Surrogate								
Decachlorobiphenyl	2051-24-3	0.5	%	73.8	----	----	----	----
EP132T: Base/Neutral Extractable Surrogates								
2-Fluorobiphenyl	321-60-8	10	%	89.6	----	----	----	----
Anthracene-d10	1719-06-8	10	%	88.1	----	----	----	----
4-Terphenyl-d14	1718-51-0	10	%	92.5	----	----	----	----
EP201S: Carbamate Surrogate								

Analytical Results

Sub-Matrix: **SEDIMENT** (Matrix: **SOIL**)			Sample ID	**EPW7A 0.0-0.5**	----	----	----	----
			Sampling date / time	31-Oct-2023 00:00	----	----	----	----
Compound	*CAS Number*	*LOR*	*Unit*	**EP2315578-001**	--------	--------	--------	--------
				Result	----	----	----	----
EP201S: Carbamate Surrogate - Continued								
4-Bromo-3.5-dimethylphenyl-N-methylcarbamate	672-99-1	0.02	%	**90.2**	----	----	----	----
EP202S: Phenoxyacetic Acid Herbicide Surrogate								
2.4-Dichlorophenyl Acetic Acid	19719-28-9	0.02	%	**54.0**	----	----	----	----

Surrogate Control Limits

Sub-Matrix: **SEDIMENT**

Compound	CAS Number	Recovery Limits (%) Low	Recovery Limits (%) High
EP068S: Organochlorine Pesticide Surrogate			
Dibromo-DDE	21655-73-2	53	152
EP068T: Organophosphorus Pesticide Surrogate			
DEF	78-48-8	28	152
EP074S: VOC Surrogates			
1.2-Dichloroethane-D4	17060-07-0	66	127
Toluene-D8	2037-26-5	66	126
4-Bromofluorobenzene	460-00-4	60	115
EP075(SIM)S: Phenolic Compound Surrogates			
Phenol-d6	13127-88-3	57	119
2-Chlorophenol-D4	93951-73-6	52	130
2.4.6-Tribromophenol	118-79-6	40	132
EP075(SIM)T: PAH Surrogates			
2-Fluorobiphenyl	321-60-8	53	139
Anthracene-d10	1719-06-8	68	124
4-Terphenyl-d14	1718-51-0	66	132
EP075S: Acid Extractable Surrogates			
2-Fluorophenol	367-12-4	34	132
Phenol-d6	13127-88-3	46	132
2-Chlorophenol-D4	93951-73-6	45	135
2.4.6-Tribromophenol	118-79-6	39	139
EP075T: Base/Neutral Extractable Surrogates			
Nitrobenzene-D5	4165-60-0	38	132
1.2-Dichlorobenzene-D4	2199-69-1	40	126
2-Fluorobiphenyl	321-60-8	43	131
Anthracene-d10	1719-06-8	49	131
4-Terphenyl-d14	1718-51-0	54	140
EP080-SD: TPH(V)/BTEX Surrogates			
1.2-Dichloroethane-D4	17060-07-0	70	130
Toluene-D8	2037-26-5	70	130
4-Bromofluorobenzene	460-00-4	70	130
EP090S: Organotin Surrogate			
Tripropyltin	----	35	130
EP094S: Pesticide Surrogate			
DEF	78-48-8	23	134
EP130S: Organophosphorus Pesticide Surrogate			
DEF	78-48-8	14	102
EP131S: OC Pesticide Surrogate			

Sub-Matrix: **SEDIMENT**

Compound	CAS Number	Recovery Limits (%) Low	High
EP131S: OC Pesticide Surrogate - Continued			
Dibromo-DDE	21655-73-2	10	119
EP131T: PCB Surrogate			
Decachlorobiphenyl	2051-24-3	10	106
EP132T: Base/Neutral Extractable Surrogates			
2-Fluorobiphenyl	321-60-8	70	130
Anthracene-d10	1719-06-8	70	130
4-Terphenyl-d14	1718-51-0	70	130
EP201S: Carbamate Surrogate			
4-Bromo-3.5-dimethylphenyl-N-methylcarbamate	672-99-1	59	137
EP202S: Phenoxyacetic Acid Herbicide Surrogate			
2.4-Dichlorophenyl Acetic Acid	19719-28-9	45	139

Inter-Laboratory Testing

Analysis conducted by ALS Brisbane, NATA accreditation no. 825, site no. 818 (Chemistry) 18958 (Biology).

(SOIL) EP003: Total Organic Carbon (TOC) in Soil

(SOIL) EP090: Organotin Compounds

(SOIL) EP090S: Organotin Surrogate

(SOIL) EP094A: Synthetic Pyrethroids

(SOIL) EP094B: Synergist

(SOIL) EP094S: Pesticide Surrogate

Analysis conducted by ALS Sydney, NATA accreditation no. 825, site no. 10911 (Chemistry) 14913 (Biology).

(SOIL) EP130A: Organophosphorus Pesticides (Ultra-trace)

(SOIL) EP130S: Organophosphorus Pesticide Surrogate

(SOIL) EP131B: Polychlorinated Biphenyls (as Aroclors)

(SOIL) EP131T: PCB Surrogate

(SOIL) EP131A: Organochlorine Pesticides

(SOIL) EP131S: OC Pesticide Surrogate

(SOIL) EP201: Carbamate Pesticides by LCMS

(SOIL) EP201S: Carbamate Surrogate

(SOIL) EP202A: Phenoxyacetic Acid Herbicides by LCMS

(SOIL) EP202S: Phenoxyacetic Acid Herbicide Surrogate

(SOIL) EK255A SD: Ammonium in Sediment

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Appendix O Desalination Discharge Literature Review

Marine Ecosystems

Literature review of potential impacts of desalination discharges in Boston Bay, with particular reference to aquaculture

Jason E. Tanner and Sharon Drabsch

SARDI Publication No. F2021/000299-1
SARDI Research Report Series No. 1105

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Department of Primary Industries and Regions

SA Water

SARDI
SOUTH AUSTRALIAN RESEARCH AND DEVELOPMENT INSTITUTE

Literature review of potential impacts of desalination discharges in Boston Bay, with particular reference to aquaculture

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ACKNOWLEDGEMENTS

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EXECUTIVE SUMMARY

SA Water are proposing to build a small seawater reverse osmosis desalination plant (4 GL yr^{-1}, with the potential for expansion to 8 GL yr^{-1}) at Port Lincoln to supplement the existing reticulated water supply from bores and the Murray River. Given the importance of aquaculture in the region, this has prompted some concern about potential impacts from the aquaculture industry. Here we review publicly available literature on the environmental impacts of desalination plants, focusing where possible on Australian studies. Impacts can result from either the seawater intake, or the brine discharge. The intake of seawater can entrain planktonic organisms and result in their loss to the system. While the total annual intake will be less than 2% of the volume of Proper and Boston bays, if the intake is in the larval dispersal pathway of blue mussels, it has the potential to impact on mussel aquaculture, which relies on wild spat collection. The source populations and dispersal pathways of these spat are currently unknown. Modern, well designed desalination plants discharge waste brine in such a way that the salinity generally drops to less than 1 psu above ambient within 100 m of the outfall. If this is met with the Port Lincoln plant, then the broader impacts of the discharge should be minimal. Provided the brine is flushed out of the bay over time, it is unlikely that it will have any broader impacts on the aquaculture industry. Any seagrasses in the immediate vicinity of the discharge, however, are likely to be lost, although if well designed this impact should extend <100m from the outfall. Expanding the current hydrodynamic modelling to examine movement pathways of the source water for the plant, would enhance our understanding of its potential to entrain blue mussel larvae. Habitat mapping around the proposed discharge point, would also provide valuable information and help with the assessment of the potential consequences for the species present.

Keywords: Aquaculture, desalination, environmental impacts, seagrass.

1. INTRODUCTION

SA Water are proposing to build a small desalination plant in the vicinity of Port Lincoln to supplement water currently obtained from the Uley South Basin bore field and the River Murray. Initially, the plant will supply 4 GL yr^{-1} of freshwater, obtained through reverse osmosis (RO) of seawater, with the potential for expansion to 8 GL yr^{-1}. Current annual reticulated water demand in the region is 7.24 GL yr^{-1}. Construction of the plant is anticipated to begin in early to mid-2022 and be completed by the end of 2023. Initially, it was proposed to construct the plant at Sleaford Bay, on the southern side of Jussieu Peninsula, however, logistical issues were identified with this site, and alternative sites in and around Boston Bay are now being considered.

Members of the aquaculture industry have expressed concern over the potential for the desalination plant to impact on the sector, which has a major presence in the region. Boston Bay and surrounds are important for southern bluefin tuna, yellowtail kingfish, mussel, oyster, and abalone aquaculture. Together, these industries have a total value of approximately $400 million per annum, making an important economic contribution to the region (Tanner et al. 2019, BDO EconSearch 2020).

Here, we provide a brief literature review of the potential impacts on the marine environment from the operation of a desalination plant in or around Boston Bay. Where possible, we focus on Australian literature, although we also include international literature where relevant. Potential impacts can be divided into those associated with the intake of seawater, primarily entrainment of larvae, eggs, and other plankton, and those associated with the brine discharge, primarily due to elevated salinity. The discharge water can also have an increased temperature, although this only ranges from 0-2 ^{o}C for RO desalination (Elsaid et al. 2020), and is therefore of limited relevance, and can include traces of chemical additives used as antiscalants and to clean fouling from the pipeline. Despite the increasing popularity of desalination plants for resolving water supply issues in many cities around the world, there is still a paucity of well-designed and peer-reviewed assessments of their ecological impacts (Roberts et al. 2010, Clark et al. 2018, Missimer and Maliva 2018, Kelaher et al. 2020). Much of the monitoring that has been done is published in the grey literature and is difficult to access. This limitation makes it difficult to conduct a comprehensive literature review of the impacts of desalination plants on the marine environment.

In this review, we focus purely on the impacts of operating a desalination plant, and do not examine the potential impacts of the construction. We also focus on actual impacts to the marine environment, and do not cover toxicity testing. As such, we also do not review the potential impacts of antiscalants and other potential chemical additives in the discharge water. This review relies on readily available information in the public domain. Additional documentation has not been obtained from desalination plant operators.

2. AUSTRALIAN CASE STUDIES

Several large-scale desalination plants have been constructed in Australia over the last decade or so, including on the Gold Coast, Sydney, Melbourne, Adelaide, and Perth. Apart from Adelaide, there appears to be very little publicly available information on their environmental impacts. While the Perth plant would provide a good case study for the Boston Bay plant, because it is located in a sheltered embayment (Cockburn Sound), no rigorous information on the outcomes of its environmental monitoring could be found. No monitoring reports for the Gold Coast or Melbourne plants could be located, while two published studies covering components of the monitoring of the Sydney plant are available.

2.1. Adelaide desalination plant

The Adelaide desalination plant (ADP) commenced operation in 2011, with a capacity of 100 GL yr^{-1}. While it has run for periods at full production, for much of this time it has only been operating at 10% capacity to maintain functionality (Figure 1), and has produced a total of ~190 GL of potable water. The plant is located about half-way up Gulf St Vincent, and discharges in ~17 m water depth into an area of sandy substrate with some nearby low-profile reef.

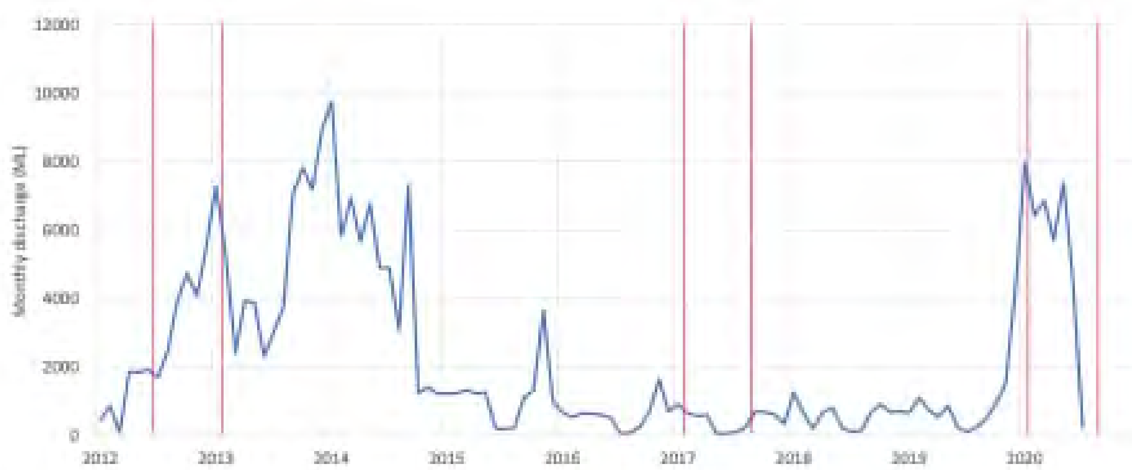

Figure 1: Monthly discharge of brine (ML) from the Adelaide desalination plant from 2012 to 2020. Red lines indicate infaunal sampling events. Source: Loo et al. (2021).

Routine monitoring of the intake and outfall water includes volume and velocity of seawater taken in and brine discharged, and water quality with a focus on salinity. Relevant license conditions include:

- average discharge salinity must not exceed the intake salinity by a factor of 2.1 for either a six-hour period, or a twenty-four-hour period.

- average salinity at 100 m from the diffuser structure must not exceed 1.3 psu above ambient salinity.

- seawater intake velocity at the entry to the intake structure must not exceed 0.15 m s^{-1} at any time.

Unfortunately, no reports that track these parameters over time are readily available, although monthly averages of some parameters are provided in quarterly reports, and some fragmentary data are available. Analysis of data from the first year of operation, however, did show that the 1.3 psu above ambient salinity threshold was not breached in that time (Kildea et al. 2013, Ayala et al. 2015a, b).

Biological monitoring has included reef, fish and infaunal community structure near the outfall compared with nearby reference sites, performed every three years. While these surveys are mentioned in yearly reports as having been done, only the infauna monitoring reports are all publicly available. The 2020 infauna monitoring report (Loo et al. 2021) included comparisons with 2013 and 2017 to examine changes in infaunal assemblages over time. There was no indication that the brine discharge from the desalination plant was impacting infaunal assemblages.

The autumn 2015 reef fish survey (Jacobs Group (Australia) Pty Ltd 2015) found no statistically significant differences between reef fish assemblages at the outfall site versus reference reefs. The total abundance of fish at the outfall site was significantly higher than at any of the reference reefs; however, this was attributed to reduced fishing pressure at the outfall site, as this site is within an Exclusion Zone that prohibits vessel access. Comparison of this data with previous fish surveys was limited because the location and habitat of the sampling changed in 2015. Comparison of the reef fish communities between outfall and reference sites in 2015 and 2018 found no evidence that the ADP was having an impact on fish communities (Brook 2018, Whitmarsh et al. 2021).

A review of the ADP's comprehensive marine monitoring data (Cheshire 2014) concluded that water quality and biological communities were largely unaffected by the operation of the plant (outside of the 100 m permitted mixing zone). In this context, the mixing zone is the region immediately around the outfall where brine dilution is permitted to be less than the target level

(Cheshire 2014), and thus where salinity might be elevated sufficiently to cause environmental harm. While there appears to have been a lot of data collected since the production of this report, it is not all readily available, and for most components of the monitoring program, it is reported in individual quarterly or annual reports with no overall assessment of the impacts, or lack thereof, over time.

2.2. Sydney desalination plant

The Sydney desalination plant, located at Kurnell, is capable of producing up to 90 GL yr^{-1} of freshwater. The intake is located ~300 m offshore of the open ocean coast, 25 m below the sea surface. The discharge is located over rocky reef at a similar distance offshore and depth. Discharged brine is twice the salinity of seawater, ~ 1 °C warmer, and returns to normal salinity and temperature within 50-75 m of the outlet (Sydney Desalination Plant 2021a), although no data are presented to support these claims. Two published studies were located on the impacts of this plant. One showed that the diversity and abundance of pelagic and demersal fish species increased when the plant was operating (Kelaher et al. 2020), and is discussed below in the section on fish. The second study examined marine invertebrates, and found a decrease in some taxa and an increase in others up to 100 m from the outfall (Clark et al. 2018), and is discussed under invertebrates below. Interestingly, the later contradicts Sydney Desalination Plant (2021a), and indicates that at 100m, salinity is still elevated by 0.8 psu above background (Clark et al. 2018). No monitoring reports appear to be publicly available.

3. GENERAL ECOLOGICAL IMPACTS

3.1. Macroalgae

Few studies have examined the impacts of brine discharges on macroalgae (Rodriguez-Rojas et al. 2020), which form an important component of intertidal and subtidal reef assemblages in southern Australia, including in Boston Bay. *Ectocarpus*, a small filamentous brown macroalga also found in Australia, showed decreased photosynthesis and increased physiological stress at sites 10 m and 30 m from a brine discharge, corresponding to an increase in salinity of 2.38 and 1.5 psu, in Chile (Rodriguez-Rojas et al. 2020).

3.2. Seagrasses

Seagrasses are a dominant component of the shallow subtidal and intertidal habitat in and around Boston Bay (Irving 2014). The main intertidal seagrass is *Zostera muelleri*, with species of *Posidonia*, *Amphibolis*, *Zostera* and *Halophila* all occurring in the subtidal, with the latter potentially occurring to depths of 20 m or more. *Posidonia* is likely to be the dominant taxon around the proposed outfall site, although this needs to be confirmed by visual surveys of the site. Seagrasses provide important habitat for many marine fauna, as well as being important primary producers, stabilising sediment, cycling nutrients, and storing carbon. Irving (2014) provides a review of seagrasses in Spencer Gulf.

Seagrass responses to increased salinity are species specific, with some having a broad tolerance to changes, while others can only cope with a very narrow salinity range (Cambridge et al. 2017). Within a species, actual salinity tolerances displayed at one location may not transfer to other locations, as distinct geographic ecotypes have evolved that accommodate local conditions (Cambridge et al. 2017). Very few studies have examined the response of Australian seagrass species to increased salinity.

Zostera muelleri, which primarily occurs in the intertidal, is capable of maintaining relatively high photosynthetic rates up to salinities of 400% of normal seawater, albeit measurements were only made over a 2 hr period after salinity was experimentally increased (Kerr and Strother 1985). Conversely, germination of *Z. muelleri* declines as salinity increases, consistent with its evolutionary origin from a freshwater ancestor (Stafford-Bell et al. 2016).

Posidonia australis, which occurs subtidally in Boston Bay alongside other *Posidonia* species, has a broad salinity range. In a 7-week experiment on plants collected in Botany Bay, there was no effect of increasing salinity to 57 psu on leaf growth (Tyerman et al. 1984). In another experiment in WA, mortality over 6 weeks was 33% at 46 psu and 60% at 54 psu, compared to 2% at 37 psu (Cambridge et al. 2017). Photosynthesis in both elevated salinities decreased after 6 weeks, but not 4. In a subsequent experiment, Cambridge et al. (2019) showed growth decreased in brine from the Perth desalination plant at 54 psu, but not in 46 psu, and not in water of the same salinity produced using salt, indicating that it was other components of the brine discharge causing the effect. Conversely, *P. oceanica*, which only occurs in the Mediterranean, has very little tolerance to changes in salinity, and experiences negative impacts with increases as little as 0.5-1 psu (e.g. Sanchez-Lizaso et al. 2008, Ruiz et al. 2009, Fernandez-Torquemada and Sanchez-Lizaso 2013, Capo et al. 2020).

Amphibolis antarctica, which also occurs in Boston Bay, although not as commonly as *Posidonia*, shows maximum production and biomass at 42 psu in Shark Bay, declining as salinities increase beyond this until it is absent at 64 psu (Walker 1985). Interestingly, both variables were substantially lower at 40 psu than 42 psu, although this is likely to reflect a local ecotype adapted to a hypersaline region, and thus these results may not be transferable to Boston Bay, where typical salinities are ~ 36.5-37 psu (Tanner et al. 2020).

Locally, both *A. antarctica* and *Posidonia* are tolerant of reduced salinities over periods of at least 7 weeks (Westphalen et al. 2005), but their response to increased salinity has not been examined. Both do occur in the upper gulfs, however, where they are exposed to salinities >40 psu over summer (Westphalen et al. 2004). Given the above, it is likely that seagrasses in Boston Bay will not be impacted by the brine discharge beyond the immediate area around the discharge point where mixing occurs if salinity is not elevated by >1 psu, although what upper threshold they can survive is currently unclear.

3.3. Invertebrates

Marine invertebrates include a diverse array of taxa, and are likely to have differing responses to desalination plant discharges. In the only published Australian study, recruitment of polychaetes, bryozoans and sponges decreased on panels placed at impact sites 100 m and 30 m from the outfall of the Sydney desalination plant during operation in comparison to reference sites 1.5-5 km away (Clark et al. 2018). Conversely, barnacle recruitment (primarily the introduced *Magabalanus coccopoma*) increased at the impact sites. In both cases, the impact was greater at 30 m, where salinity increased by 1 psu, compared with 100 m, where salinity only increased by 0.8 psu. Ascidian cover did not show any changes. There were no differences between impact and reference sites during an extended plant shutdown. As the differences observed were unexpected given the small increase in salinity documented, the authors hypothesized that the impacts were related to changes in water velocity, which were calculated to be roughly double ambient at the 100 m site.

In Spain, infaunal polychaetes were significantly impacted by a brine discharge from a 50 GL yr^{-1} desalination plant that caused an increase in salinity to 49 psu within 250 m of the discharge point (Del-Pilar-Ruso et al. 2015). After a diffuser was added to the discharge, salinity decreased to ~1 psu above ambient at the most impacted sample site, and after two years the assemblage had recovered in terms of diversity and richness, but not abundance or community composition.

Also in Spain, a study of echinoderm abundance in the plume of a brine discharge showed that even small increases in salinity (0.3-0.4 psu) could lead to a complete loss of echinoderms in a seagrass meadow (Fernandez-Torquemada et al. 2013). The assemblage studied included sea cucumbers, starfish and sea urchins. When the brine was diluted with seawater prior to discharge, the salinity at the impact site returned to ambient, and echinoderm densities recovered. In this study, the impact site was 2 km directly offshore from the desalination plant, which discharged brine at 68 psu directly onto the shore, rather than subtidally through diffusers. At another location, Gacia et al. (2007) also found a loss of echinoderms in a seagrass meadow with salinity up to 2.5 psu above ambient.

In California, 16 invertebrate species (6 echinoderms, 2 cnidarians, 1 crustacean, 6 molluscs, 1 polychaete) were exposed to salinities ~1 psu above ambient for 5 ½ months with no ill effect (Voutchkov 2011). Three of these species were also tested for 19 days at up to 4 psu above ambient, also with no ill effect. In another Spanish study, 12 months of sampling mobile invertebrates before and after a desalination plant commenced operating showed no impacts on community structure (Raventos et al. 2006). Salinity at the site returned to normal within 10 m of the discharge pipe, and impact site transects were within this zone, although no data is given on actual salinity levels.

3.4. Fish

There have been two recently published papers on the impacts of desalination plants on temperate fish assemblages in Australia. Brine discharges between 661 and 1287 ML $month^{-1}$ from the Adelaide desalination plant did not have any detectable impact on fish assemblages assessed using baited remote underwater video, with species diversity and abundance being similar to those found on other nearby artificial reef habitats not exposed to increased salinity

(Whitmarsh et al. 2021). In contrast, fish diversity and abundance increased during operation of the Sydney desalination plant compared to before it commenced operation (but after construction), but there was no effect when the plant was not discharging (Kelaher et al. 2020). While benthic fishes did not appear to respond to the discharge, both pelagic and demersal species increased in abundance, including a number targeted by commercial and recreational fishers. In both studies, salinities were <1 psu above ambient within 100 m of the outfall.

3.5. Larval entrainment

Depending on the design, the intakes of desalination plants, like those of power plants, have the potential to impinge and entrain marine organisms. Impingement is when larger organisms are trapped on the screens covering the intake and can largely be avoided with low velocity intakes. Entrainment is when smaller planktonic organisms, including larvae and eggs, with limited or no swimming ability are sucked into the intake. It is possible to avoid most entrainment with subterranean intakes, although these are not always feasible (Missimer and Maliva 2018, Elsaid et al. 2020).

For the Melbourne desalination plant, modelling was used to predict the reduction in larval abundance in the zone of influence around the intake (Department of Sustainability and Environment 2006). This zone varied in size with larval duration, ranging from $<2km^2$ for 1-day larval duration, to hundreds of km^2 for larvae of 120 days duration. Predicted reductions in larval abundance were always <2%. These modelled reductions were for a 200 GL yr^{-1} plant, which is 25 times larger than the proposed plant at Port Lincoln. The modelled plant was also on a high energy coastline, compared to the more sheltered proposed location of the Port Lincoln plant.

For the Adelaide desalination plant, Cheshire (2014) developed a rough estimate of the likely consequences of entrainment for Australian sardine. This indicated that when operating at full capacity (100 GL yr^{-1}), entrainment would be equivalent to increasing the commercial catch by in the order of 0.001%

Based on larval sampling, it was estimated that a ~4 GL yr^{-1} desalination plant in Sant Cruz, on an open ocean coast, would increase mortality of larvae from a range of fish species by <0.1% (Tenera Environmental 2010). Mortality of the crustacean species studied was predicted to be even lower.

4. IMPACTS ON AQUACULTURE

No literature could be found on the direct impacts of seawater desalination on aquaculture operations or production. Any potential impacts could be separated into two categories: impacts of the brine discharge, and impacts of entrainment in the intake water.

The brine discharge could affect aquaculture either through increased salinity, or the discharge of other chemicals such as antiscalants. Assessment of chemical impacts requires an understanding of what chemicals may be added to the discharge water, and it is recommended that relevant ecotoxicology studies, such as those done for the Adelaide desalination plant and the previously proposed Olympic Dam plant, as well as others around Australia and potentially elsewhere, be reviewed. If these previous studies do not cover relevant aquaculture species, then they may need to be the subject of appropriate whole effluent toxicity testing. Relevant species will depend on the location of the discharge and the predicted dispersal pathway of the plume, but could include blue mussels, oysters, and yellowtail kingfish. Blue mussels would be particularly relevant, as the industry relies on the collection of wild spat, whereas the oyster and kingfish industries rely on hatchery cultivation, providing a greater opportunity to separate the early life phases, which are likely to be the most sensitive, from the impacts of brine discharge. The potential for salinity impacts will be governed by the location of the discharge outlet and how rapidly the discharge is diluted. In open areas, salinity increases generally drop to < 1psu within 100 m of the discharge point (e.g. Kelaher et al. 2020, Whitmarsh et al. 2021), although this will need to be confirmed by hydrodynamic modelling for the proposed discharge site in Boston Bay. Provided there are no aquaculture leases, or substantial blue mussel wild stocks, in areas with >1 psu elevation in salinity, it is unlikely that increased salinity will impact on aquaculture operations. The other possible pathway for increased salinity to impact aquaculture would be if the discharge is placed in a major pathway of blue mussel larval dispersal.

The proposed desalination plant could have a more direct impact on the blue mussel industry if the intake is placed in the dispersal pathway of larval blue mussels, because any larvae entrained into the intake would be lost. The larval phase of blue mussels lasts for 1-1.5 months (Zagata et al. 2008), providing an extended period of opportunity for them to become entrained if the intake is not appropriately positioned. However, with an intake of only 20 GL yr^{-1} at maximum production, compared to an estimated volume of 1280 GL for Boston and Proper Bays (estimate provided by SA Water), this is only likely to impact if the intake is positioned directly in a major dispersal pathway. It should be noted, however, that these dispersal pathways are currently unknown, and further work may be needed to assess the likely impacts of entrainment on mussels.

5. SITING

Across the literature reviewed, it is broadly agreed that the positioning of the discharge site is critical for reducing the ecological impacts of desalination plants (Roberts et al. 2010). Ideally, the discharge should be in a high energy, well flushed site, where the brine will be rapidly diluted and dispersed (Sagastegui and Sala 2006, Petersen et al. 2019). Importantly, where possible, it should avoid sensitive habitats such as seagrass meadows and reefs (Hopner and Windelberg 1997, Sagastegui and Sala 2006, Roberts et al. 2010), and preferably target areas with already impacted sandy substrates (Petersen et al. 2019). However, both the Perth and Sydney desalination plants appear to contravene at least some of these principles, apparently without environmental impact. The Perth desalination plant is located in Cockburn Sound, an enclosed body of water with a low flushing rate, and has been reported to have limited to no ecological impacts (International Water Association 2016), although no peer reviewed studies or monitoring reports appear to be publicly availableto support this. While the Sydney desalination plant discharges into a high energy open ocean environment, it does so on a rocky reef, with little impact on the components of the marine community assessed outside of a small mixing zone (Kelaher et al. 2020, Sydney Desalination Plant 2021b). Irrespective, hydrodynamic models should be used to understand the potential dispersal of the brine plume, and how rapidly it will be diluted. This work is currently being undertaken by SARDI's oceanographic team and includes a 12-month field program to validate the model outputs.

The other aspect of siting of the plant that needs to be addressed is the location of the intake structure. Operationally, there is a need to ensure that the intake does not entrain high salinity water, either from shallow inshore areas with low flushing, or from the brine outfall. Environmentally, a key issue is to assess the potential extent of entrainment of blue mussel larvae.

6. CONCLUSIONS

Despite the paucity of high quality publications on the marine environmental impacts of desalination plants, this literature reviewed suggests that a well-designed desalination plant with the intake designed and placed to minimise entrainment of marine organisms, and an outfall designed to promote mixing and not in a vulnerable area, should have minimal environmental impacts beyond 100-200 m from the outfall. This conclusion is primarily based on the fact that it should be possible to design the plant so that salinity is not elevated by more than 1 psu beyond 100 m from the outfall. Whilst a threshold salinity increase for environmental impacts cannot be derived from the literature available, the data available suggest that it is unlikely that there will be a substantial impact on areas where salinity is elevated by no more than 1 psu. Given the small size of the proposed Port Lincoln plant (initially 4 GL yr^{-1}, with later expansion to 8 GL yr^{-1}) compared to most of the plants studied (50-100 GL yr^{-1}), it should be possible to ensure that the plant does not have any adverse impacts on the environment or other users of the area, including aquaculture. As the proposed desalination plant may be located in the vicinity of the current SA Water wastewater treatment plant (WWTP) at Billy Lights Point, one possibility to increase mixing may to be discharge the two waste streams together. The effectiveness of such a strategy will depend in part on the variability in the WWTP flows, and it needs to be confirmed that a mixed discharge does not have increased impacts due to the alteration in the ionic balance, as has been suggested elsewhere (Missimer and Maliva 2018). An alternative strategy may be to mix the brine with additional seawater, although this will require a larger intake and result in the entrainment of additional larvae.

To minimize environmental impacts, it will be important to ensure that the brine is discharged in such a way that it is rapidly mixed with the surrounding water, and that the receiving water body is well flushed. Hydrodynamic modelling and field studies are currently being undertaken to examine these issues. If the mixing zone is confirmed to be small, then the primary impact of the discharge will be on the immediate surrounding environment, which in this case is potentially a seagrass meadow. This needs to be confirmed through field surveys, and potential impacts on any seagrass species present, as well as associated fauna, examined.

It is also important to understand where the water being taken in is coming from and going to, as well as the potential for the plant to entrain mussel larvae, in order to avoid impacts on the blue mussel industry, which relies on wild spatfall. It is thus recommended that the current hydrodynamic modelling be extended to examine the source water, and that larval sampling be undertaken at the proposed intake site, with a focus on blue mussel larvae.

There is a paucity of readily accessible and peer-reviewed information on the environmental effects of operational desalination plants. Even in Australia, where the regulatory regime is strong, and it appears that there are robust monitoring programs in place (e.g. Sydney, Melbourne, Adelaide and Perth), little of this information is published. Monitoring reports only appear to be available for the Adelaide desalination plant, through the South Australian Environmental Protection Authority website, and even these are fragmentary, with reports examining individual monitoring events rather than providing holistic analyses of all data collected over the course of the monitoring program. While the information that is available suggests that a well-designed and located desalination plant in Boston Bay should have minimal environmental impact, it would be beneficial in future if environmental monitoring reports take a more holistic approach than is generally demonstrated, and importantly, that they are readily available.

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Appendix P Marine Habitat Video Analysis Report

Boston Bay
Marine Habitat Video Analysis

Report prepared for SA Water

by

J Diversity Pty Ltd

Rev 3, 2 March 2023

Cover photo: Seagrass *Posidonia sinuosa* in Boston Bay. Source: SA Water.

Disclaimer

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Executive Summary

Introduction and Background

SA Water proposes to construct a desalination plant on the Eyre Peninsula to relieve pressure on the Uley South Basin and provide water security to current customers while also enabling future growth. The former BHP site at Billy Lights Point (Port Lincoln) and a site near Point Boston were identified as potential sites for the plant. Accordingly, habitat mapping is required for the bays surrounding the Billy Lights Point and Point Boston sites.

A review of previous habitat surveys by CSIRO, the Environment Protection Authority (EPA) and University of Adelaide found that Proper Bay was dominated by dense seagrass with a dense cover of epiphytes, Boston Bay had dense seagrass cover to the north of the Bay, along the northern and western coastlines of the Bay and near Boston Island, with bare substrate in deeper areas, and Louth Bay had dense seagrass along the western side of the bay and west of Louth Island, with patchier areas in between, and patchiness or less certainty southwards towards Point Boston.

Habitat condition in the area had been assessed by the EPA during 2010 and 2016, finding that many sites were under stress from high levels of nutrients, resulting in epiphyte growth which can result in seagrass loss over time. Seagrass cover had reduced in southern Boston Bay, but increased in Louth Bay and northern Boston Bay between 2010 and 2016. A number of nutrient sources had been identified by the EPA, including finfish aquaculture, waste water treatment plant discharge, fish processing discharges and seasonal outflows from the Tod River, with the former likely to be 1–2 orders of magnitude higher than the other sources combined.

Twenty-eight pest species have been identified in Proper, Boston and Louth Bays (Wiltshire et al. 2010, PIRSA unpublished data), including six microalgae, a brown macroalga, two hydroids, six polychaete worms, a barnacle, two molluscs (both farmed species), five bryozoans and five ascidians.

Methods

For the current study, SA Water had collected video footage of the seabed from 150 sites throughout Louth, Boston and Proper Bays. The aim of the study was to analyse the video footage and classify each site into broad habitat groups based on predominate life forms and classify seagrass in relation to density and epiphyte cover.

Five frames separated by equal time intervals were extracted from the video and 12 point intercepts were arranged in a regular 3 x 4 grid on each frame. A percentage cover of each feature at each site was calculated from the number of point intercepts that feature divided by the total number of point classifications minus any points excluded because they could not be identified. The presence of introduced species was noted for each site from observation of the video.

Two methods were used to determine an overall habitat class for each site based on the various habitat features recorded. The first method was based on multivariate clustering, and the second was a rule-based framework that prioritised features identified by a literature review as being potentially impacted by desalination plant discharges, including seagrasses, filter feeding invertebrates and macroalgae.

Results and Discussion

Usable video durations (from when the seafloor came into focus until the camera was retrieved) ranged from 18–151 seconds (mean 68 seconds). Habitat features identified during the point intercept analysis included seagrasses *Posidonia, Zostera and Halophila*, epiphytic algae, turfs (including microphytobenthos), other macroalgal lifeforms, filter feeders and sediment.

The clustering process identified 13 habitat classes characterised by various densities of *Posidonia* and epiphytes, *Halophila*, various densities of red macroalgae and turfing algae, filter feeders and largely bare sediment. The "rule based" features that were not distinguished during the clustering process include dense *Posidonia* with no epiphytes, and *Zostera*.

Spatial patterns were evident across the Bays. *Posidonia* was the dominant habitat throughout Proper Bay, with relatively dense cover generally close to the western and southern coastlines of the Bay. There was an isolated site with dense *Zostera* in the middle of the Bay. *Posidonia* in Boston Bay was restricted to inshore sites and in the lee of northern Boston Island. *Halophila* and filter feeders were the dominant habitats to the north and west of Boston Island, respectively. Red macroalgae dominated the area directly east from Billy Lights Point to the south-east of Boston Island, and in the north of Boston Bay. Turfing macroalgae were dominant to the north-west and south-west of Boston Island, and bare substrate to the north-east. Dense *Posidonia* was the dominant habitat in Louth Bay, transitioning to sparser *Posidonia* to the south and turfing macroalgae around Point Boston. *Zostera* was recorded between Louth and Rabbit Islands and further south.These findings were generally consistent with broad-scale patterns of cover mapped by University of Adelaide, including vegetative cover throughout Proper Bay, on the north-eastern shoreline of Boston Bay and in Louth Bay.

The distribution of *Posidonia* appeared to be influenced by wave exposure and depth, but several additional factors including water quality, substrate type and species may influence seagrass distribution.

The most abundant introduced species observed during video analysis was the European fan worm *Sabella spallanzanii*, with a dense cover at three sites, a relatively sparse cover at 35 sites and possible identifications at a further four sites, with a distribution extending up to 5 km to the north and 10 km to the south and east of Port Lincoln. It is one of the pest species of most concern within South Australia and has been declared 'noxious' under the *Fisheries Management Act 2007*. It may compete with native or farmed filter feeders. The feather duster worm *Myxicola infundibulum* was recorded at two sites but is not considered to be a significant threat to the ecology of the region. Many of the introduced species previously recorded in the region would not be recognisable from video footage and the lack of observations of other species does not imply their absence.

Conclusion

The habitat survey found dense *Posidonia* throughout Louth Bay (west of Louth Island), along the shallow, sheltered western coastline of Boston Bay. The relatively deep waters further west in Boston Bay were dominated by *Halophila* and red macroalgae in the north, filter feeding invertebrates in the centre of the Bay, and bare sediment to the south. *Posidonia* extended throughout most of Proper Bay but was at lower densities than the western side of the Bay. *Zostera* was found at the deepest sites to the south-east and south of Louth Island, and a site near the centre of Proper Bay.

Other habitats identified as being particularly relevant to desalination discharge are macroalgae, which were relatively dense towards the north of Boston Bay and sparser south of Boston Island, and filter feeders, which were dominant in deeper water west of Boston Island.

The current survey showed that epiphyte levels remain high in Louth Bay, Proper Bay and southern Boston Bay, indicating that these areas may remain under stress from nutrient enrichment.

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1 Introduction

1.1 Background

SA Water proposes to construct a desalination plant on the Eyre Peninsula to relieve pressure on the Uley South Basin (the last remaining major productive groundwater source on the Eyre Peninsula suitable for supplying drinking water to the region) and provide water security to current customers while also enabling future growth.

The former BHP site at Billy Lights Point (Port Lincoln) and a site near Point Boston were identified as potential sites for the plant. Accordingly, habitat mapping is required for the bays surrounding the Billy Lights Point and Point Boston sites.

SA Water has collected video footage of the seabed from 150 sites throughout Louth, Boston and Proper Bays. J Diversity Pty Ltd was engaged to analyse the video footage and:

- Classify each site into broad habitat groups based on predominate life forms
- Produce broad classification relationships assessed using multivariate analysis of predominate life forms
- Classify seagrass in relation to density (e.g. sparse, medium, dense) and epiphyte cover (e.g. low, medium, high)

1.2 Existing habitat data

1.2.1 Habitat mapping

Broad scale (1:100,000) mapping by CSIRO using satellite imagery in 1998 showed seagrass throughout Proper Bay, along the western and southern coasts of Spalding Cove, around the western and northern coastline of Boston Island, along the western and northern coastlines of Boston Bay and throughout Louth Bay (Edyvane 1999, Figure 1). Finer scale mapping and video camera ground truthing undertaken elsewhere on Eyre Peninsula by Miller et al. (2009) was not undertaken in Boston, Proper and Louth Bays.

The EPA undertook video transects at 40 sites in 2012 (EPA unpublished data). with more extensive towed camera surveys undertaken by the EPA in 2010 and 2016–2018 at a number of sites (EPA 2018, Figure 1). Percentage cover of seagrass and epiphytes (Table 1) was estimated from video footage, obtained using a downward facing camera, of 10 transects each of 50 m length within a radius of 200 m of the site mark.

The University of Adelaide used Landsat image archives (Earth Explorer) from 1991, 2008, 2015 and 2021 to map vegetation cover and bare substrate in Proper, Boston and Louth Bays, using a threshold cover of 50% to distinguish these two categories (Hennekam & Clarke 2021, Figure 2).

Comparisons of satellite imagery between the four survey events showed a gain of cover (likely seagrass) in the inshore area of north-west Boston Bay, but cover loss (also likely seagrass) further offshore in north-west Boston Bay, south-western Boston Bay and south-eastern Proper Bay. Between 2015 and 2021, however, there was no loss of cover, and small gains in northern Boston Bay (Hennekam & Clarke 2021).

The three studies (CSIRO, EPA and University of Adelaide) used different methods applied at different scales. A synthesis of their findings is that:

- Proper Bay was dominated by dense seagrass (with a dense cover of epiphytes), with less certainty or reduced density towards the south-eastern extent of the Bay
- Boston Bay had dense seagrass cover to the north of the Bay, along the northern and western coastlines of the Bay and near Boston Island, with bare substrate in deeper areas
- Louth Bay had dense seagrass along the western side of the bay and west of Louth Island, with patchier areas in between, and patchiness or less certainty southwards towards Point Boston.

Table 1. Percentage cover of seagrass and epiphytes recorded during surveys by EPA in 2010 and 2016–2018 Aut = autumn, Spr = spring. Note that seagrass cover is expressed as a percentage of the seafloor, but epiphyte cover is expressed as a percentage of seagrass cover. EPA site locations are shown in Figure 1. Source: EPA (2018), EPA unpublished data.

EPA site code	Seagrass cover (%)					Epiphyte cover (%)				
	2010		2016	2017	2018	2010		2016	2017	2018
	Aut	Spr	Aut	Spr	Aut	Aut	Spr	Aut	Spr	Aut
m0111	39	49	71	56	40	35	52	32	40	41
m0113	3	26	34	31	19	3	50	19	30	30
m0107	5	5	13			16	27	13		
m0105	20	6	51	58	59	28	31	27	59	59
m0106	12	0	1			6	0	8		
m0103	18	4	13			18	21	20		
m0104	40	38	31	33	23	51	54	61	59	53
m0109	39	27	30	30	41	44	75	56	46	70
m0110	19	8	9	1	0	30	38	8	2	1
m0118	72	51	51	46	42	90	84	74	80	72
m0108	5	6	13	11	11	20	70	47	60	42
m0101	79	65	70			88	90	66		
m0100	66	69	64			82	89	87		
m0102	48	38	21	27	14	72	69	83	57	62

Figure 1. Broad scale (1:100,000) mapping by CSIRO and EPA monitoring sites. Source: DEW 2022a (CSIRO mapping), EPA 2018 (EPA monitoring sites).

Figure 2. Mapping of areas with vegetative cover and bare substrate undertaken by University of Adelaide (Hennekam & Clarke 2021), also showing EPA survey sites (EPA 2018).

1.2.2 Habitat condition

The EPA generates Aquatic Ecosystem Condition Reports (AECRs) on the condition of many coastal marine biounits in South Australia, based on criteria including water quality, changes in seagrass cover and seagrass epiphyte loads. The 2016 AECR report on the Jussieu Biounit, which extends from Cape Catastrophe to Tumby Bay, concluded that (EPA 2018):

- condition of sites in the south of Louth Bay had improved, with increases in seagrass cover during 2010–2016 suggesting recovery from disturbance, but widespread elevated epiphyte loads and high abundances of holothurians (sea cucumbers) were indicators of substantial nutrient enrichment.
- sites in the north of Boston Bay were in relatively good condition, with increases in seagrass cover during 2010–2016, while sites in southern Boston Bay were generally showing decreasing condition, based on reduced seagrass cover and elevated phytoplankton levels.
- condition of sites within Proper Bay was variable, with two sites maintaining dense and continuous seagrass, while another showed a 67% decline in seagrass cover during 2010–2016.
- all sites within Proper Bay showed high epiphyte load on seagrass and elevated phytoplankton levels suggesting excess nutrients.

The EPA (2018) noted that many sites were under stress from nutrient enrichment, resulting in epiphyte growth which can result in seagrass loss over time.

The EPA (2018) identified several potential sources of nutrients in Proper, Boston and Louth Bays, including finfish aquaculture, wastewater treatment plant discharge, fish processing discharges and seasonal outflows from the Tod River. Nutrient inputs from finfish aquaculture are likely to be 1–2 orders of magnitude higher than the other sources combined (Gaylard et al. 2014)[1].

A regional monitoring program for aquaculture during 2015–2019 identified that tuna and other finfish aquaculture were having a detectable impact on nutrient levels and phytoplankton communities within Boston Bay, and the potential impact of these nutrients on seagrasses in the region is being investigated during the 2019–2023 monitoring program (Tanner 2020).

Discharges of ammonia from the Port Lincoln wastewater treatment plant at Billy Lights Point have reduced in previous years as the results of reuse of treated water and improvements to the treatment process (Figure 3).

The EPA (2018) reported that two fish processing facilities discharged to the marine environment, but there was an intent to facilitate discharges to the local sewer network. The status of this initiative is unknown.

The quality of water flowing to the sea from the Tod River is likely to be poor, bringing nutrients and sediments from the agricultural land within its catchment (EPA 2018).

[1] In 2011/12, estimates of Tuna and kingfish aquaculture nutrient inputs at Port Lincoln, including offshore, were approximately 2,000 t, while the other inputs listed were < 10 t.

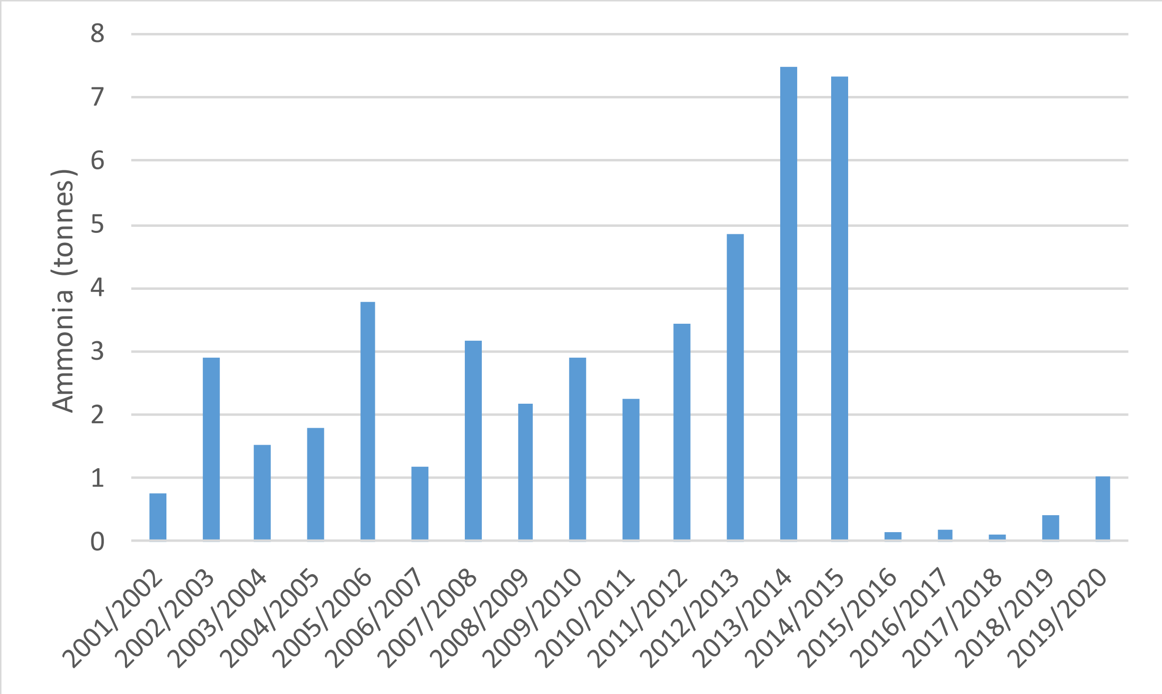

Figure 3. Discharge of ammonia from the wastewater treatment plant at Billy Lights Point. Source: DAWE (2021).

Twenty-eight pest species have been identified in Proper, Boston and Louth Bays (Wiltshire et al. 2010, PIRSA unpublished data), including six microalgae, a brown macroalga, two hydroids, six polychaete worms, a barnacle, two molluscs (both farmed species), five bryozoans and five ascidians (Table 2).

Table 2. Introduced species previously recorded in Proper, Boston and Louth Bays

Group	Species
Microalgae	*Alexandrium catenella*
	Alexandrium minutum
	Chattonella marina
	Gymnodinium catenatum
	Heterosigma akashiwo
	Vicicitus globosus
Macroalgae	*Stictyosiphon soriferus*
Hydroids	*Coryne eximia*
	Halecium delicatulum
Polychaetes	*Boccardia chilensis*
	Hydroides elegans
	Myxicola infundibulum
	Polydora ciliata
	Pseudopolydora paucibranchiata
	Sabella spallanzanii
Barnacles	*Megabalanus tintinnabulum*
Molluscs	*Crassostrea gigas*
	Mytilus galloprovincialis
Bryozoans	*Bugula flabellata*
	Bugula neritina
	Schizoporella unicornis
	Watersipora arcuata
	Watersipora subtorquata
Ascidians	*Ascidiella aspersa*
	Botrylloides leachi
	Botryllus schlosseri
	Ciona intestinalis
	Styela plicata

2 Methods

2.1 Acquisition of video data

Video footage was acquired by SA Water at the sites shown in Figure 4, and provided to the author. The acquisition was spread across several periods (28 September 2021, 16 November 2021 and 26–27 May 2022), with the study area expanding during the desalination site selection process.

Each sample site was inspected by using a 'camera-drop' methodology, whereby a submersible Scielex video camera was lowered alongside a stationary boat, using a cable through which standard definition video was transmitted to the vessel. A GPS was linked to the camera topside system to accurately determine the position and date and time of each transect. A high resolution (GoPro) video camera was mounted above the Scielex camera to provide additional high-resolution imagery for post-field analysis. For each drop, the camera was lowered to approximately 0.5 m above the seafloor for 30 seconds for detailed observations, then to approximately 2 m above the seafloor for a further 30 seconds for an overall view. General observations and impressions of the benthic cover and exposure were denoted during field inspections using the Scielex 'real-time' video output, but the assessment of the benthic habitats using the high resolution video footage for the current study was completed post-field.

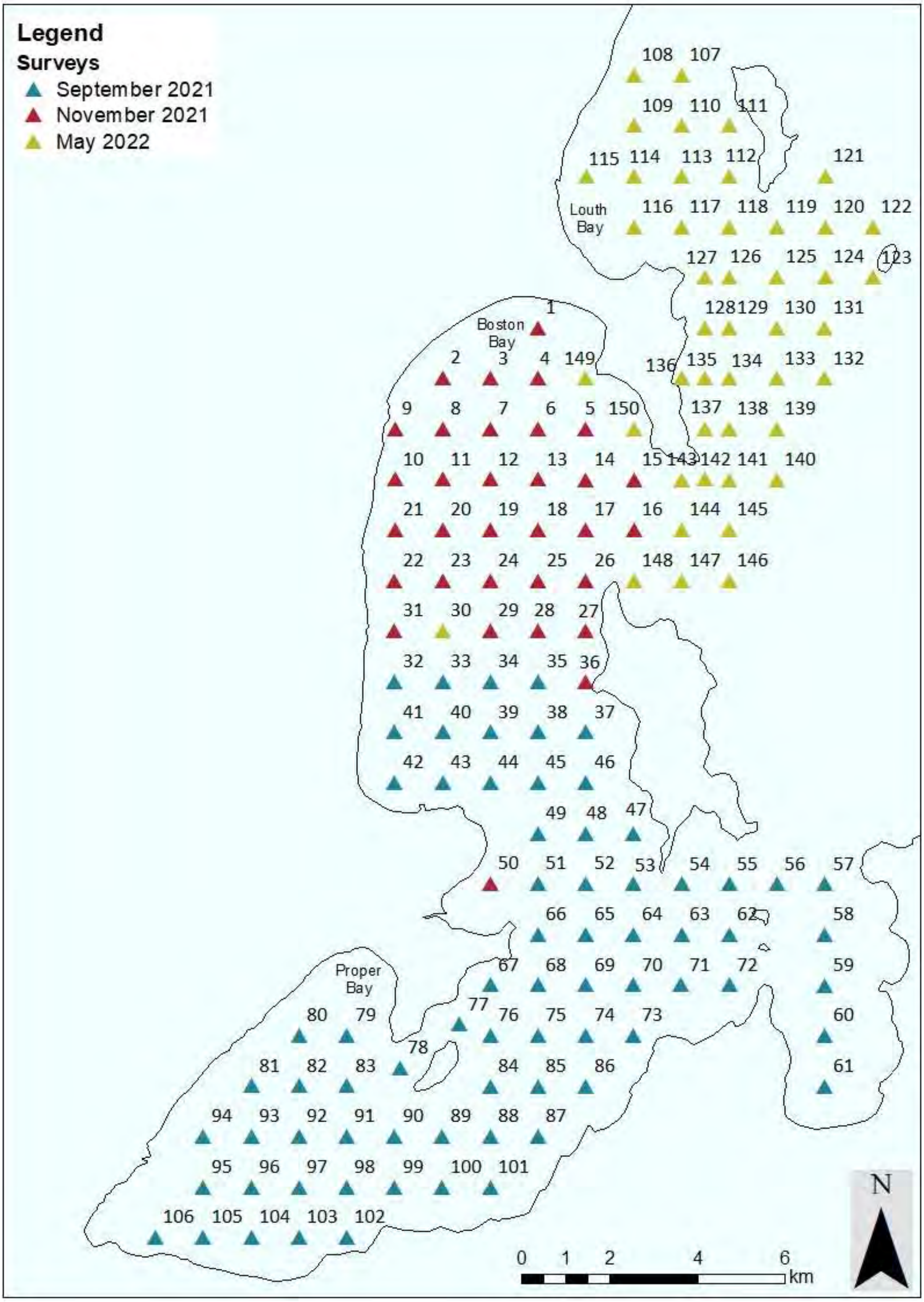

Figure 4. Towed video survey sites

2.2 Quantification of habitat features

The usable portion of video for each site was identified, which was generally from when the seabed first came into focus after camera descent to the commencement of camera ascent. Five frames separated by equal time intervals were extracted from the video using a custom R script in conjunction with the open source ffmpeg program, and point overlay files were generated for use with the Coral Point Count with extensions (CPCe) program (Kohler & Gill 2006). Twelve point intercepts were arranged in a regular 3 x 4 grid over an area of each frame image within a margin of 300 pixels at the top and 100 pixels on the other sides (Figure 5). The greater margin at the top was because the supplied video was taken at a forward-facing angle rather than straight down, and hence the seabed was not as clearly visible at the top of the image as at the bottom. A percentage cover of each feature at each site was calculated from the number of point intercepts that feature divided by the total number of point classifications (60) minus any points excluded because they could not be identified (e.g. were in shadow). For seagrass, the cover was assumed to overlap with the cover of epiphytes.

The presence of introduced species was noted for each site from observation of the video.

Two methods were used to determine an overall habitat class for each site based on the various habitat features recorded. The first method was based on multivariate analyses using the CLUSTER and SIMPROF routines of the PRIMER software, Version 6 (Clarke and Warwick 2001, Clarke and Gorley 2006) to determine habitat classes, and the SIMPER routine to determine the features that characterised each habitat class.

The second method was a rule-based framework that prioritised features identified by a literature review as being potentially impacted by desalination plant discharges (Tanner & Drabsch 2021). These features included seagrasses, filter feeding invertebrates and macroalgae, prioritised as per Table 1. The classification distinguished between turfing and other macroalgae because of functional differences and possible representation of different condition states between these groups, noting that within each of these categories there remain differences in morphology and ecology (Turner et al. 2006, Connell et al 2014).

Figure 5. Sample screen from the 'Coral Point Count' program.

Table 3. Rule-based habitat classification

Rule	Habitat Class
If *Posidonia* cover > 66%	*Posidonia* dense
Else if *Posidonia* cover > 33%	*Posidonia* moderate
Else if *Posidonia* cover > 0%	*Posidonia* sparse
Else if *Halophila* cover > 10%	*Halophila*
Else if *Zostera* cover > 10%	*Zostera*
Else if filter feeder cover > 10%	Filter feeders
Else if (red/green/brown) macroalgal cover > 50%	Macroalgae dense
Else if (red/green/brown) macroalgal cover > 10%	Macroalgae sparse
Else if turf cover > 50%	Turf dense
Else if turf cover > 10%	Turf sparse
Else	Bare sediment

3 Results

Usable video durations (from when the seafloor came into focus until the camera was retrieved) ranged from 18–151 seconds (mean 68 seconds).

Habitat features identified during the point intercept analysis included seagrass, epiphytic algae, turfs (including microphytobenthos), other macroalgal lifeforms, filter feeders and sediment.

The clustering process identified the following 13 habitat classes characterised by:

- Dense *Posidonia* with epiphytes (Plate 1)
- High to moderately dense *Posidonia* with epiphytes (Plate 2)
- Moderately dense *Posidonia* with epiphytes (Plate 3)
- Sparse *Posidonia* (Plate 4)
- Sparse *Posidonia* with large brown macroalgae (Plate 5)
- *Halophila australis* and red macroalgae (Plate 6)
- Moderately dense red macroalgae (Plate 7)
- Sparse red macroalgae (Plate 8)
- Sparse red macroalgae/turf (Plate 9)
- Moderately dense turf (Plate 10)
- Sparse turf
- Filter feeders (Plate 11)
- Bare sediment (Plate 12, but see also coarser sand in Plate 8)

Details of the habitat features scored during the point intercept analysis and their corresponding habitat classes are provided in Appendix A. Details of the clustering process including the dendrogram, SIMPER analysis and multi-dimensional scaling plot are provided in Appendix A.

Habitat classes not identified by the clustering process but which were included in the rule-based classification include *Zostera* (Plate 13) and dense *Posidonia* with no/few epiphytes (Plate 14). The *Posidonia* species throughout Proper and Boston Bays was *P. sinuosa*[2], A number of *Posidonia* sites in Louth Bay included *P. australis*, either as monospecific stands (Plate 15) or mixed with *P. sinuosa* (Plate 16). Atypical sites included Site 81, with a distinct boundary between dense red macroalgae and seagrass (Plate 17), and Site 105 with green filamentous macroalgae prevalent amongst the *Posidonia* (Plate 18).

The results of the cluster- and rule-based habitat classifications are shown in Figure 6. A summary of the comparison of the two habitat classification methods is provided in Table 4. Classification using the rule-based scheme rather than cluster-based scheme saw the reallocation of sites classified as ‘bare sediment’ or ‘turf sparse’ to *Halophila*, *Zostera*, sparse *Posidonia,* sparse red macroalgae or sparse turf categories, while some of the ‘*Halophila*/red macroalgae’ sites were reclassified to sparse *Posidonia* or dense red macroalgae categories. It is emphasised that these habitat classes are named according to their dominant (for cluster-based classes) or important (for rule-based classes) features but may include other biota. In particular, the ‘bare sediment’ rule-based habitat class may have up to 10% seagrass, macroalgae or filter feeders and the equivalent cluster-based class may also include biota.

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[2] It is possible that other thin-strapped *Posidonia* species, e.g. *P. angustifolia*, were present.

Seagrass and epiphyte covers are shown in Figure 7.

The most abundant introduced species observed during video analysis was the European fan worm *Sabella spallanzanii*, with a dense cover (many present in each video frame) at three sites, a relatively sparse cover at 35 sites and possible identifications at a further four sites (Figure 8). The cryptogenic species *Myxicola infundibulum* (feather-duster worm) was also observed at Sites 26 and 76.

Table 4. Number of sites assigned to each habitat class for both cluster- and rule-based classification systems.

	Rule-based habitat classes										
Cluster-based habitat classes	*Halophila*	*Zostera*	*Posidonia* dense	*Posidonia* moderate density	*Posidonia* sparse	Red macroalgae dense	Red macroalgae sparse	Turf dense	Turf sparse	Filter feeders	Bare sediment
*Halophila/*red macroalgae	2				2	2					
Posidonia dense			30	5							
Posidonia mod. to high density				14							
Posidonia moderate density				5	5						
Posidonia sparse					5						
Posidonia sparse/macroalgae					1						
Red macroalgae moderate					1	1	6				
Red macroalgae sparse	1				1		3				
Red macroalgae/turf sparse					2		2			1	
Turf moderate density					2		4	6	4	1	
Turf sparse	1	2			1		3		13		
Filter feeders										4	
Bare sediment	3	2			1		1		1		12

Plate 1. Dense *Posidonia sinuosa,* with dense epiphyte cover

Plate 2. Moderate to high density *Posidonia sinuosa,* with moderate epiphyte cover

Plate 3. Moderately dense *Posidonia sinuosa*

Plate 4. Sparse *Posidonia sinuosa*

Plate 5. Sparse *Posidonia* with large brown macroalgae

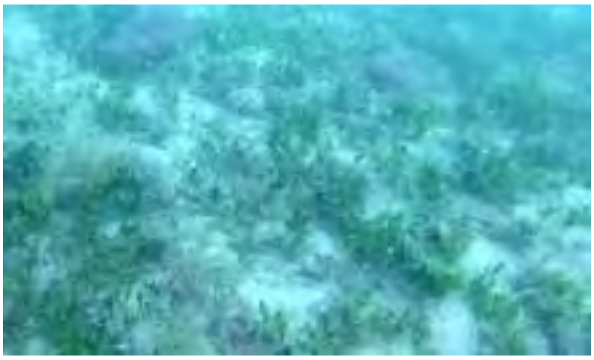


Plate 6. *Halophila australis* with red macroalgae

Plate 7. Moderately dense red macroalgae

Plate 8. Sparse red macroalgae

Plate 9. Sparse red macroalgae/turf

Plate 10. Moderately dense turfing algae (including microphytobenthos)

Plate 11. Filter feeders including razor clam *Pinna bicolor* and mauve-mouthed ascidian *Polycarpa viridis*

Plate 12. Predominantly bare substrate

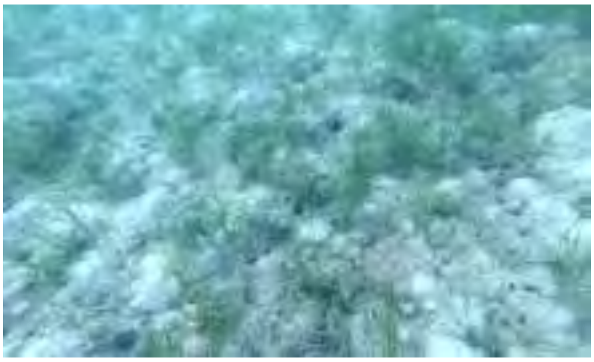


Plate 13. ***Zostera,*** **probably** ***Z. nigricaulis***

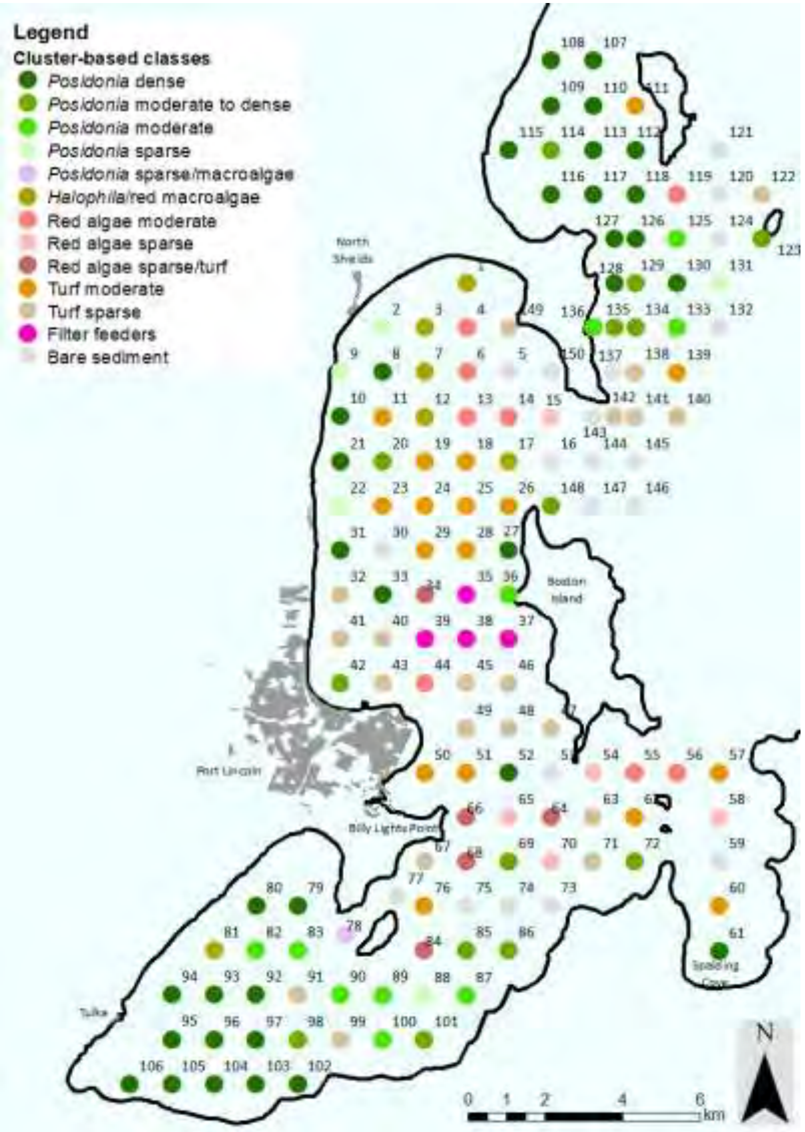
Plate 14. Dense ***Posidonia sinuosa,*** **with few epiphytes**

Plate 15. ***Posidonia australis***

Plate 16. ***Posidonia australis*** **mixed with** ***P. sinuosa***

Plate 17. Red macroalgae/***Posidonia sinuosa*** **boundary**

Plate 18. ***Posidonia sinuosa*** **with green filamentous macroalgae**



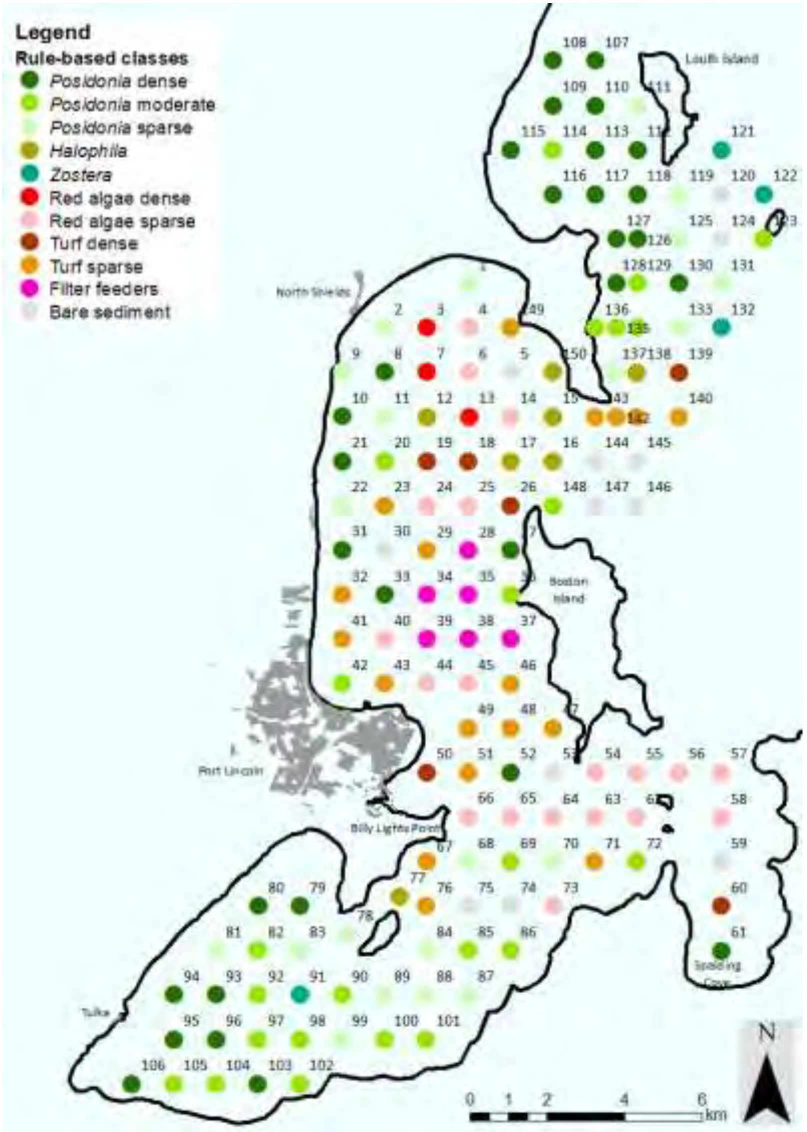


Figure 6. Habitat classifications based on clustering (left) or hierarchical rules (right).

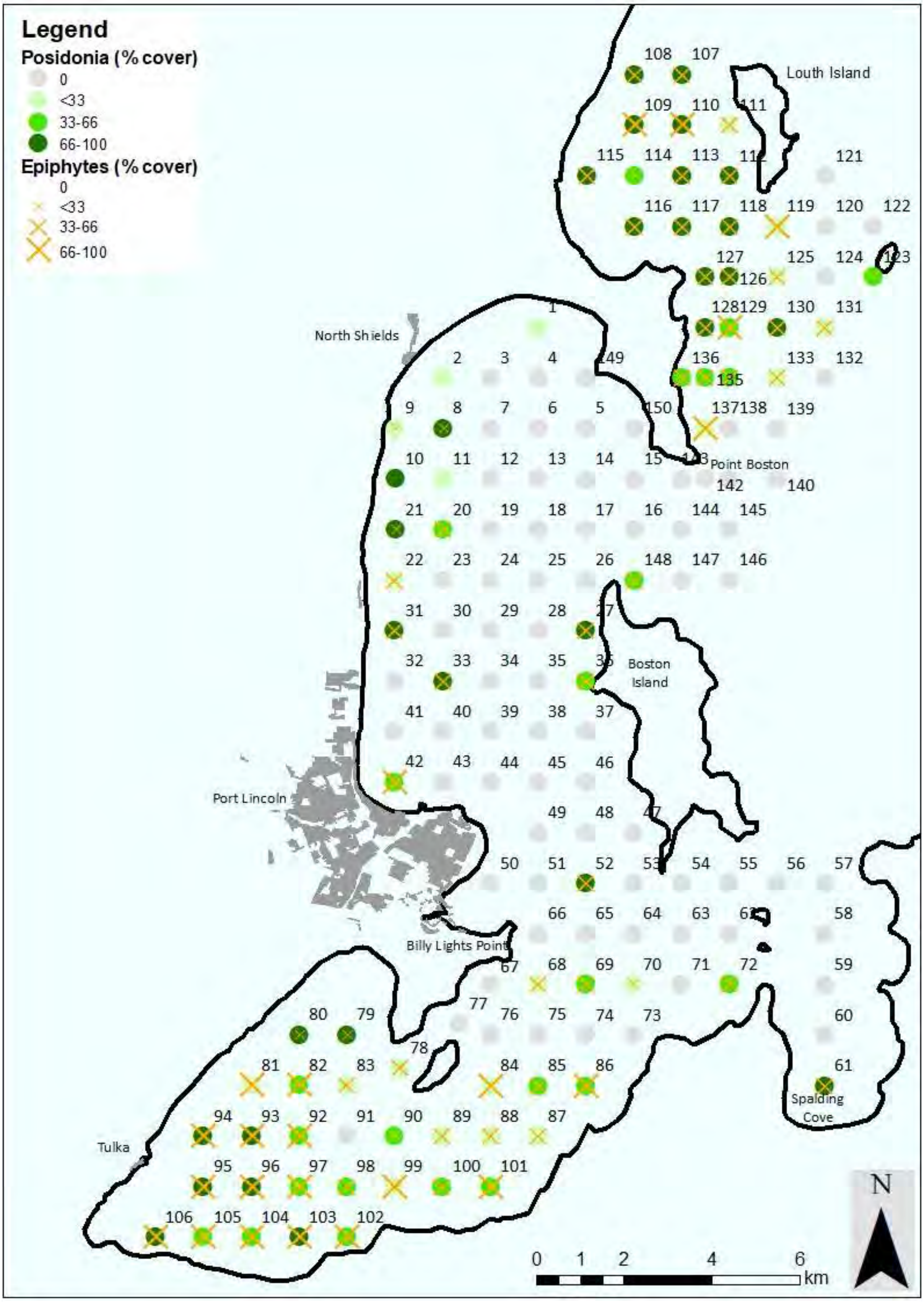


Figure 7. Percentage cover classes of *Posidonia* at each site, overlaid by percentage epiphyte cover classes. Note that *Posidonia* cover is a percentage of the seafloor, but epiphyte cover is a percentage of *Posidonia* cover.

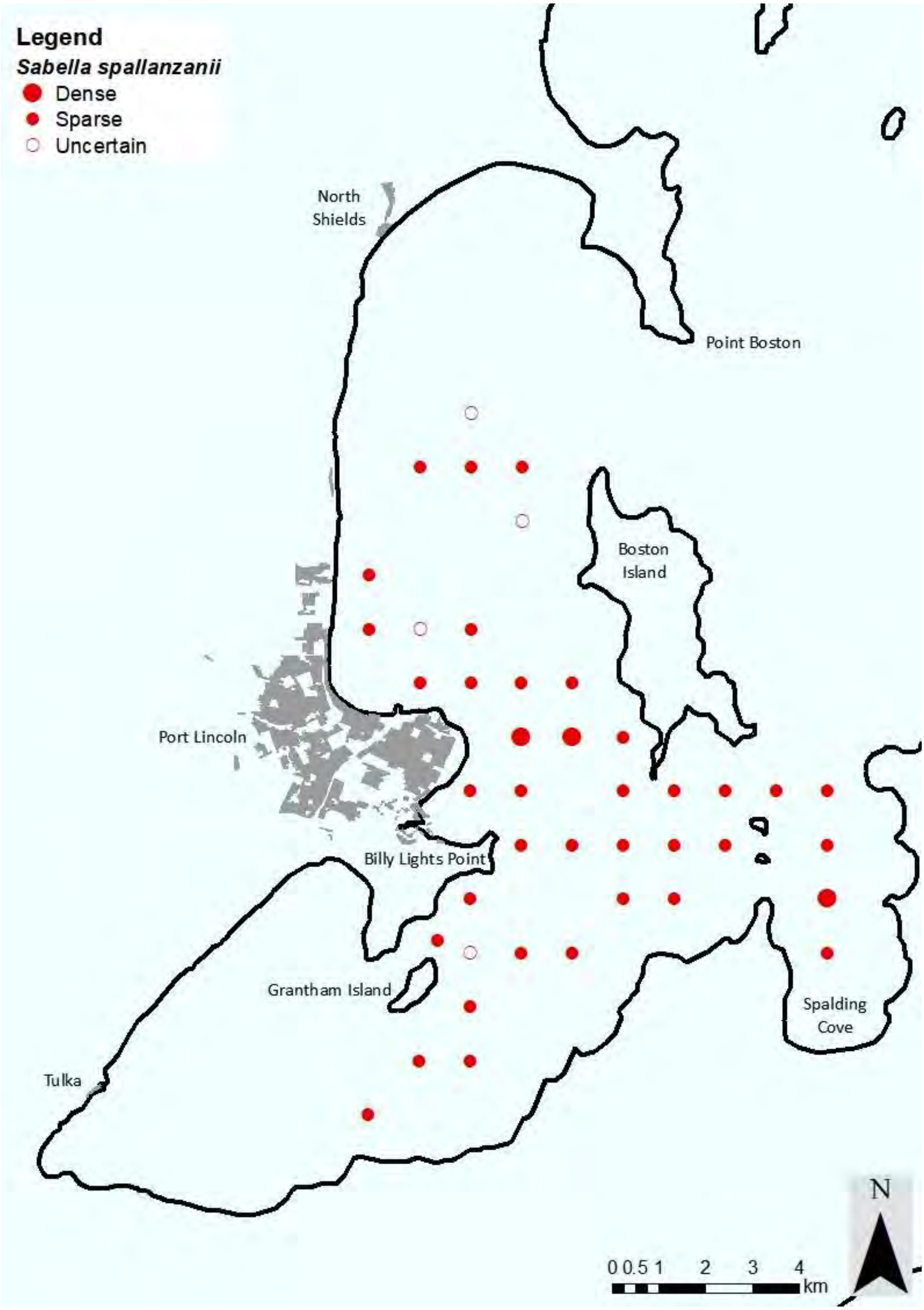


Figure 8. Distribution of the European fan worm *Sabella spallanzanii*.

4 Discussion

4.1 Spatial patterns and physical drivers

Spatial patterns were evident across the Bays (Figure 6). *Posidonia* seagrass was the dominant habitat throughout Proper Bay, with relatively dense cover generally close to the western and southern coastlines of the Bay. There was an isolated site with dense *Zostera* in the middle of the Bay.

Posidonia in Boston Bay was restricted to inshore sites and in the lee of northern Boston Island. *Halophila* and filter feeders were the dominant habitats to the north and west of Boston Island, respectively. Red macroalgae dominated the area directly east from Billy Lights Point to the south-east of Boston Island, and in the north of Boston Bay. Turfing macroalgae were dominant to the north-west and south-west of Boston Island, and bare substrate to the north-east (Figure 6).

Dense *Posidonia* was the dominant habitat in Louth Bay, transitioning to sparser *Posidonia* to the south and turfing macroalgae around Point Boston. *Zostera* was recorded between Louth and Rabbit Islands and further south (Figure 6).

These findings were generally consistent with broad-scale patterns of cover mapped by University of Adelaide, including vegetative cover throughout Proper Bay, on the north-eastern shoreline of Boston Bay and in Louth Bay (Figure 2, Figure 6).

Epiphyte levels were generally highest in Louth Bay and Proper Bay, and in the south of Boston Bay (Figure 7).

Both bays are relatively sheltered from wave exposure, with most of the mainland shoreline classified as 'low' or 'very low', the lowest of a five-level classification by DEW (2022). Relatively few areas classified as *Posidonia* were found in the areas with relatively high (i.e. 'low' rather than 'very low') wave exposure (Figure 9). Epiphytes levels were generally highest in sheltered waters, and it should be noted that the high epiphyte levels near Point Boston are on seagrass of less than 2% cover and determined from a single point overlay.

Depth is also likely be a major influence on seagrass distribution, noting that the *Posidonia* sites were generally at shallower depths (less than 10 m) and *Halophila* and *Zostera* were in relatively deep areas (Figure 9). The maximum depth of *Posidonia* in Boston Bay is shallower than other locations in South Australia, including the Adelaide metropolitan coastline, where it is usually found to depths of 15 m (Westphalen et al. 2005).

There could be several additional factors controlling seagrass distribution including water quality, substrate type and species. It should be noted that the spatial patterns observed in this study are potentially confounded by temporal change between the three sampling events each targeting a different set of sites (Figure 4). However, the dominant species in the region was *Posidonia,* which is a perennial species. Seasonal changes in its distribution are not usually observed other than in relation to blade density (shed during autumn and winter and grow during spring and summer). These changes may have some minor impact on percentage cover estimates but seasonal differences in meadow aerial production would not be expected (Short et al. 2017).

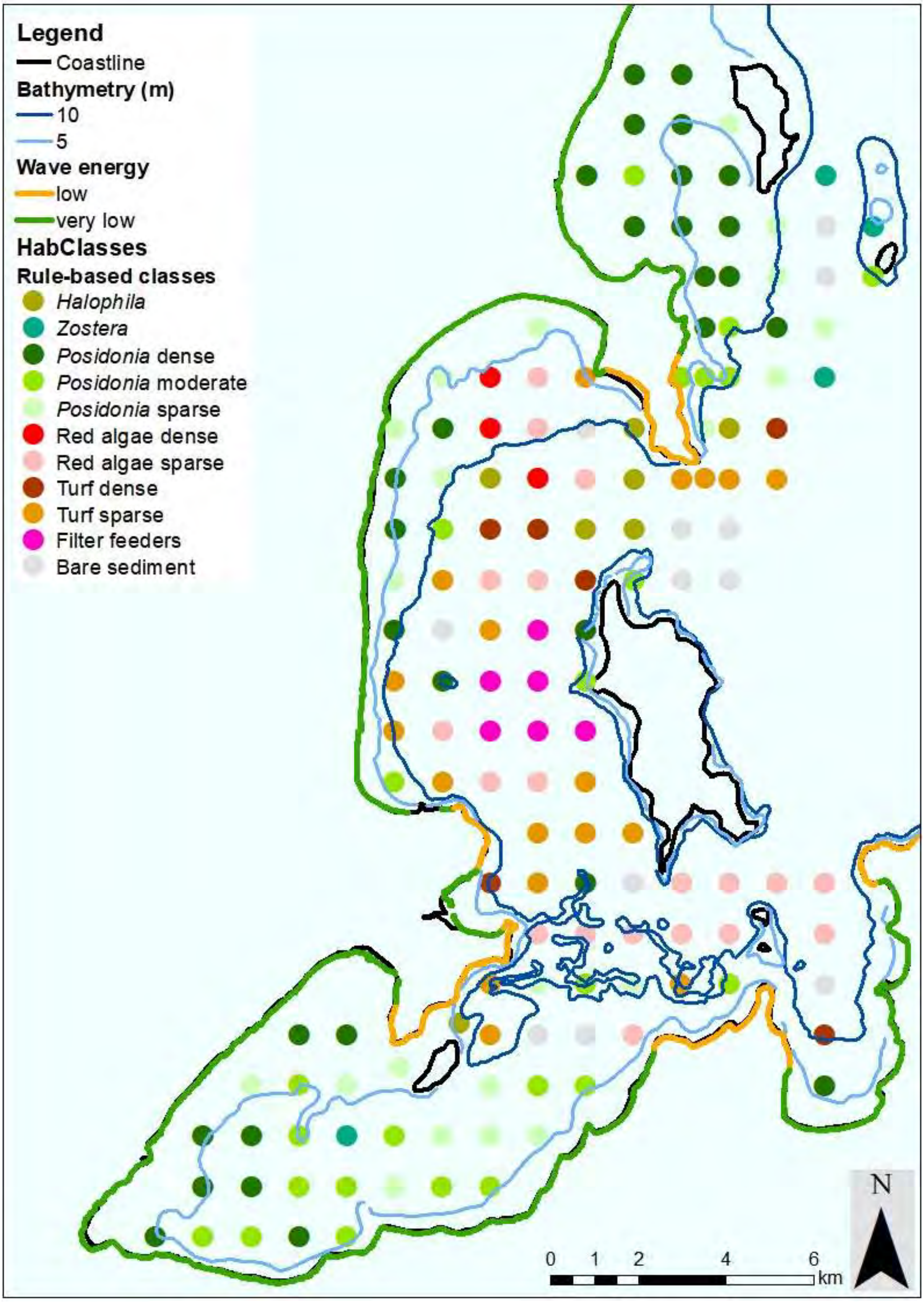


Figure 9. Wave energy at mainland shorelines in Proper Bay and Boston Bay, bathymetry contours and habitat classes derived for this study. Note that wave energy at island shorelines has not been classified. Source: DEW 2022b (wave exposure), DEW 2022c (bathymetry).

4.2 Habitat condition

The EPA noted that from their 2018 survey of Boston, Proper and Louth Bays (EPA, 2018) that many sites monitored were under stress from nutrient enrichment, resulting in epiphyte growth which could result in seagrass loss over time (Section 1.2.2). The current study showed that epiphyte levels appeared highest in Proper Bay, south of Boston Bay (near Port Lincoln) and Louth Bay (near Louth Island) and were similar to levels recorded by the EPA (2018) in these areas.

The data presented in this report are not sufficient to draw inferences on the impact of aquaculture on habitat condition in Boston, Proper or Louth Bays, with reasons including the lack of before and after data obtained using a consistent method, and inadequate spatial coverage of the 'before' data. Similarly, there is insufficient spatial coverage and resolution to draw conclusions about change in habitat condition since the reduction of nutrient discharge from the WWTP.

The European fan worm has been identified as one of the pest species of most concern within South Australia (PIRSA undated) and has been declared 'noxious' under the *Fisheries Management Act 2007* (PIRSA 2019). It may compete with native or farmed filter feeders. There were no records near Port Lincoln from a review of marine pests by Wiltshire et al. (2010), nor from a regional survey that included Port Lincoln wharf and marina (Dittmann et al. 2010), but there was a record from 2010 near the wharf (SARDI unpublished data). The current study showed a distribution extending up to 5 km to the north and 10 km to the south and east of Port Lincoln (Figure 8). The feather duster worm *Myxicola infundibulum,* a cryptogenic[3] species observed at two sites, is not considered to be a significant threat to the ecology of the region. Many of the introduced species previously recorded in the region would not be recognisable from video footage and the absence of observations does not mean an absence of these species.

5 Conclusion

The habitat survey found dense *Posidonia* throughout Louth Bay (west of Louth Island), along the shallow, sheltered western coastline of Boston Bay. The relatively deep waters further west in Boston Bay were dominated by *Halophila* and red macroalgae in the north, filter feeding invertebrates in the centre of the Bay, and bare sediment to the south. *Posidonia* extended throughout most of Proper Bay but was at lower densities than the western side of the Bay. *Zostera* was found at the deepest sites to the south-east and south of Louth Island, and a site near the centre of Proper Bay.

Other habitats identified as being particularly relevant to desalination discharge are macroalgae, which were relatively dense towards the north of Boston Bay and sparser south of Boston Island, and filter feeders, which were dominant in deeper water west of Boston Island.

The current survey showed that epiphyte levels remain high in Louth Bay, Proper Bay and southern Boston Bay, indicating that these areas may remain under stress from nutrient enrichment.

[3] i.e. uncertain origin

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Appendix A. Point intercept scores and habitat classes

Note that total percentages for each site may exceed 100% because of overlap between seagrass and epiphytes.

Site	Epiphytes	*Posidonia*	*Halophila*	*Zostera*	Sediment	Turf	Green macroalgae	Brown macroalgae	Red macroalgae	Filter feeders	Cluster-based class	Rule-based class
1	0.0	1.7	0.0	0.0	23.3	0.0	0.0	0.0	75.0	0.0	*Halophila*/red macroalgae	*Posidonia* sparse
2	0.0	18.6	0.0	0.0	81.4	0.0	0.0	0.0	0.0	0.0	*Posidonia* sparse	*Posidonia* sparse
3	0.0	0.0	0.0	0.0	16.7	0.0	0.0	0.0	83.3	0.0	*Halophila*/red macroalgae	Red macroalgae dense
4	0.0	0.0	0.0	0.0	60.7	0.0	0.0	0.0	39.3	0.0	Red macroalgae moderate density	Red macroalgae sparse
5	0.0	0.0	0.0	0.0	90.0	0.0	0.0	0.0	7.3	0.0	Bare sediment	Bare sediment
6	0.0	0.0	0.0	0.0	63.3	0.0	0.0	0.0	36.7	0.0	Red macroalgae moderate density	Red macroalgae sparse
7	0.0	0.0	0.0	0.0	13.3	0.0	0.0	0.0	86.7	0.0	*Halophila*/red macroalgae	Red macroalgae dense
8	6.7	90.0	0.0	0.0	10.0	0.0	0.0	0.0	0.0	0.0	*Posidonia* dense	*Posidonia* dense
9	1.7	13.3	0.0	0.0	86.7	0.0	0.0	0.0	0.0	0.0	*Posidonia* sparse	*Posidonia* sparse
10	0.0	98.3	0.0	0.0	1.7	0.0	0.0	0.0	0.0	0.0	*Posidonia* dense	*Posidonia* dense
11	0.0	5.0	0.0	0.0	45.0	41.7	0.0	3.3	3.3	1.7	Turf moderate density	*Posidonia* sparse
12	0.0	0.0	43.3	0.0	15.0	25.0	0.0	0.0	16.0	0.0	*Halophila*/red macroalgae	*Halophila*
13	0.0	0.0	0.0	0.0	42.4	0.0	0.0	0.0	57.6	0.0	Red macroalgae moderate density	Red macroalgae dense
14	0.0	0.0	0.0	0.0	51.7	0.0	0.0	0.0	48.3	0.0	Red macroalgae moderate density	Red macroalgae sparse
15	0.0	0.0	20.0	0.0	66.7	0.0	0.0	0.0	12.0	0.0	Red macroalgae sparse	*Halophila*
16	0.0	0.0	13.3	0.0	81.7	0.0	0.0	0.0	5.0	0.0	Bare sediment	*Halophila*
17	0.0	0.0	58.3	0.0	28.3	0.0	0.0	0.0	13.3	0.0	*Halophila*/red macroalgae	*Halophila*
18	0.0	0.0	0.0	0.0	0.0	96.7	0.0	0.0	3.3	0.0	Turf moderate density	Turf dense
19	0.0	0.0	0.0	0.0	5.0	93.3	0.0	0.0	1.7	0.0	Turf moderate density	Turf dense

Site	Epiphytes	*Posidonia*	*Halophila*	*Zostera*	Sediment	Turf	Green macroalgae	Brown macroalgae	Red macroalgae	Filter feeders	Cluster-based class	Rule-based class
20	38.3	58.3	0.0	0.0	28.3	10.0	0.0	0.0	0.0	3.3	*Posidonia* mod. to high density	*Posidonia* moderate density
21	8.3	90.0	0.0	0.0	10.0	0.0	0.0	0.0	0.0	0.0	*Posidonia* dense	*Posidonia* dense
22	12.1	19.0	0.0	0.0	77.6	1.7	0.0	0.0	0.0	1.7	*Posidonia* sparse	*Posidonia* sparse
23	0.0	0.0	0.0	0.0	40.0	46.7	0.0	0.0	5.3	6.7	Turf moderate density	Turf sparse
24	0.0	0.0	0.0	0.0	41.7	40.0	0.0	0.0	15.0	3.3	Turf moderate density	Red macroalgae sparse
25	0.0	0.0	0.0	0.0	30.0	45.0	0.0	0.0	23.3	1.7	Turf moderate density	Red macroalgae sparse
26	0.0	0.0	0.0	0.0	40.7	57.6	0.0	0.0	1.7	0.0	Turf moderate density	Turf dense
27	32.7	80.0	0.0	0.0	12.7	0.0	0.0	3.6	3.6	0.0	*Posidonia* dense	*Posidonia* dense
28	0.0	0.0	0.0	0.0	29.3	53.4	0.0	0.0	1.7	15.5	Turf moderate density	Filter feeders
29	0.0	0.0	0.0	0.0	40.0	50.0	0.0	0.0	0.0	10.0	Turf moderate density	Turf sparse
30	0.0	0.0	0.0	0.0	90.0	8.3	0.0	1.7	0.0	0.0	Bare sediment	Bare sediment
31	44.1	72.9	0.0	0.0	25.4	0.0	0.0	0.0	0.0	1.7	*Posidonia* dense	*Posidonia* dense
32	0.0	0.0	0.0	0.0	75.9	13.8	0.0	0.0	2.7	6.9	Turf sparse	Turf sparse
33	54.2	84.7	0.0	0.0	11.9	0.0	0.0	0.0	1.7	1.7	*Posidonia* dense	*Posidonia* dense
34	0.0	0.0	0.0	0.0	51.7	15.5	0.0	0.0	19.0	13.8	Red macroalgae sparse/turf	Filter feeders
35	0.0	0.0	0.0	0.0	58.3	5.0	0.0	0.0	0.0	36.7	Filter feeders	Filter feeders
36	18.3	36.7	0.0	0.0	55.0	8.3	0.0	0.0	0.0	0.0	*Posidonia* mod	*Posidonia* moderate density
37	0.0	0.0	0.0	0.0	50.0	16.7	0.0	0.0	1.7	31.7	Filter feeders	Filter feeders
38	0.0	0.0	0.0	0.0	58.3	3.3	0.0	0.0	13.3	25.0	Filter feeders	Filter feeders
39	0.0	0.0	0.0	0.0	53.3	15.0	0.0	1.7	2.0	26.7	Filter feeders	Filter feeders
40	0.0	0.0	0.0	0.0	63.3	18.3	0.0	0.0	11.7	6.7	Turf sparse	Red macroalgae sparse
41	0.0	0.0	0.0	0.0	66.7	20.0	0.0	0.0	3.3	10.0	Turf sparse	Turf sparse

Site	Epiphytes	*Posidonia*	*Halophila*	*Zostera*	Sediment	Turf	Green macroalgae	Brown macroalgae	Red macroalgae	Filter feeders	Cluster-based class	Rule-based class
42	33.9	39.0	0.0	0.0	47.5	1.7	0.0	0.0	8.5	3.4	*Posidonia* mod. to high density	*Posidonia* moderate density
43	0.0	0.0	0.0	0.0	73.3	16.7	0.0	0.0	10.0	0.0	Turf sparse	Turf sparse
44	0.0	0.0	0.0	0.0	58.3	10.0	0.0	0.0	30.0	1.7	Red macroalgae moderate density	Red macroalgae sparse
45	0.0	0.0	0.0	0.0	66.7	20.0	0.0	0.0	11.7	1.7	Turf sparse	Red macroalgae sparse
46	0.0	0.0	0.0	0.0	71.7	16.7	0.0	0.0	1.7	10.0	Turf sparse	Turf sparse
47	0.0	0.0	0.0	0.0	71.7	20.0	0.0	0.0	5.0	3.3	Turf sparse	Turf sparse
48	0.0	0.0	0.0	0.0	68.3	23.3	0.0	0.0	3.3	5.0	Turf sparse	Turf sparse
49	0.0	0.0	0.0	0.0	72.9	22.0	0.0	0.0	1.7	3.4	Turf sparse	Turf sparse
50	0.0	0.0	0.0	0.0	25.9	69.0	0.0	0.0	1.7	3.4	Turf moderate density	Turf dense
51	0.0	0.0	0.0	0.0	45.0	46.7	0.0	0.0	0.0	8.3	Turf moderate density	Turf sparse
52	51.7	86.7	0.0	0.0	13.3	0.0	0.0	0.0	0.0	0.0	*Posidonia* dense	*Posidonia* dense
53	0.0	0.0	0.0	0.0	80.0	5.0	0.0	0.0	6.7	8.3	Bare sediment	Bare sediment
54	0.0	0.0	0.0	0.0	66.7	13.3	0.0	0.0	16.7	3.3	Red macroalgae sparse	Red macroalgae sparse
55	0.0	0.0	0.0	0.0	58.3	6.7	0.0	0.0	31.7	3.3	Red macroalgae moderate density	Red macroalgae sparse
56	0.0	0.0	0.0	0.0	60.0	1.7	0.0	0.0	38.3	0.0	Red macroalgae moderate density	Red macroalgae sparse
57	0.0	0.0	0.0	0.0	38.3	43.3	0.0	0.0	18.3	0.0	Turf moderate density	Red macroalgae sparse
58	0.0	0.0	0.0	0.0	71.4	8.9	0.0	1.8	14.3	3.6	Red macroalgae sparse	Red macroalgae sparse
59	0.0	0.0	0.0	0.0	85.0	10.0	0.0	0.0	5.0	0.0	Bare sediment	Bare sediment
60	0.0	0.0	0.0	0.0	26.7	73.3	0.0	0.0	0.0	0.0	Turf moderate density	Turf dense
61	41.4	87.9	0.0	0.0	3.4	3.4	0.0	0.0	5.2	0.0	*Posidonia* dense	*Posidonia* dense
62	0.0	0.0	0.0	0.0	35.0	50.0	0.0	0.0	15.0	0.0	Turf moderate density	Red macroalgae sparse
63	0.0	0.0	0.0	0.0	66.7	18.3	0.0	0.0	15.0	0.0	Turf sparse	Red macroalgae sparse

Site	Epiphytes	*Posidonia*	*Halophila*	*Zostera*	Sediment	Turf	Green macroalgae	Brown macroalgae	Red macroalgae	Filter feeders	Cluster-based class	Rule-based class
64	0.0	0.0	0.0	0.0	46.7	21.7	0.0	0.0	28.3	3.3	Red macroalgae sparse/turf	Red macroalgae sparse
65	0.0	0.0	0.0	0.0	75.0	6.3	0.0	0.0	18.8	0.0	Red macroalgae sparse	Red macroalgae sparse
66	0.0	0.0	0.0	0.0	58.3	15.0	0.0	0.0	16.7	10.0	Red macroalgae sparse/turf	Red macroalgae sparse
67	0.0	0.0	0.0	0.0	70.0	28.3	0.0	0.0	0.0	1.7	Turf sparse	Turf sparse
68	6.7	13.3	0.0	0.0	58.3	15.0	0.0	0.0	13.3	0.0	Red macroalgae sparse/turf	*Posidonia* sparse
69	18.6	47.5	0.0	0.0	39.0	5.1	0.0	0.0	6.8	1.7	*Posidonia* mod. to high density	*Posidonia* moderate density
70	1.7	6.7	0.0	0.0	66.7	6.7	0.0	0.0	16.7	3.3	Red macroalgae sparse	*Posidonia* sparse
71	0.0	0.0	0.0	0.0	71.7	21.7	0.0	0.0	6.7	0.0	Turf sparse	Turf sparse
72	15.0	45.0	0.0	0.0	50.0	0.0	0.0	0.0	3.3	1.7	*Posidonia* mod. to high density	*Posidonia* moderate density
73	0.0	0.0	0.0	0.0	86.7	0.0	0.0	0.0	13.3	0.0	Bare sediment	Red macroalgae sparse
74	0.0	0.0	0.0	0.0	90.0	0.0	0.0	3.3	5.0	1.7	Bare sediment	Bare sediment
75	0.0	0.0	0.0	0.0	78.3	5.0	0.0	0.0	10.0	6.7	Bare sediment	Bare sediment
76	0.0	0.0	0.0	0.0	48.3	50.0	0.0	0.0	0.0	1.7	Turf moderate density	Turf sparse
77	0.0	0.0	10.0	0.0	78.3	6.7	0.0	0.0	5.0	0.0	Bare sediment	*Halophila*
78	3.3	6.7	0.0	0.0	68.3	0.0	0.0	11.7	6.7	6.7	*Posidonia*/macroalgae	*Posidonia* sparse
79	26.7	86.7	0.0	0.0	13.3	0.0	0.0	0.0	0.0	0.0	*Posidonia* dense	*Posidonia* dense
80	21.7	93.3	0.0	0.0	6.7	0.0	0.0	0.0	0.0	0.0	*Posidonia* dense	*Posidonia* dense
81	20.0	26.7	0.0	0.0	1.7	3.3	0.0	0.0	68.3	0.0	*Halophila*/red macroalgae	*Posidonia* sparse
82	25.0	35.0	1.7	0.0	53.3	8.3	0.0	0.0	1.7	0.0	*Posidonia* mod	*Posidonia* moderate density
83	16.7	31.7	0.0	0.0	65.0	3.3	0.0	0.0	0.0	0.0	*Posidonia* mod	*Posidonia* sparse
84	3.3	5.0	0.0	0.0	55.0	15.0	0.0	0.0	18.3	6.7	Red macroalgae sparse/turf	*Posidonia* sparse
85	25.0	38.3	0.0	0.0	36.7	25.0	0.0	0.0	0.0	0.0	*Posidonia* mod. to high density	*Posidonia* moderate density

Site	Epiphytes	*Posidonia*	*Halophila*	*Zostera*	Sediment	Turf	Green macroalgae	Brown macroalgae	Red macroalgae	Filter feeders	Cluster-based class	Rule-based class
86	41.7	58.3	0.0	0.0	38.3	3.3	0.0	0.0	0.0	0.0	*Posidonia* mod. to high density	*Posidonia* moderate density
87	10.0	28.3	0.0	0.0	56.7	5.0	0.0	0.0	10.0	0.0	*Posidonia* mod	*Posidonia* sparse
88	6.7	15.0	0.0	0.0	75.0	8.3	0.0	0.0	0.0	1.7	*Posidonia* sparse	*Posidonia* sparse
89	8.3	21.7	0.0	0.0	63.3	13.3	0.0	0.0	1.0	0.0	*Posidonia* mod	*Posidonia* sparse
90	5.0	40.0	0.0	0.0	53.3	6.7	0.0	0.0	0.0	0.0	*Posidonia* mod	*Posidonia* moderate density
91	0.0	0.0	0.0	23.3	61.7	10.0	0.0	0.0	3.3	1.7	Turf sparse	*Zostera*
92	53.3	65.0	0.0	0.0	16.7	13.3	0.0	0.0	3.3	1.7	*Posidonia* dense	*Posidonia* moderate density
93	73.3	88.3	0.0	0.0	1.7	10.0	0.0	0.0	0.0	0.0	*Posidonia* dense	*Posidonia* dense
94	60.0	76.7	0.0	0.0	8.3	15.0	0.0	0.0	0.0	0.0	*Posidonia* dense	*Posidonia* dense
95	68.3	78.3	0.0	0.0	1.7	18.3	0.0	0.0	1.7	0.0	*Posidonia* dense	*Posidonia* dense
96	50.0	66.7	0.0	0.0	1.7	28.3	0.0	3.3	0.0	0.0	*Posidonia* dense	*Posidonia* dense
97	48.3	61.7	0.0	0.0	6.7	31.7	0.0	0.0	0.0	0.0	*Posidonia* dense	*Posidonia* moderate density
98	25.0	46.7	0.0	0.0	50.0	1.7	0.0	0.0	1.7	0.0	*Posidonia* mod. to high density	*Posidonia* moderate density
99	1.7	1.7	0.0	0.0	60.0	23.3	0.0	0.0	1.7	13.3	Turf sparse	*Posidonia* sparse
100	18.3	38.3	0.0	0.0	55.0	6.7	0.0	0.0	0.0	0.0	*Posidonia* mod	*Posidonia* moderate density
101	36.7	45.0	0.0	0.0	40.0	13.3	0.0	1.7	0.0	0.0	*Posidonia* mod. to high density	*Posidonia* moderate density
102	46.7	51.7	0.0	0.0	1.7	35.0	0.0	10.0	1.7	0.0	*Posidonia* dense	*Posidonia* moderate density
103	76.7	78.3	0.0	0.0	0.0	21.7	0.0	0.0	0.0	0.0	*Posidonia* dense	*Posidonia* dense
104	56.7	65.0	0.0	0.0	16.7	16.7	0.0	1.7	0.0	0.0	*Posidonia* dense	*Posidonia* moderate density
105	45.0	48.3	0.0	0.0	0.0	0.0	48.3	0.0	3.3	0.0	*Posidonia* dense	*Posidonia* moderate density
106	85.0	93.3	0.0	0.0	5.0	1.7	0.0	0.0	0.0	0.0	*Posidonia* dense	*Posidonia* dense
107	55.2	86.2	0.0	0.0	13.8	0.0	0.0	0.0	0.0	0.0	*Posidonia* dense	*Posidonia* dense

Site	Epiphytes	*Posidonia*	*Halophila*	*Zostera*	Sediment	Turf	Green macroalgae	Brown macroalgae	Red macroalgae	Filter feeders	Cluster-based class	Rule-based class
108	60.0	94.5	0.0	0.0	5.5	0.0	0.0	0.0	0.0	0.0	*Posidonia* dense	*Posidonia* dense
109	64.4	94.9	0.0	0.0	5.1	0.0	0.0	0.0	0.0	0.0	*Posidonia* dense	*Posidonia* dense
110	75.0	83.3	0.0	0.0	16.7	0.0	0.0	0.0	0.0	0.0	*Posidonia* dense	*Posidonia* dense
111	8.3	13.3	0.0	0.0	40.0	38.3	0.0	0.0	2.0	5.0	Turf moderate density	*Posidonia* sparse
112	45.0	76.7	0.0	0.0	23.3	0.0	0.0	0.0	0.0	0.0	*Posidonia* dense	*Posidonia* dense
113	57.6	93.2	0.0	0.0	6.8	0.0	0.0	0.0	0.0	0.0	*Posidonia* dense	*Posidonia* dense
114	19.0	65.5	0.0	0.0	31.0	3.4	0.0	0.0	0.0	0.0	*Posidonia* mod. to high density	*Posidonia* moderate density
115	43.6	98.2	0.0	0.0	1.8	0.0	0.0	0.0	0.0	0.0	*Posidonia* dense	*Posidonia* dense
116	28.1	84.2	0.0	0.0	15.8	0.0	0.0	0.0	0.0	0.0	*Posidonia* dense	*Posidonia* dense
117	50.0	91.1	0.0	0.0	8.9	0.0	0.0	0.0	0.0	0.0	*Posidonia* dense	*Posidonia* dense
118	30.4	71.4	0.0	0.0	23.2	3.6	0.0	0.0	1.0	0.0	*Posidonia* dense	*Posidonia* dense
119	6.7	10.0	0.0	0.0	53.3	0.0	0.0	0.0	36.7	0.0	Red macroalgae moderate density	*Posidonia* sparse
120	0.0	0.0	0.0	0.0	85.0	6.7	0.0	0.0	7.7	0.0	Bare sediment	Bare sediment
121	0.0	0.0	0.0	5.0	83.3	8.3	0.0	0.0	2.0	0.0	Bare sediment	*Zostera*
122	0.0	0.0	0.0	1.7	61.7	30.0	0.0	3.3	2.7	0.0	Turf sparse	*Zostera*
123	15.4	50.0	0.0	0.0	25.0	0.0	0.0	13.5	6.0	0.0	*Posidonia* mod. to high density	*Posidonia* moderate density
124	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	Bare sediment	Bare sediment
125	8.3	25.0	0.0	0.0	65.0	3.3	0.0	0.0	3.0	1.7	*Posidonia* mod	*Posidonia* sparse
126	32.8	69.0	0.0	0.0	29.3	0.0	0.0	0.0	1.0	0.0	*Posidonia* dense	*Posidonia* dense
127	39.0	76.3	0.0	0.0	20.3	1.7	0.0	0.0	0.0	1.7	*Posidonia* dense	*Posidonia* dense
128	47.5	83.1	0.0	0.0	16.9	0.0	0.0	0.0	0.0	0.0	*Posidonia* dense	*Posidonia* dense
129	40.0	58.3	0.0	0.0	41.7	0.0	0.0	0.0	0.0	0.0	*Posidonia* mod. to high density	*Posidonia* moderate density

Site	Epiphytes	*Posidonia*	*Halophila*	*Zostera*	Sediment	Turf	Green macroalgae	Brown macroalgae	Red macroalgae	Filter feeders	Cluster-based class	Rule-based class
130	28.1	82.5	0.0	0.0	17.5	0.0	0.0	0.0	0.0	0.0	*Posidonia* dense	*Posidonia* dense
131	6.7	16.7	0.0	0.0	78.3	3.3	0.0	0.0	1.0	0.0	*Posidonia* sparse	*Posidonia* sparse
132	0.0	0.0	0.0	3.3	96.7	0.0	0.0	0.0	0.0	0.0	Bare sediment	*Zostera*
133	11.9	32.2	0.0	0.0	66.1	0.0	0.0	0.0	1.0	0.0	*Posidonia* mod	*Posidonia* sparse
134	25.9	55.2	0.0	0.0	39.7	0.0	0.0	0.0	2.0	1.7	*Posidonia* mod. to high density	*Posidonia* moderate density
135	19.0	46.6	0.0	0.0	25.9	5.2	0.0	12.1	4.0	3.4	*Posidonia* mod. to high density	*Posidonia* moderate density
136	15.0	35.0	0.0	0.0	55.0	1.7	0.0	0.0	4.0	1.7	*Posidonia* mod	*Posidonia* moderate density
137	1.7	1.7	0.0	5.0	83.3	8.3	0.0	0.0	1.0	0.0	Bare sediment	*Posidonia* sparse
138	0.0	0.0	1.7	0.0	66.7	30.0	0.0	0.0	1.7	0.0	Turf sparse	*Halophila*
139	0.0	0.0	0.0	0.0	41.7	53.3	0.0	0.0	2.0	1.7	Turf moderate density	Turf dense
140	0.0	0.0	0.0	0.0	70.0	23.3	0.0	3.3	0.0	3.3	Turf sparse	Turf sparse
141	0.0	0.0	0.0	0.0	76.7	18.3	0.0	0.0	0.0	5.0	Turf sparse	Turf sparse
142	0.0	0.0	0.0	0.0	60.0	38.3	0.0	0.0	0.0	1.7	Turf sparse	Turf sparse
143	0.0	0.0	0.0	0.0	85.0	13.3	0.0	0.0	0.0	1.7	Bare sediment	Turf sparse
144	0.0	0.0	0.0	0.0	91.7	1.7	0.0	1.7	2.0	1.7	Bare sediment	Bare sediment
145	0.0	0.0	0.0	0.0	96.7	1.7	0.0	0.0	1.7	0.0	Bare sediment	Bare sediment
146	0.0	0.0	0.0	0.0	93.3	1.7	0.0	0.0	3.0	0.0	Bare sediment	Bare sediment
147	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	Bare sediment	Bare sediment
148	17.2	41.4	0.0	0.0	48.3	5.2	0.0	0.0	3.0	0.0	*Posidonia* mod. to high density	*Posidonia* moderate density
149	0.0	0.0	0.0	0.0	73.3	25.0	0.0	0.0	1.0	0.0	Turf sparse	Turf sparse
150	0.0	0.0	6.7	0.0	90.0	3.3	0.0	0.0	0.0	0.0	Bare sediment	*Halophila*

Appendix B. PRIMER outputs from habitat classification process

The dendrogram from hierarchical clustering is shown in Figure 10, followed by the output from SIMPER analysis of the groups identified by clustering, and an MDS plot showing site groupings in Figure 11.

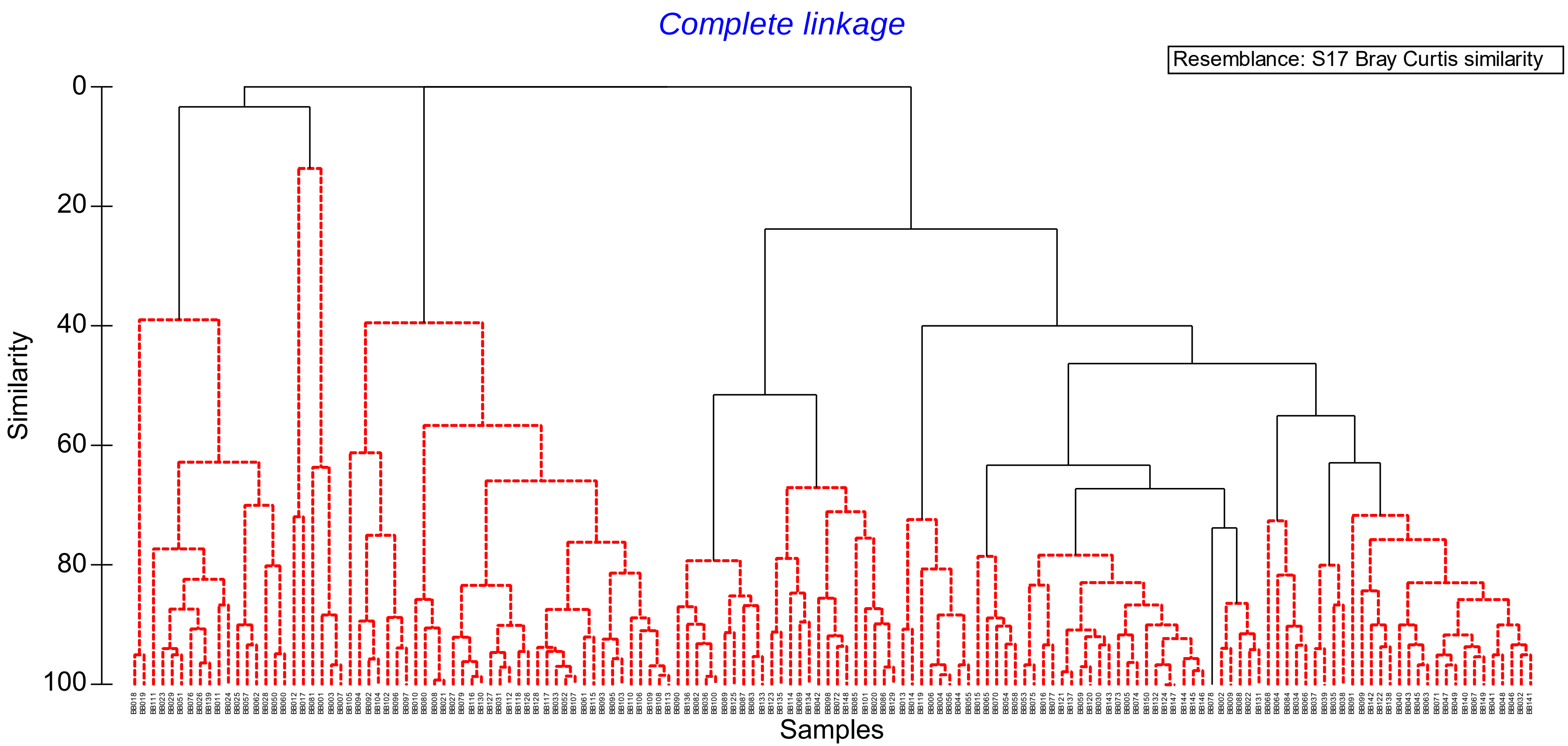

Figure 10. Dendogram showing site clustering according to habitat features identified using Coral Point Count. Red lines show clusters with no significant structure (P<0.01), resulting in 11 groups.

SIMPER
Similarity Percentages - species contributions

One-Way Analysis

Data worksheet
Name: CPC_data(3)
Data type: Abundance
Sample selection: All
Variable selection: All

Parameters
Resemblance: S17 Bray Curtis similarity
Cut off for low contributions: 90.00%

Factor Groups

Sample	CCF2
BB001	b
BB003	b
BB007	b
BB012	b
BB017	b
BB081	b
BB002	j
BB009	j
BB022	j
BB088	j
BB131	j
BB004	f
BB006	f
BB013	f
BB014	f
BB044	f
BB055	f
BB056	f
BB119	f
BB005	h
BB016	h
BB030	h
BB053	h
BB059	h
BB073	h
BB074	h
BB075	h
BB077	h
BB120	h
BB121	h
BB124	h
BB132	h
BB137	h
BB143	h
BB144	h
BB145	h
BB146	h
BB147	h
BB150	h
BB008	c
BB010	c
BB021	c
BB027	c
BB031	c
BB033	c
BB052	c
BB061	c
BB079	c
BB080	c

BB092	c
BB093	c
BB094	c
BB095	c
BB096	c
BB097	c
BB102	c
BB103	c
BB104	c
BB105	c
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BB113	c
BB115	c
BB116	c
BB117	c
BB118	c
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BB130	c
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BB018	a
BB019	a
BB023	a
BB024	a
BB025	a
BB026	a
BB028	a
BB029	a
BB050	a
BB051	a
BB057	a
BB060	a
BB062	a
BB076	a
BB111	a
BB139	a
BB015	g
BB054	g
BB058	g
BB065	g
BB070	g
BB020	e
BB042	e
BB069	e
BB072	e
BB085	e
BB086	e
BB098	e
BB101	e
BB114	e
BB123	e
BB129	e
BB134	e
BB135	e
BB148	e
BB032	m
BB040	m
BB041	m
BB043	m
BB045	m
BB046	m
BB047	m
BB048	m

```
BB049  m
BB063  m
BB067  m
BB071  m
BB091  m
BB099  m
BB122  m
BB138  m
BB140  m
BB141  m
BB142  m
BB149  m
BB034  k
BB064  k
BB066  k
BB068  k
BB084  k
BB035  l
BB037  l
BB038  l
BB039  l
BB036  d
BB082  d
BB083  d
BB087  d
BB089  d
BB090  d
BB100  d
BB125  d
BB133  d
BB136  d
BB078  i
```

Group b
Average similarity: 50.58

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Red algae	57.11	36.53	1.27	72.22	72.22
Sediment	16.39	10.85	1.50	21.45	93.67

Group j
Average similarity: 90.66

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Sediment	79.79	73.28	21.56	80.83	80.83
Posidonia	16.52	14.27	8.64	15.74	96.57

Group f
Average similarity: 86.66

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Sediment	56.01	51.81	7.88	59.79	59.79
Red algae	39.82	34.43	7.91	39.73	99.52

Group h
Average similarity: 88.26

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Sediment	88.25	84.64	16.97	95.90	95.90

Group c
Average similarity: 79.30

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Posidonia	80.81	51.11	4.99	64.46	64.46
Epiphytes	45.92	23.06	2.23	29.07	93.53

Group a
Average similarity: 76.26

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Turf	55.78	46.57	5.69	61.07	61.07
Sediment	33.68	26.62	1.86	34.91	95.98

Group g
Average similarity: 86.25

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Sediment	69.29	67.10	42.61	77.80	77.80
Red algae	15.67	14.07	7.12	16.31	94.11

Group e
Average similarity: 81.57

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Posidonia	49.65	35.77	8.02	43.85	43.85
Sediment	38.66	26.78	4.85	32.82	76.67
Epiphytes	26.47	16.40	3.89	20.11	96.78

Group m
Average similarity: 87.13

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Sediment	68.44	65.47	14.97	75.14	75.14
Turf	21.87	18.34	4.32	21.05	96.19

Group k
Average similarity: 84.48

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Sediment	54.01	50.00	13.14	59.19	59.19
Red algae	19.13	15.62	6.24	18.49	77.67
Turf	16.44	14.76	42.38	17.47	95.15

Group l
Average similarity: 86.18

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Sediment	55.00	52.68	16.05	61.12	61.12
Filter feeders	30.00	26.75	10.44	31.04	92.16

Group d
Average similarity: 87.25

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Sediment	58.78	49.38	12.32	56.60	56.60
Posidonia	32.39	25.52	6.08	29.25	85.84
Epiphytes	13.69	8.84	2.69	10.13	95.98

Group i
Less than 2 samples in group

[Note that this group contains only Site 78 which has 7% *Posidonia*, red macroalgae and filter feeders, and 12% large brown macroalgae]

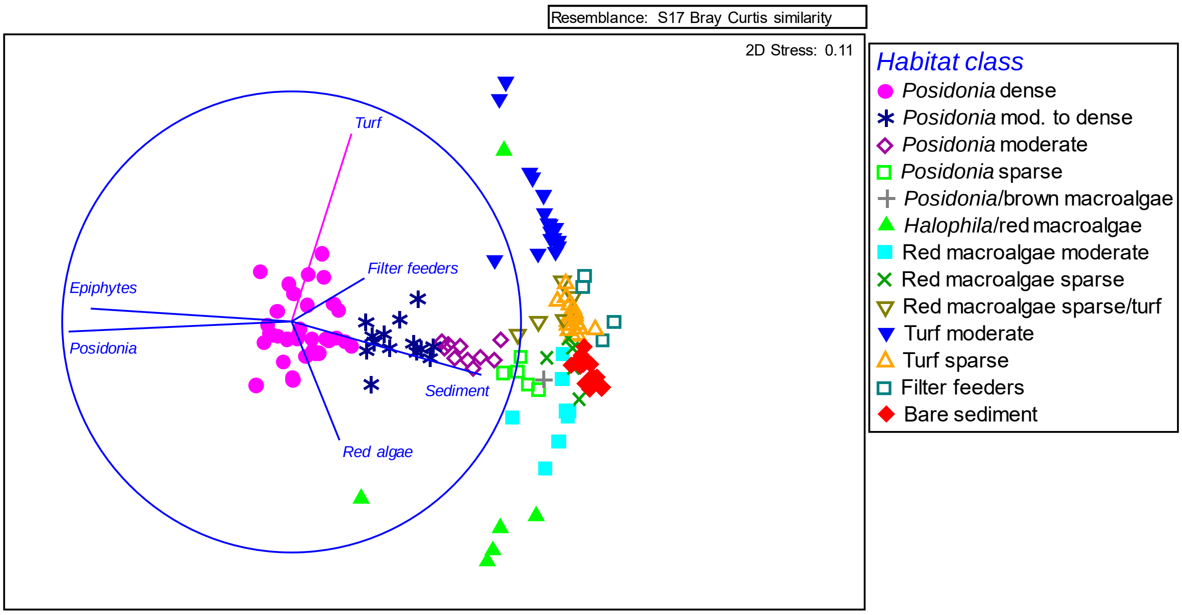

Figure 11. MDS plot showing habitat classes determined using clustering (see Figure 10). Habitat class names describe features identified using SIMPER analysis of groupings identified by CLUSTER. Vectors show correlation (> 0.2) with habitat features.

Appendix Q Marine Habitat Mapping Site Assessment

EP Desalination Project
Habitat Mapping Report

Report for SA Water

J Diversity Pty Ltd

Rev 0
26 May 2024

Cover photo: Strapweed *Posidonia* adjacent to a bivalve bed. November 2023.

Disclaimer

Revision history

Rev	Date	Comment	Author	Reviewed/ approved
A	20/01/2024	Initial Draft	J. Brook	H. Vandeleur
0	26/05/2024	Updated to extend spatial scale of mapping and address review comments.	J. Brook	H. Vandeleur

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Executive Summary

SA Water proposes to construct a desalination plant on the Eyre Peninsula at Billy Lights Point (Port Lincoln) to relieve pressure on the Uley South Basin and provide water security to current customers while also enabling future growth.

This study builds upon previous mapping of Louth, Boston and Proper Bays and presents habitat mapping of the area surrounding the proposed intake and outfall alignments extending eastwards from Billy Lights Point.

Towed video surveys were conducted in November 2023 and May 2024 within a study area that includes contours of predicted 99th percentile exceedances of species protection trigger values, which are a conservative indicator of potentially impacted areas. A total of 282 transects were undertaken, and were supplemented with additional data captured by SA Water in some areas in July 2021. High definition video footage was captured and analysed post-field, with a habitat classification assigned to each second of the video, and a GPS point assigned, subject to some limitations in accuracy.

Habitat classifications were based on combinations of substrate type, composition of habitat forming species, density (percentage cover of the identified species) and epiphyte cover. Density classifications of sparse, medium and dense were delimited with thresholds of 33% and 66%. The habitat forming species included macroalgae, seagrasses and macroinvertebrates, all of which were identified by a literature review for the project as being relevant to the impact assessment.

The habitat features identified during analysis of the towed camera footage included: bare sand, reef and bivalve beds as substrate; the large bodied seagrass *Posidonia* (“strapweed”), mainly *P. australis*, of varying densities and sometimes with dense epiphytes, colonising seagrasses including *Halophila* (“paddleweed”) and *Zostera* (“eelgrass”), macroalgae of varying densities and turf mats; and mixed habitats with two or more of the above components. A total of 45 habitat classifications were used to generate a set of habitat points which are one of the main products of the study and were used to map the distribution of ecosystem components such as large-bodied seagrasses, colonising seagrasses, macroalgae and bivalves (predominantly razor clams).

To produce a polygon-based habitat map that allowed consideration of the mapping within engineering design optimisation, the detailed habitat classification was summarised into a simpler classification that distinguished the main biota groups (seagrass species, macroalgae or bivalves) and simplified density classes. The resultant habitat points were used to guide the manual construction of habitat polygons based on the dominant habitat class within them. Polygon boundaries crossed through significant habitat transitions identified during transects, followed relevant bathymetric contours and bisected the distance between points with different habitat classes. The resulting habitat map distilled a seascape with considerable habitat heterogeneity and complexity in terms of substate type, dominant flora, densities and epiphytes into a dozen broad habitat classes that assisted in informing the design locations and can provide a baseline for future monitoring.

The main patterns observed within the study area include: mainly *Posidonia* seagrass with a small section of reef in the habitat above most of the tunnelled component of the proposed intake and outfall alignments; macroalgae, with a surrounding buffer of sparser macroalgae along most of the seafloor component of the proposed intake and outfall alignments; isolated areas of *Zostera* seagrass mixed with macroalgae towards the end of the outfall alignment, and at several other

locations within the study area; and *Halophila* mixed with macroalgae to the east of the intake and outfall alignments.

It is important that any use of the mapping products from this report have regard to the limitations in precision and accuracy associated with the methods adopted.

1 Introduction

SA Water proposes to construct a desalination plant on the Eyre Peninsula to relieve pressure on the Uley South Basin (the last remaining major productive groundwater source on the Eyre Peninsula suitable for supplying drinking water to the region) and provide water security to current customers while also enabling future growth.

The desalination plant will be located on a section of the former BHP sand export site at Billy Lights Point (Port Lincoln) with the marine pump station and intake/discharge pipelines running out to sea, on decommissioned lagoons at the existing SA Water Port Lincoln Wastewater Treatment Plant (WWTP).

J Diversity Pty Ltd was previously engaged to assist SA Water with broad-scale habitat mapping of Louth, Boston and Proper Bays, based on transects spaced on an approximately one-kilometre grid, surveyed during 2021 and 2022 (J Diversity 2023, Figure 1). The mapping showed that habitats in the area of interest (as defined in Section 2.1) were sparse red macroalgae near and to the east of the intake and outfall alignments, and sparse turf and *Posidonia* seagrass further south (Figure 1).

This study builds upon the previous mapping and presents habitat mapping of the area surrounding the proposed intake and outfall alignments extending eastwards from Billy Lights Point.

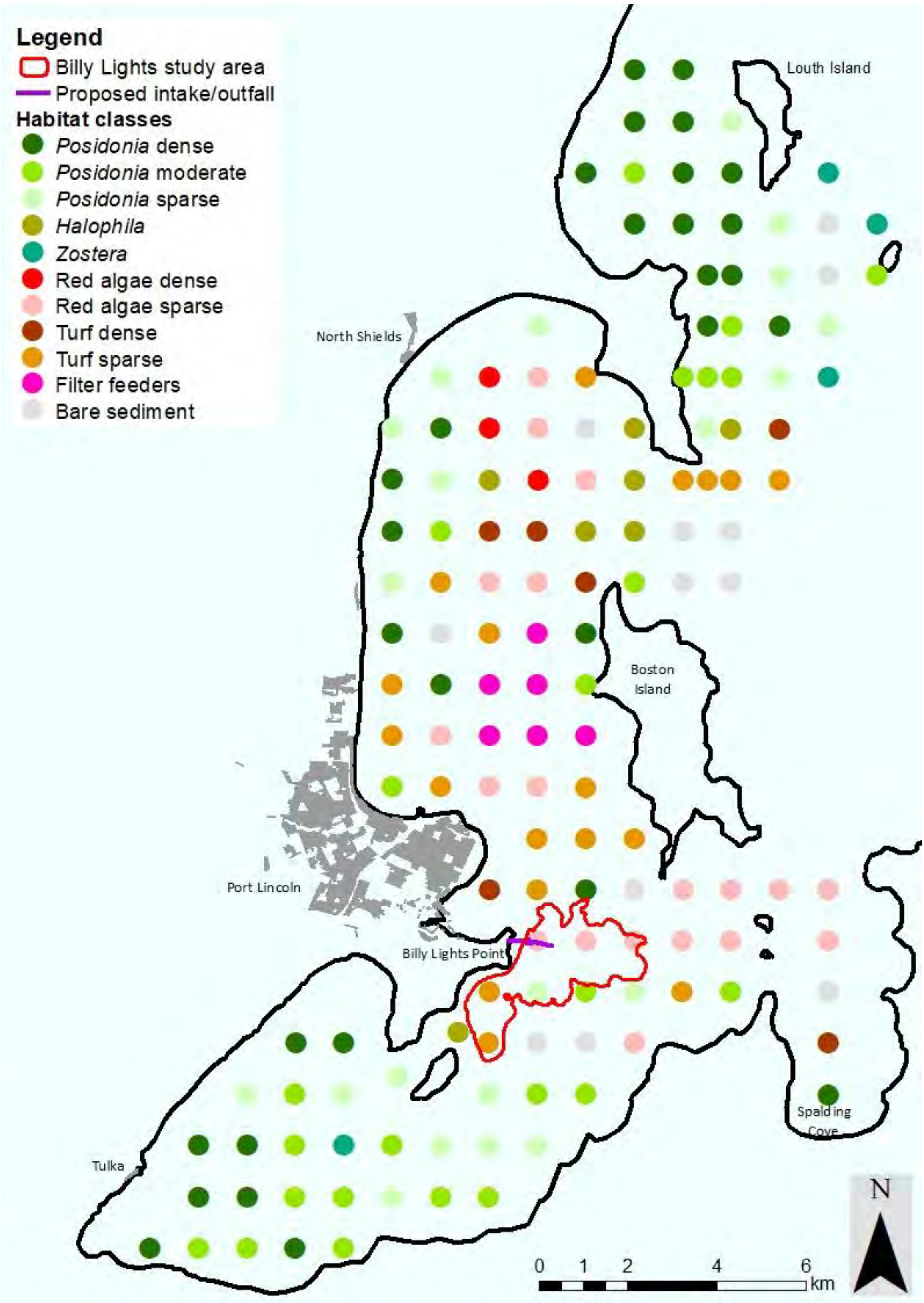


Figure 1. Habitat classes mapped from towed camera surveys undertaken in Louth, Boston and Proper Bays during 2021 and 2022.

2 Methods

2.1 Surveys and sites

Towed camera surveys in the vicinity of Billy Lights Point were undertaken in several phases.

- SA Water completed one transect extending 900 m directly east of the WWTP on 5 July 2021 and three transects of length 150–400 m near the BHP Jetty on 26 July 2021 (Figure 2). This work was in relation to a previous design option for the intake and outfall alignments.
- 70 transects were undertaken near later during analysis of alternative option intake and outfall alignments, on 9 November 2023. These transects were in the direction of the prevailing wind/current and were generally 50 m long. They included (Figure 2):
  - 21 transects along the alignments with start points spaced approximately 50 m apart, each approximately 50 m long
  - 23 transects forming a buffer around the proposed alignment, with start points spaced approximately 100 m apart, and 100 m from the proposed alignment
  - 16 transects covering a broader area 200 m north, 300 m east and 600 m south of the proposed alignment, with start points spaced approximately 200 m apart
  - Five transects near the old and new WWTP outfalls
  - Five transects opportunistically located to capture habitat transitions identified during that survey trip.
- 95 transects were undertaken during 13–14 November 2023 following initial hydrodynamic modelling results of the site. These transects filled gaps in the predicted saline plume locations for both summer (Figure 3) and winter (Figure 3). Spacing of transects was approximately 100 m in the area where predicted salinity increases (99^{th} percentile) were 0.30–0.45 and 200 m where predicted salinity increases were 0.15–0.30. The location of some of these transects was adjusted to capture information relating to particular bathymetric features (Figure 5).
- 117 transects were undertaken during 9–10 May 2024 following further hydrodynamic modelling of the predicted discharge plumes. The study boundary was extended to include the union of the 99^{th} percentile contours for two seasonal modelling scenarios, which extended the area mainly to the south and east (Figure 6). Transects in the extended area were spaced approximately 200 m apart. Additional transects were added to increase the resolution in areas of uncertainty from the previous mapping.

Using a study boundary based on the 99^{th} percentile is considered to very conservative, delimiting an area larger than is likely to be exposed to significant impact from the desalination return water. The overall study area used for this report extends beyond the 99^{th} percentile in a few areas to accommodate all 282 transects (and several extended SA Water transects), including those undertaken before the most recent modelling was available (Figure 6).

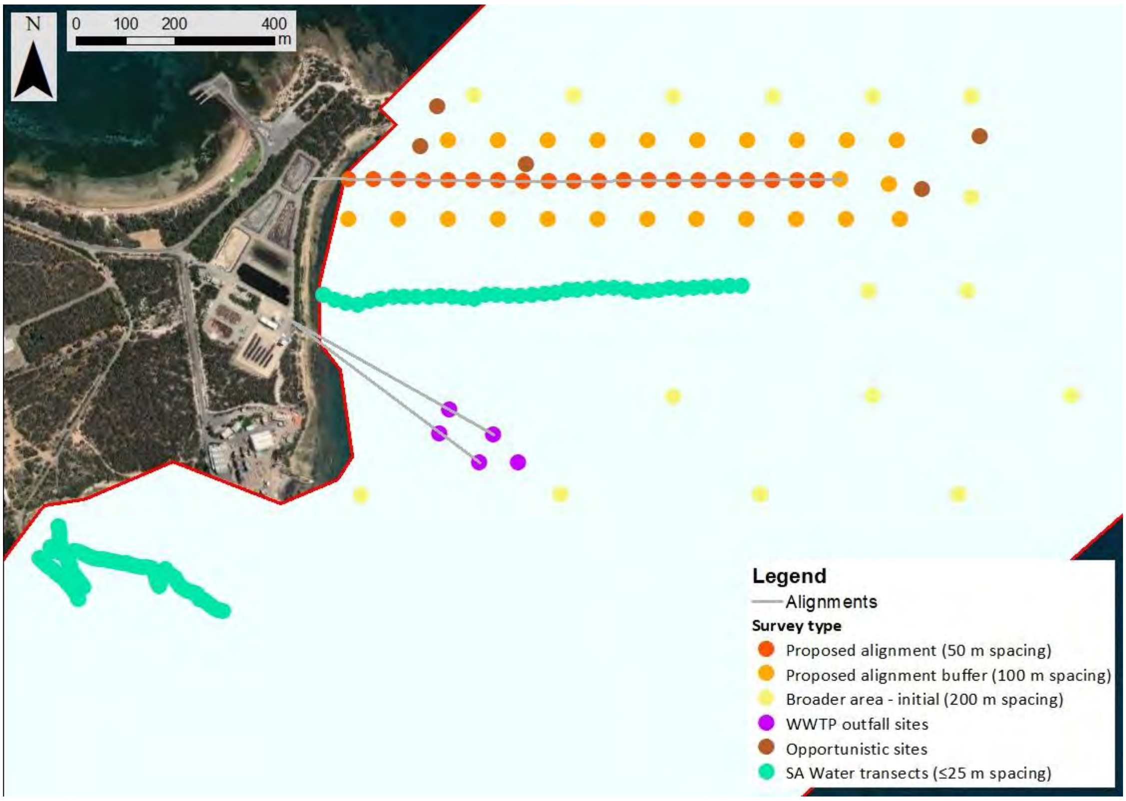


Figure 2. Transect locations during the first survey by J Diversity and previous surveys by SA Water.

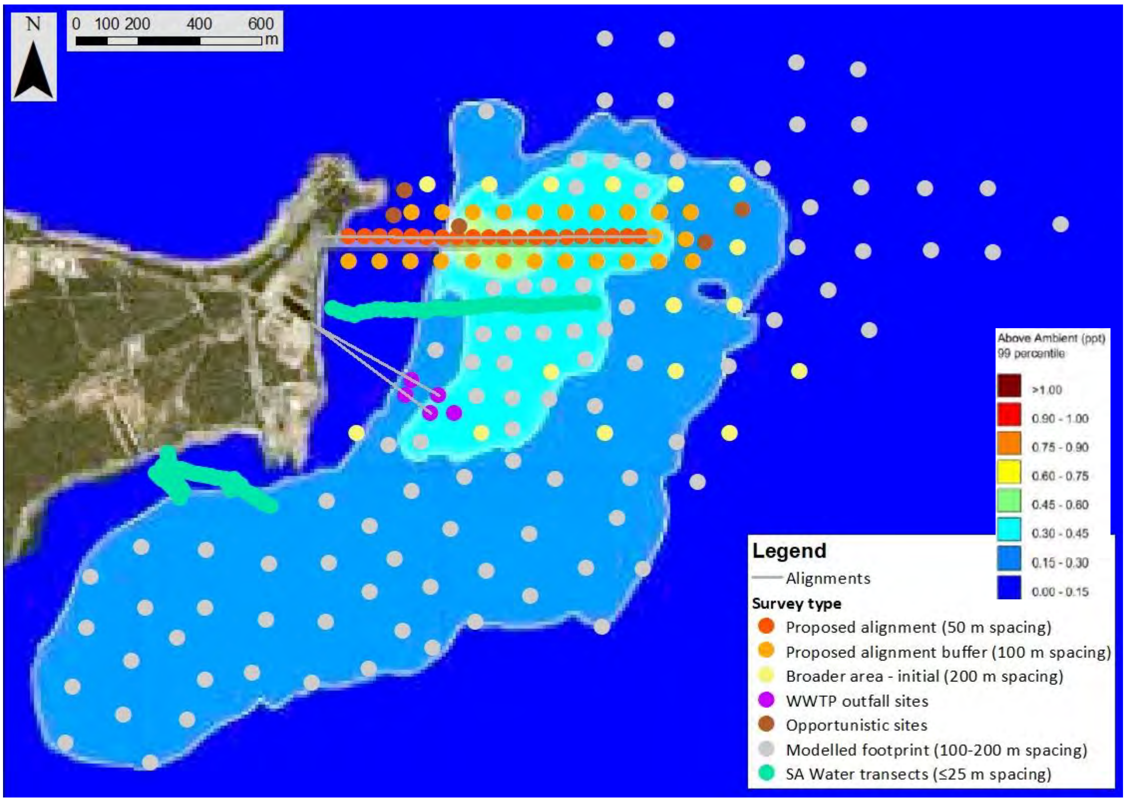


Figure 3. Transect locations from first and second surveys, overlaid on the predicted 99th percentile summer saline plume dispersion map provided by SA Water (extent based on early modelling results).

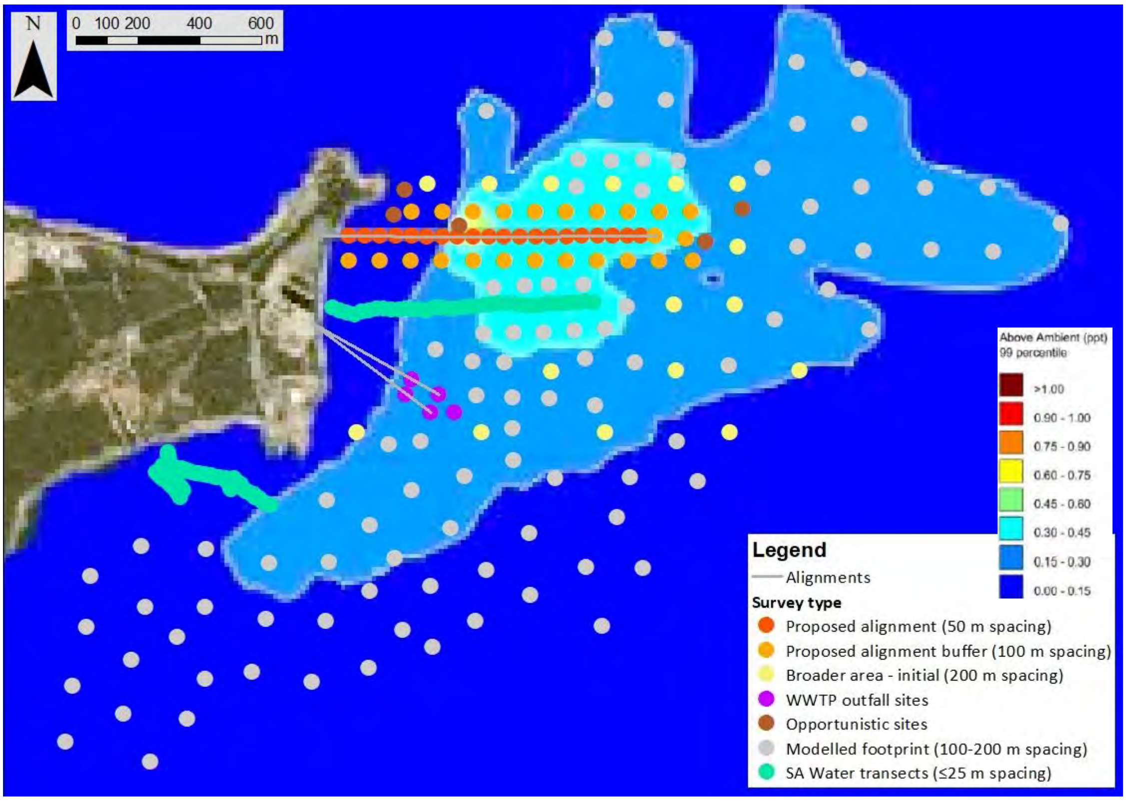


Figure 4. Transect locations from first and second surveys, overlaid on the predicted 99th percentile winter saline plume dispersion map provided by SA Water (extent based on early modelling results).

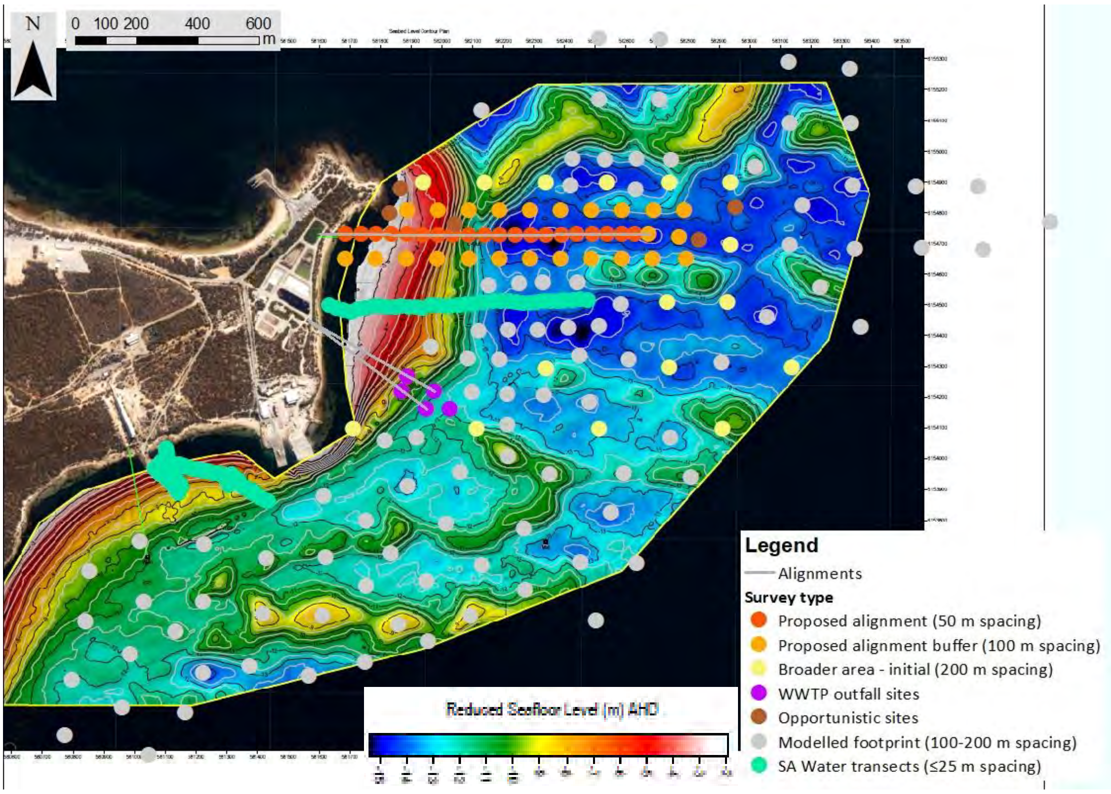


Figure 5. Transect locations from first and second surveys, overlaid on bathymetry map provided by SA Water.

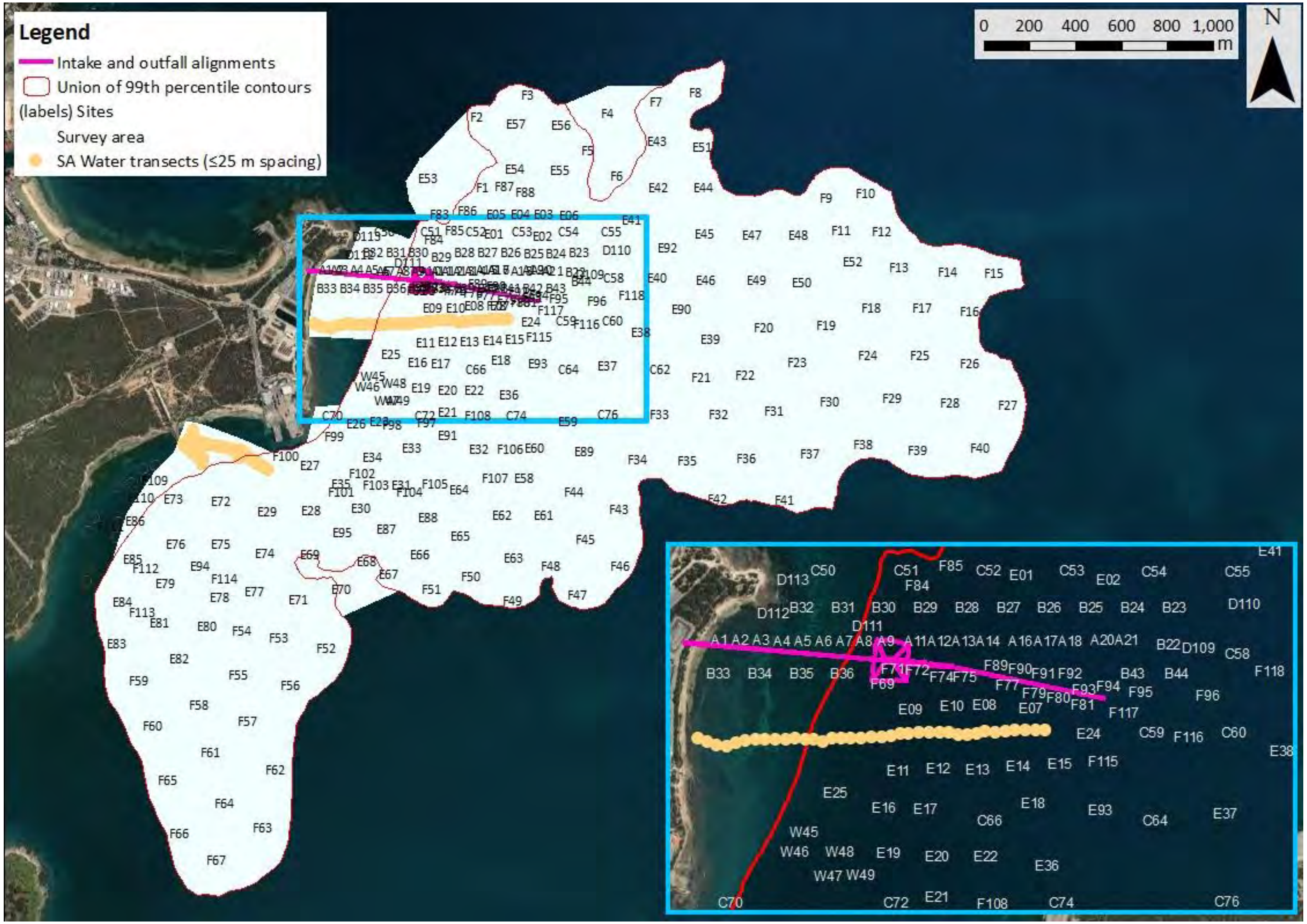


Figure 6. Sites of towed camera surveys undertaken to inform habitat mapping near Billy Lights Point during 2023/24. Note that the inconsistent site labelling scheme reflects the incremental nature of the survey program.

2.2 Camera system

The camera system consisted of:

- a composite standard definition camera aimed 45° below horizontal, and streamed to a screen on the vessel
- two high-definition cameras with wide angle lenses (Go Pro Hero 4), one of which also aimed 45° below horizontal and captured video, and the other which faced downward capturing video and still images at five second intervals.

The camera system was deployed to a depth of about 1 m above the seafloor from a vessel drifting with the wind and current, occasionally using engine bursts to maintain a speed of approximately 0.5–1 knots.

Vessel position was recorded throughout each transect using a handheld, non-differential GPS unit. Video subtitles were generated showing time and GPS position (datum WGS84), noting that time is accurate to within one second and position to within 30 m (allowing for GPS error, the distance moved by the vessel in one second and the lag of the camera, on tether, behind the vessel).

2.3 Map generation

Habitat classifications were informed by and built upon earlier video analysis of habitats throughout Boston and Proper Bays (J Diversity 2023). For that study, two approaches to habitat classification were adopted: multivariate clustering of the outputs from point intercept analysis of representative images from each transect, and a rules-based approach based on ecosystem components identified by Tanner & Drabsch (2021) as being relevant to desalination plant impact assessment, namely macroalgae, seagrasses and invertebrates. The study showed a general convergence of the habitat classes identified by these two approaches (J Diversity 2023).

The current study adopted a habitat mapping classification approach similar to the 'rules-based' approach referred to above. Habitat classes were based on combinations of substrate type, composition of habitat forming species, density (percentage cover of the identified species) and epiphyte cover. Density classifications of sparse, medium and dense were delimited with thresholds of 33% and 66%.

One such habitat class was assigned to each second of video from when the camera reached the seafloor until its retrieval commenced. These habitat points provide the most detail at the finest scale and are an important product of the mapping process used in this report to map particular ecosystem components (*Posidonia* seagrass, colonising seagrasses, macroalgae and bivalves).

To produce a polygon-based habitat map that allowed the design to avoid and mitigate impacts on key habitat and to inform future construction and operational monitoring, the detailed habitat classification was summarised into a simpler classification that distinguished the main biota groups (seagrass species, macroalgae or bivalves) and simplified density classes. The resultant habitat points were used to guide the manual construction of habitat polygons based on the dominant habitat class within them. There were three considerations applied, in order of priority, to place the boundaries such that they:

- crossed through significant habitat transitions identified during transects
- followed relevant bathymetric contours

- bisected the distance between points with different habitat classes in the same manner as the Thiessen polygon algorithm (ESRI 2021).

The polygons were projected using the Map Grid of Australia (Zone 53).

3 Results

The habitat features identified during analysis of the towed camera footage included: bare sand, reef and bivalve beds as substrate; the large bodied seagrass *Posidonia* ("strapweed"), mainly *P. australis* in shallow water (<5 m) and *P. sinuosa* in deeper water, of varying densities and sometimes with dense epiphytes, colonising seagrasses including *Halophila* ("paddleweed") and *Zostera* ("eelgrass"), macroalgae of varying densities and turf mats; and mixed habitats with two or more of the above components.

The full list of habitats is provided in Table 1, which includes references to representative images of many of these habitats.

Posidonia was generally restricted to depths less than 12 m AHD[1] (Figure 7[2]). Inshore, north of the WWTP, *Posidonia* was generally dense and free of epiphytes. It transitioned to reef or bivalve beds near the Point. To the west of the BHP Jetty, it was typically sparse. Beyond depths of approximately 10 m, *Posidonia* was generally interspersed with macroalgae or had epiphytic (plant-covering) filamentous brown macroalgae, except on the bank near the south-eastern corner of the study area. Mixed seagrass communities were observed in deeper water in this area (Figure 7).

The dominant seagrass in depths greater than 12 m was *Halophila*, generally interspersed with macroalgae or turf mats (Figure 8). *Zostera*, generally sparse or in association with *Posidonia* was present at the most inshore sites east of the WWTP (Figure 8).

Macroalgae, often interspersed with turf mats, was present throughout most of the study area (Figure 9). Density was typically low or medium. In the north-eastern corner of the study area, macroalgae was in association with *Halophila*, and near the south-eastern corner, it was in association with *Posidonia*. The most inshore areas north of the WWTP were characterised by reef with sparse macroalgae, becoming dense macroalgae near the Point (Figure 9).

Invertebrate-based habitats, including razor clams and reef-forming bivalve beds (comprised of razor clams, hammer oysters and occasional scallops and mussels) were restricted to inshore areas near the northern tip of Billy Lights Point, or south-west of the BHP Jetty (Figure 10).

The habitat polygons and habitat points used to identify them in Figure 11, along with the 12 m bathymetric contour that influenced the placement of many boundaries, and the habitat map based on these polygons is shown in Figure 12.

---

[1] Below Australian Height Datum

[2] Note that at the map scale of this and subsequent figures, points may be largely obscured by other points from the same transect.

Table 1. Habitat classes identified from towed camera footage

Habitat class	Points	Image	Map habitat class
Posidonia dense	1348	Plate 1	*Posidonia*
Posidonia dense/epiphytes	1767	Plate 2	*Posidonia*
Posidonia dense/turf	31		*Posidonia*
Posidonia medium	406	Plate 3	*Posidonia*
Posidonia medium/epiphytes	590		*Posidonia*
Posidonia medium/turf	139		*Posidonia*
Posidonia sparse	432	Plate 4	*Posidonia* sparse
Posidonia sparse/epiphytes	175		*Posidonia* sparse
Posidonia sparse/turf	57		*Posidonia* sparse
Posidonia/*Zostera*	52	Plate 5	*Posidonia* mixed
Posidonia/*Zostera*/*Halophila*	44		*Posidonia* mixed
Posidonia/*Zostera*/*Halophila*/macroalgae	76		*Posidonia* mixed
Posidonia/*Zostera*/macroalgae	51		*Posidonia* mixed
Posidonia/*Halophila*	108	Plate 6	*Posidonia* mixed
Posidonia/*Halophila*/macroalgae	515	Plate 7	*Posidonia* mixed
Posidonia/*Halophila*/turf	10		*Posidonia* mixed
Posidonia/macroalgae	2419	Plate 8	*Posidonia*/macroalgae
Posidonia/macroalgae/turf	220		*Posidonia*/macroalgae
Posidonia/reef	208	Plate 9	*Posidonia*/macroalgae
Posidonia/bivalve bed	225		*Posidonia*
Posidonia medium/razor clams	11		*Posidonia*/bivalves
Posidonia sparse/razor clams	50		*Posidonia*/bivalves
Zostera	44	Plate 10	*Zostera*
Zostera sparse	91		*Zostera* sparse
Zostera/*Halophila*	76	Plate 11	Seagrass mixed
Zostera/*Halophila*/macroalgae	8		Seagrass mixed
Zostera/macroalgae	153	Plate 12	*Zostera*/macroalgae
Halophila	26	Plate 13	*Halophila*
Halophila/macroalgae	2088	Plate 14	*Halophila*/macroalgae
Halophila/turf	20		*Halophila*/macroalgae
Halophila/macroalgae/turf	383		*Halophila*/macroalgae
Reef/dense macroalgae	51	Plate 15	Reef
Reef/sparse macroalgae	86	Plate 16	Reef
Macroalgae dense	599	Plate 17	Macroalgae
Macroalgae dense/turf	199		Macroalgae
Macroalgae medium	1148	Plate 18	Macroalgae
Macroalgae medium/turf	1055		Macroalgae
Macroalgae sparse	2760		Macroalgae sparse
Macroalgae sparse/turf	1564	Plate 19	Macroalgae sparse
Turf	107		Turf mat
Bivalve bed	65	Plate 20	Bivalves
Bivalve bed/macroalgae	21	Plate 21	Bivalves
Razor clams	8	Plate 22	Bivalves
Razor clams/turf	4		Bivalves
Sand	440		Sand

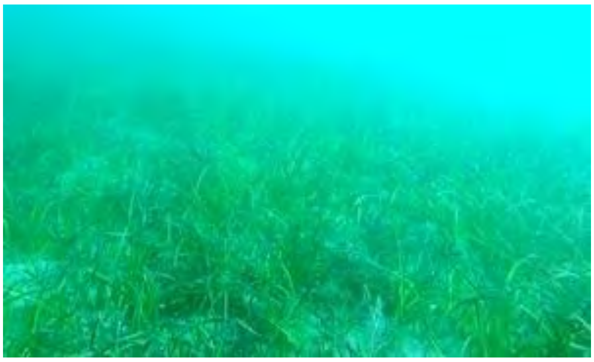


Plate 1. Dense *Posidonia*

Plate 2. Dense *Posidonia* with epiphytes

Plate 3. Medium density *Posidonia*

Plate 4. Sparse *Posidonia*

Plate 5. *Posidonia* and *Zostera*

Plate 6. *Posidonia* and *Halophila*

Plate 7. *Posidonia*, *Halophila* and macroalgae

Plate 8. *Posidonia* and macroalgae

Plate 9. *Posidonia* and reef with macroalgae

Plate 10. *Zostera*

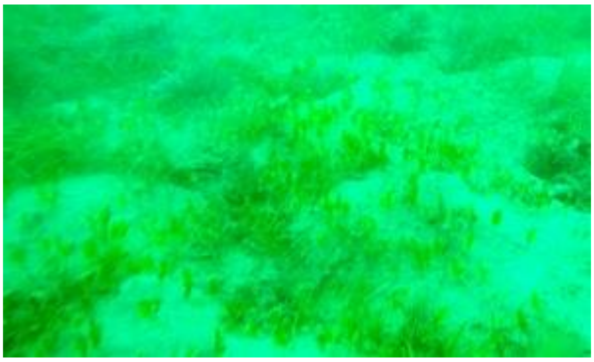


Plate 11. *Zostera* and *Halophila*

Plate 12. *Zostera* and macroalgae

Plate 13. *Halophila*

Plate 14. *Halophila* and macroalgae

Plate 15. Reef with dense macroalgae

Plate 16. Reef with sparse macroalgae

Plate 17. Dense macroalgae

Plate 18. Medium density macroalgae

Plate 19. Sparse macroalgae and turf mat

Plate 20. Bivalve bed

Plate 21. Bivalves with macroalgae

Plate 22. Razor clams

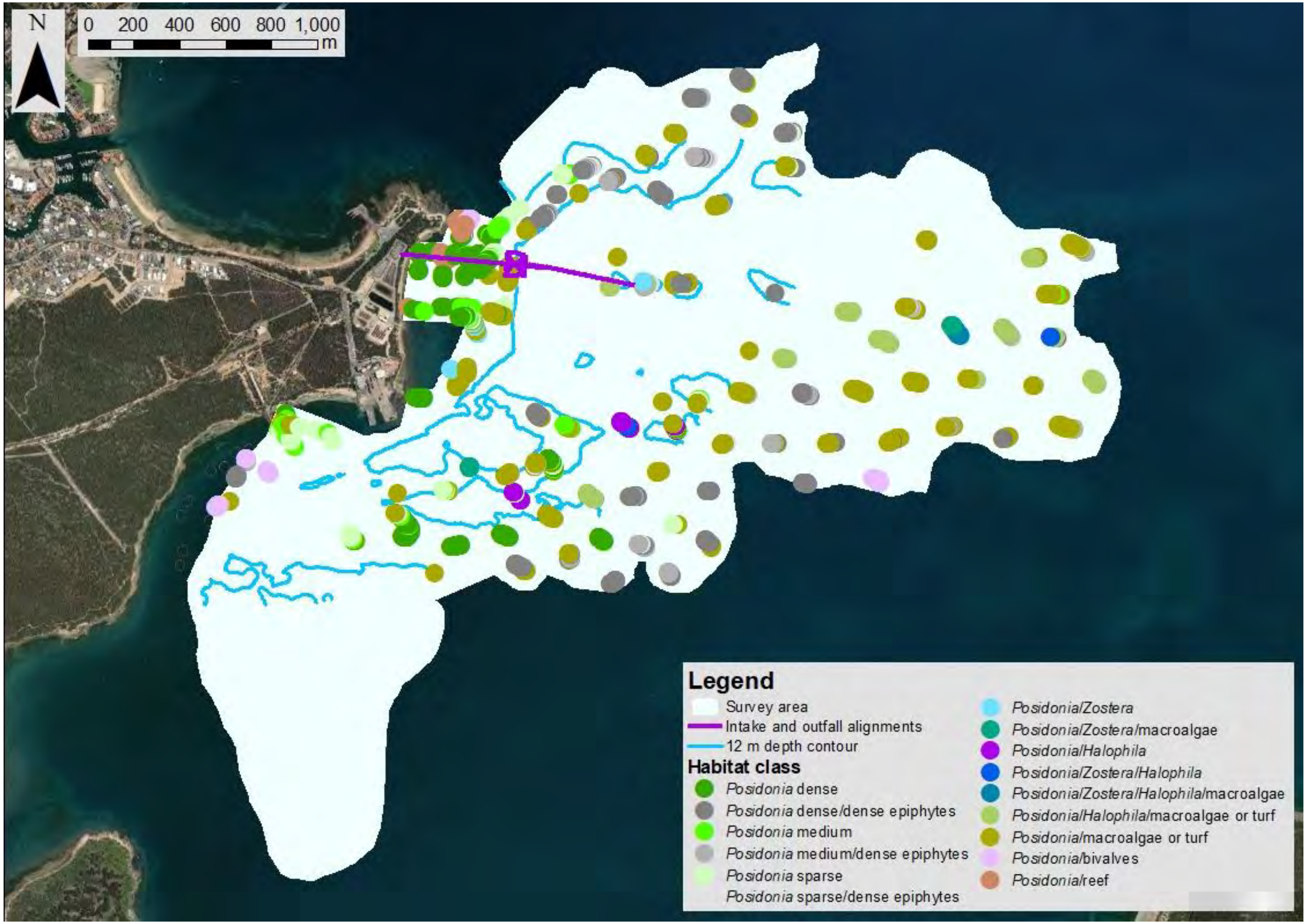


Figure 7. *Posidonia* habitat points.

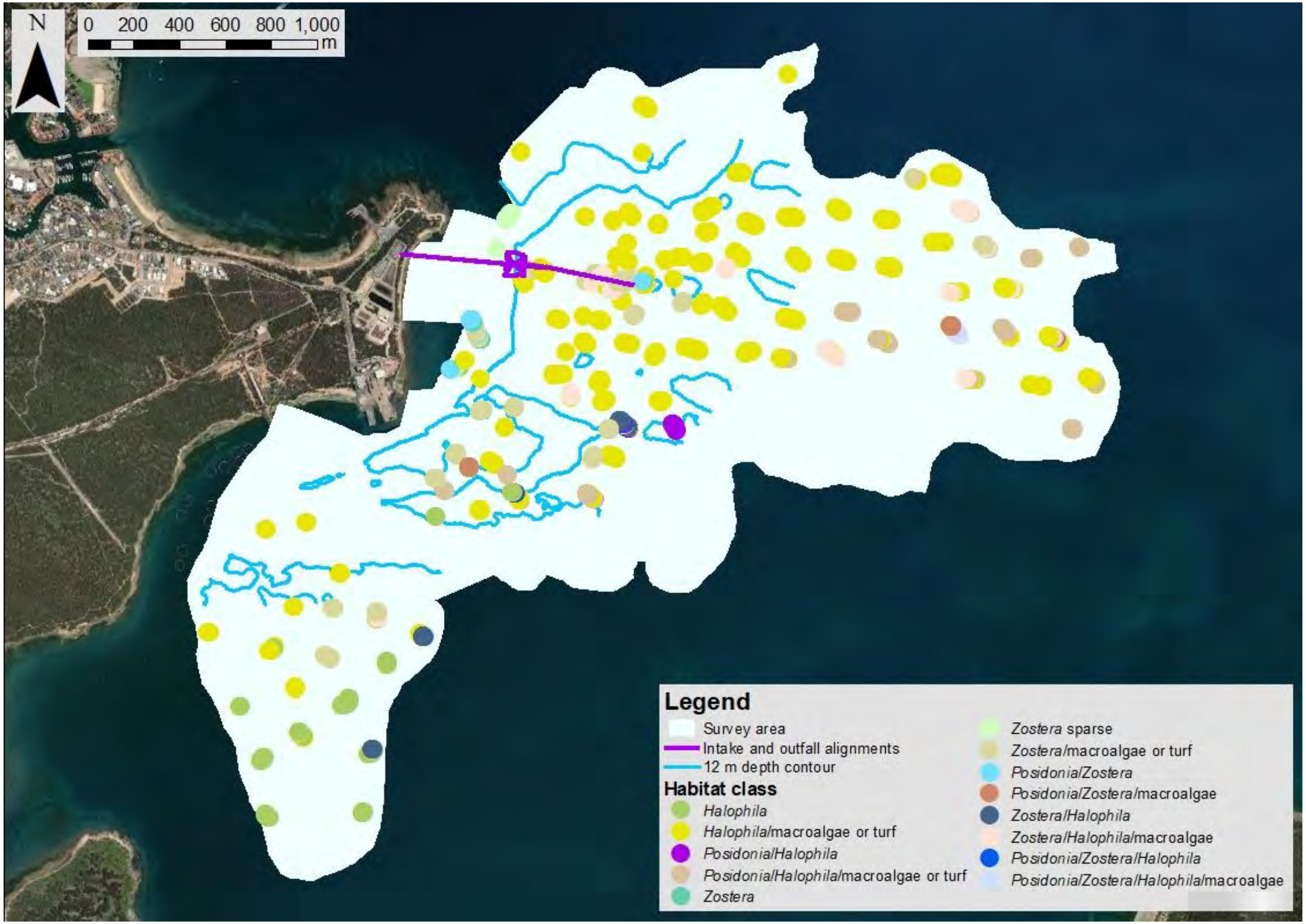


Figure 8. Colonising seagrass (*Zostera* and *Halophila*) habitat points

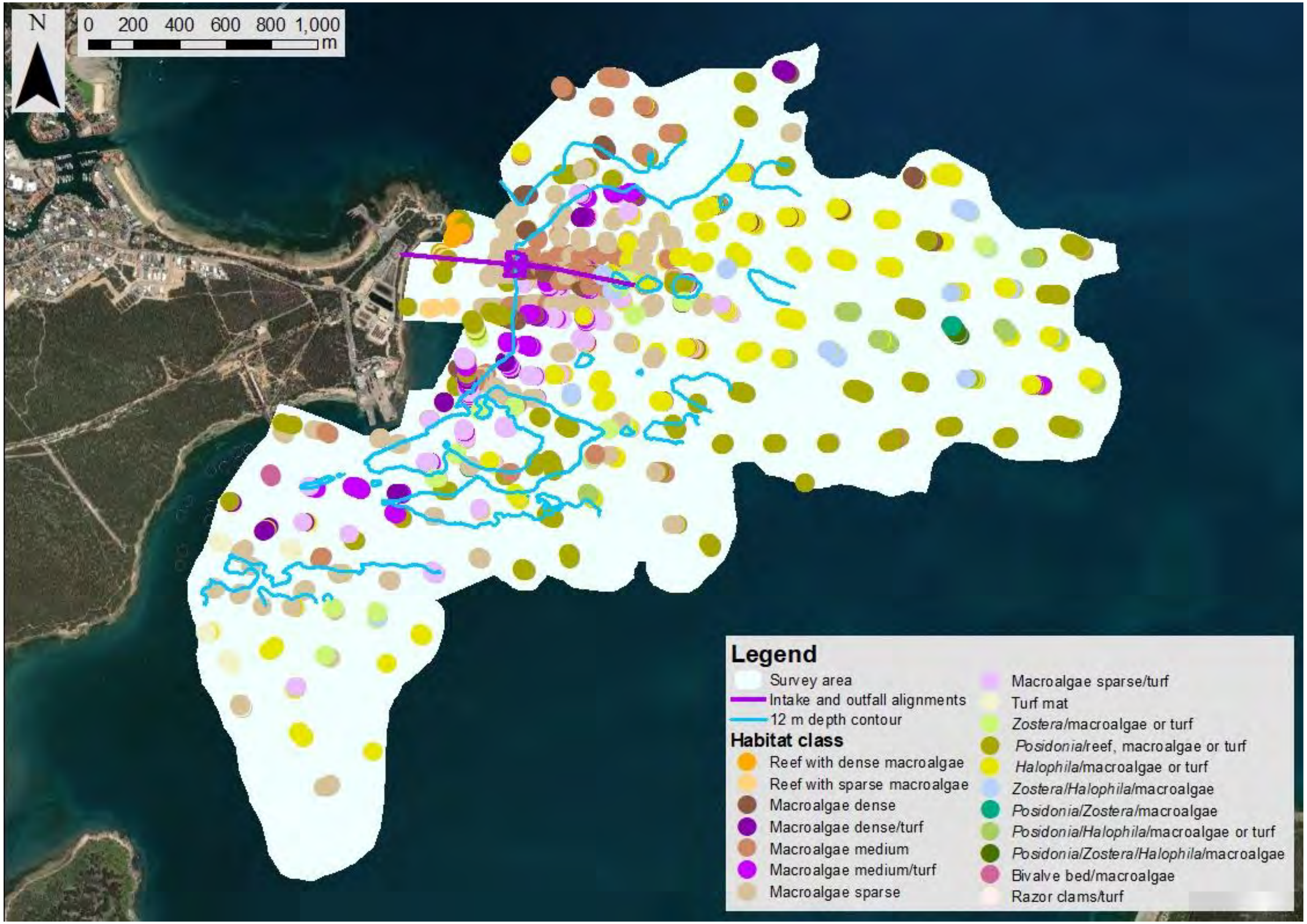


Figure 9. Macroalgae habitat points

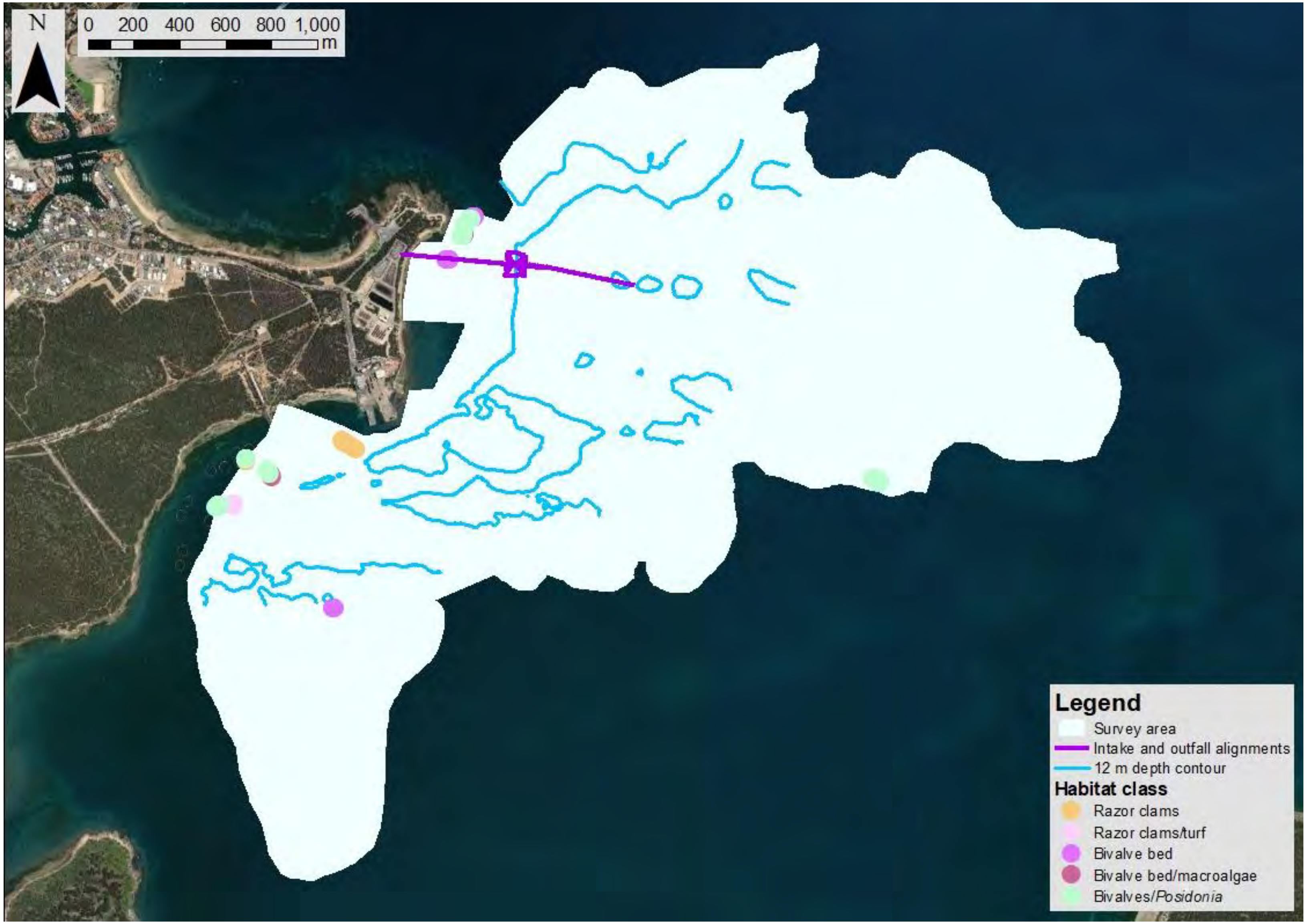


Figure 10. Invertebrate –based habitat points

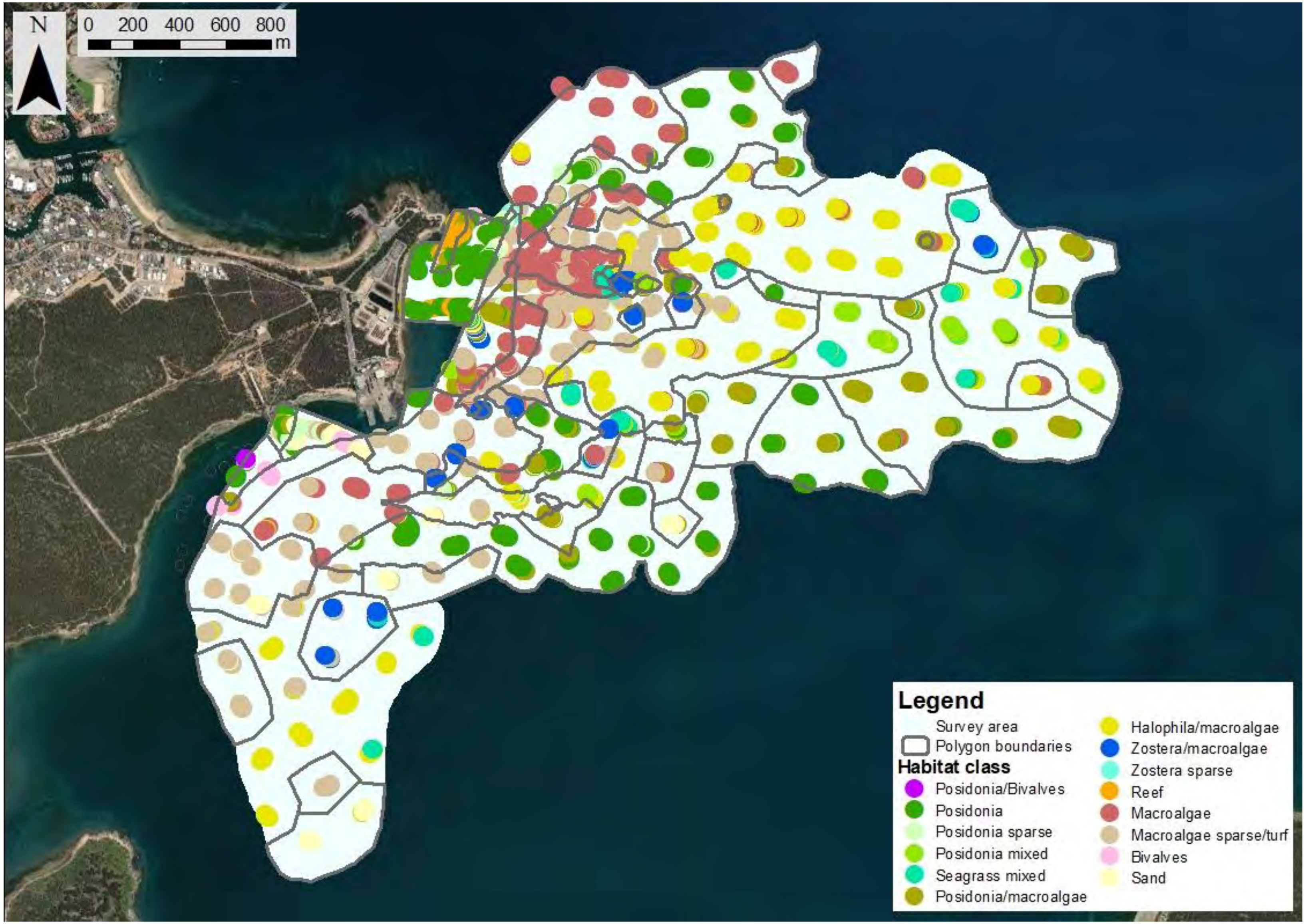


Figure 11. Habitat polygon boundaries overlaid with habitat points and the 12 m bathymetric contours.

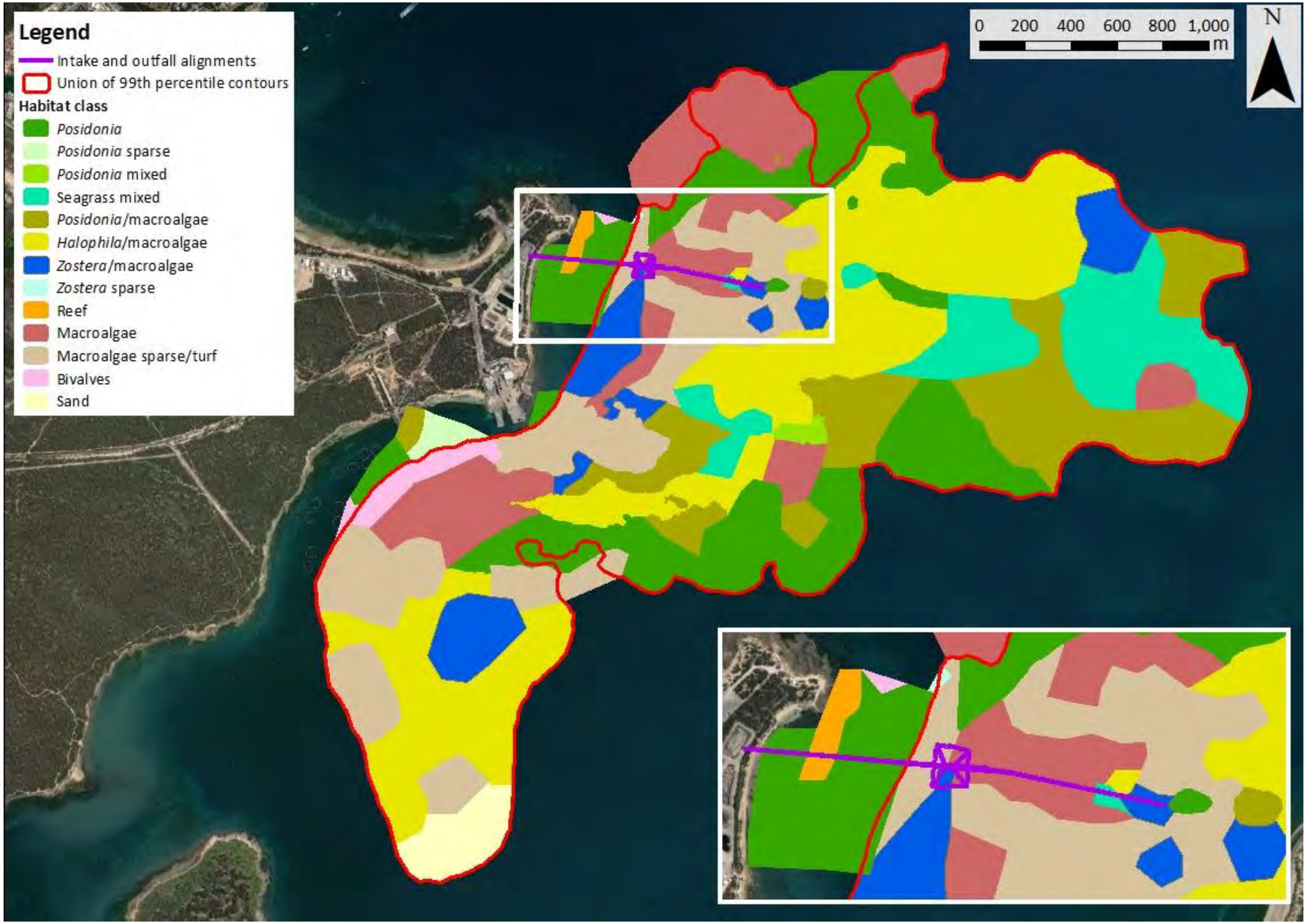


Figure 12. Habitat polygons based on broad habitat classes shown in Table 1, and indicating polygons with a relative low certainty of the habitat classification.

4 Discussion

The habitat map generated in Figure 12 distills a seascape with considerable habitat heterogeneity and complexity in terms of substate type, dominant flora, densities and epiphytes into a dozen broad habitat classes that can be used toinform the design location and future constrcution and operational monitoring of outfall locations.

The accuracy of the map is largely reliant on the spatial resolution of the underlying habitat points, which is variable, with higher concentrations along the proposed (and previously proposed) alignments and the lowest in areas where salinity increases will be lowest (Section 2.2). Furthermore, there are limitations to the spatial accuracy of boundaries across the extent of the map that are inherent in towed camera operations (Section 2.2). In some cases, an assumption was made that, at the scale of tens of metres, that the bathymetry contour will more accurately reflect boundaries with seagrass habitats.

Any use of this map should be informed by the detail provided in Figure 7 to Figure 10 and the information provided in Section 2.2 about spatial accuracy. More generally, it is important to recognise the limitations associated with mapping an area with considerable variability at the scale of metres based on a grid spacing of tens to hundreds of metres.

Nevertheless, the maps provided are considered to show a useful representation of the habitats in the study area. The main patterns observed were (Figure 12):

- *Posidonia* seagrass and a small section of reef above most of the tunnelled component of the proposed intake and outfall alignments
- macroalgae, with a surrounding buffer of sparser macroalgae along most of the seafloor component of the proposed intake and outfall alignments
- isolated areas of *Zostera* seagrass mixed with macroalgae towards the end of the outfall alignment, and at several other locations within the study area.
- *Halophila* mixed with macroalgae to the east of the intake and outfall alignments
- *Posidonia*, with dense epiphytes (Figure 7), near the northern extent of the study area, but also areas of macroalgae
- *Posidonia*, sometimes mixed with macroalgae, or with dense epiphytes (Figure 7), towards the south-eastern extent of the study area
- *Halophila* mixed with macroalgae near the southern extent of the study area
- Bivalves (predominantly razor clams) near the western extent of the study area

5 References

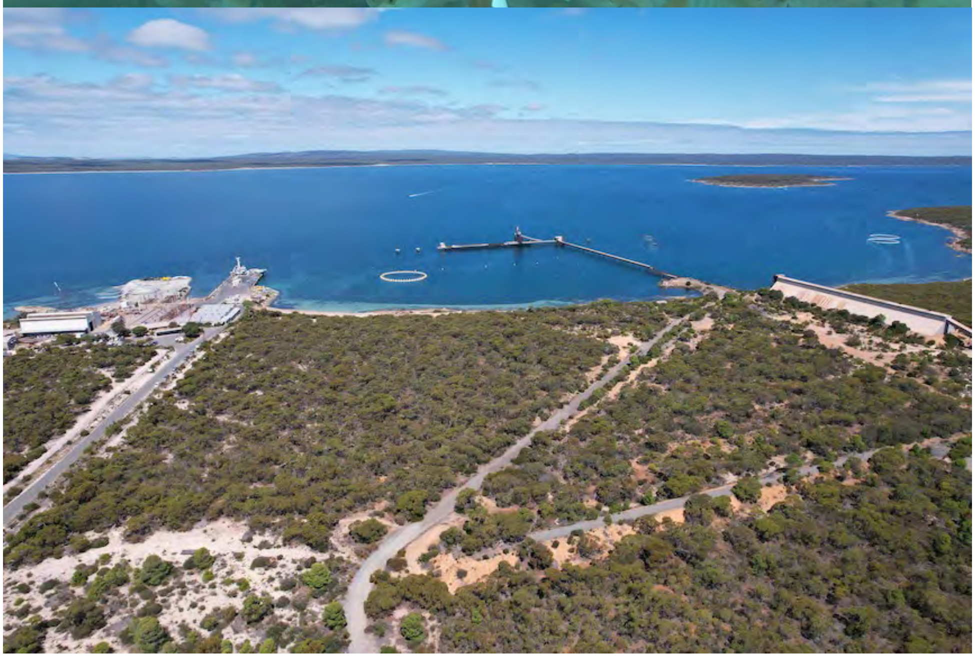
ESRI (2021), *Create Thiessen Polygons*, ArcMap 10.8 Help archive.

J Diversity (2023), *Boston Bay Marine Habitat Video Analysis,* Report to SA Water by J Diversity Pty Ltd.

Tanner, JE & Drabsch, S (2021). *Literature review of potential impacts of desalination discharges in Boston Bay, with particular reference to Aquaculture*. South Australian Research and Development Institute (Aquatic Sciences), Adelaide. SARDI Publication No. F2021/000299-1. SARDI Research Report Series No. 1105. 17pp.

Appendix R Baited Fish Assessment

Baseline assessment of fish diversity and abundance at the proposed Boston Bay desalination site (March 2024)



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1. EXECUTIVE SUMMARY

Security of water supplies is a key state government priority for regional communities in South Australia. The proposed desalination project site is situated ~4 km southeast of Port Lincoln township near Billy Lights Point, with intake and outfall pipes into Proper and Boston Bays (Figure 1). The site is located on land previously owned by BHP and now owned by Lukin Corporation. The project involves the construction of a new 5.3 GL/a with the ability to upgrade to 8 GL/a desalination plant and all necessary associated infrastructure including an above ground power supply, infrastructure for sourcing and treating seawater, transferring the treated drinking water to SA Water's existing network system, and returning the saline concentrate from the desalination plant to the ocean.

SA Water engaged Flinders University to conduct a preliminary assessment of fish abundance and diversity using Baited Remote Underwater Video Stations (BRUVS) at the proposed site of the desalination outfall to assess potential impacts on the marine environment. Two sites (to the north and south) outside the proposed outfall location were also assessed as control sites.

Surveys of fish abundance and diversity at the proposed outfall site and control sites were conducted in October 2021, May 2022, and March 2024. Substrata at each survey were characterised where the BRUVS landed, confirming that all three sites were primarily composed of silt/sand with high epiphyte loading and sparse sponge gardens. Across three years of sampling, 38 fish species were identified, consisting of teletosts (27 species), decapods (5 species), chondrichthyans (3 species), Cephalopods (3 species), and one species of marine mammal. Fish communities at the proposed outfall site differed from those at the northern control site, but were no different to that at the southern control site. However, temporal changes in assemblages were observed, with significant differences detected across sampling periods. These findings offer a preliminary insight into the fish communities around Boston Bay and the proposed outfall site, and offer a baseline assessment which should be used to assess future changes in fish assemblages.

2. ACKNOWLEDGEMENTS

We acknowledge Tim Kildae and Hazel Vandeleur (SA Water) for assistance in planning field work; Chloe Roberts (2021 and 2022), Joshua Davey (2021), Taryn-Lee Perrior (2021), Matt Lloyd (2022), Laura Holmes (2022), Oli Petersen (2024), Bradley Hayman (2024), and Brianna Hobby (2024) for assistance in the field; and Sasha Whitmarsh for contributions to species identification.

3. BACKGROUND

Security of water supplies is a key state government priority for regional communities in South Australia. The proposed project site is approximately 4 km southeast of Port Lincoln township with intake and outfall pipes into Proper and Boston Bay (Figure 1). The site is located on land previously owned by BHP and now owned by Lukin Corporation. The proposed project involves the construction of a new 5.3 GL/a with the ability to upgrade to 8 GL/a desalination plant and all necessary associated infrastructure including an above ground power supply, infrastructure for sourcing the seawater, treating the seawater, transferring the treated drinking water to SA Water's existing network system, and returning the saline concentrate from the desalination plant to the ocean.

SA Water has committed to a thorough assessment and management of potential risks to the marine environment. As part of this assessment, SA Water engaged Flinders University to conduct a preliminary assessment of fish abundance and diversity at the proposed site of the desalination outfall location to assess potential impacts on the marine environment. Fish communities were initially surveyed in October 2021 and May 2022, with a subsequent survey in March 2024. Two sites outside the proposed outfall location were also assessed as control sites (northern and southern control sites).

4. METHODS

Surveys of fish communities followed previous methods detailed in reports from Dennis & Huveneers (2021) and Clarke & Huveneers (2022). Fish assemblages were assessed using Baited Remote Underwater Video Stations (BRUVS). BRUVS are a frequent method for assessing communities of fish (Whitmarsh et al. 2017, Langlois et al. 2020), and have previously been applied to a wide range of studies, including the assessment of the efficacy of marine protected areas, effects of anthropogenic impacts, or spatial variation in fish communities (Folpp et al. 2014, Whitmarsh et al. 2014, Clarke et al. 2019, Whitmarsh 2019). Studies comparing BRUVS to other sampling methods have shown that BRUVS is well suited to sample mobile species but may underrepresent small, cryptic species that are undetected (Langlois et al. 2010, Harvey et al. 2012, Whitmarsh et al. 2017, Whitmarsh et al. 2018).

During each sampling period (October 2021, May 2022, March 2024), eight BRUVS replicates were deployed at each the proposed outfall site, and two control sites ~1.5 km to the north and south of the outfall site (72 deployments total; 24 each sampling period; Figure 1). Replicates within each sampling site were deployed a minimum of ~400 m apart to avoid potential for double-counting the same individual fish between replicates (Bouchet & Meeuwig 2015, Langlois et al. 2020). GoPro Hero 7 Black cameras (wide angle, resolution 720 p, acquisition 60 frames per second, GoPro Inc., San Mateo, CA, USA, gopro.com), were attached to steel BRUVS frames. These cameras were selected due to their relative low cost, ability to record in high definition, long battery life, wide-angle viewing, and image quality in low light conditions. Mono (single), horizontal set-ups were used rather than a stereo as fish lengths were not measured in this study. Each BRUVS was baited with 500 g of minced sardines (*Sardinops sagax*) and set to continuously record over a deployment of 1 h before retrieval. Deployment locations were similar across surveys (i.e. October 2021, May 2022, and March 2024) to enable comparison of fish assemblages over time.

Videos collected from BRUVS were analysed using the specialised SeaGIS EventMeasure software (SeaGIS Pty Ltd, Bacchus Marsh, VIC, Australia; seagis.com.au/event.html). On each replicate, taxa were identified to the finest taxonomic level where possible (mostly species; Gomon et al. 2008) and counted using the relative abundance measure, MaxN. MaxN is the maximum number of individual fish (for each species or taxon) observed in a single frame throughout the deployment duration (Priede et al. 1994). Thus, MaxN is a conservative estimate of abundance, particularly where large fish numbers are present or there is a large turnover of individuals during deployment (Priede et al. 1994, Ellis & DeMartini 1995, Willis & Babcock 2000). Most species were easily distinguishable, but, if taxa were not able to be reliably identified to species level, then they were grouped into genus, e.g. two trevally species could not be differentiated and thus were grouped as *Pseudocaranx* spp.

Statistical analyses were conducted using PRIMER v7 (Clarke and Gorley, 2015) with PERMANOVA+ add-on (PRIMER-E Ltd; Anderson et al. 2008). Multivariate data were transformed using a log(X+1) transformation by site to account for the variable abundances as a result of schooling nature of some fish species (Clarke et al. 2006) and a PERMANOVA was used to test differences between sites on a Bray–Curtis resemblance matrix. Pairwise tests were used to further investigate differences between the sites and across sampling periods. Similarity percentage (SIMPER) analyses were used to determine the similarity between groups and which species were driving any observed differences. Bootstrap averages (run 100 times) were calculated and used to construct a non-metric multi-dimensional scaling (nMDS) ordination plot to visualise differences within and between sites and seasons.

Figure 1. Locations of Baited Remote Underwater Video Stations (BRUVS) deployments from three sites (northern control [purple], proposed outfall [blue], southern control [pink]) in Boston Bay, Port Lincoln. White circles indicate location of proposed intake towers and outfall diffusers.

5. RESULTS & DISCUSSION

Habitat characteristics

Across all years of sampling, substrata at all sites were dominated by silt/sand characterised by high epiphyte loading and intermittent sponge gardens. Due to the consistency in habitat and bathymetry (13–16 m) across sites and surveys, the influence of habitat on fish assemblages was not tested.

Fish assemblages

A total of 38 species, including 6,642 individuals were observed across the three sampling periods (Table 1, Figure 2). Fish abundance was highest in 2024 (5,624 individuals; Figure 2) compared to 2021 (714 individuals) and 2022 (304 individuals). This is attributed to large schools of bluefin leatherjacket *Thamnaconus degeni* which was observed on every replicate in 2024, despite being infrequently seen in previous sampling periods (Table 1). Fish diversity was generally consistent across sampling periods, with 59 species observed in 2021, 38 in 2022, and 47 in 2024. Five species were detected in 2024, but not in previous years: elongate flounder *Ammotretis elongatus*, surf crab *Ovalipes australiensis*, pencil weed whiting *Siphonognathus beddomei*, snook *Sphyraena novaehollandiae*, southern fiddler ray *Trygonorrhina dumerilii*, and bottlenose dolphin *Tursiops* sp. The interaction between study site and sampling period had a significant effect on the fish assemblages (Pseudo-F = 10.592, P[perm] < 0.05).

Differences in fish assemblages between sites

In March 2024, the outfall site was the most diverse (21 species), followed by the southern (17 species) and northern control sites (9 species). This trend is consistent with findings from previous years, with more species observed at the outfall site in 2021 and 2022 (22 and 17 species, respectively), compared to northern (16 and 9 species) and southern (21 and 12 species) control sites. In March 2024, fish assemblages observed at the outfall site were significantly different to those at the northern control site (p[perm] <0.05, Table 2), but not statistically different to those at the southern control site. This is similar to the difference between sites in October 2021 and May 2022. Fish assemblages were also significantly different between the Southern and northern control sites (p[perm] <0.05, Table 2). The difference of assemblages at the northern control site compared to the outfall and southern control site is attributed to lower abundances of trevally *Pseudocaranx* spp. and bluefin leatherjackets *T. degeni*, and more frequently observed yellowtail scad *Trachurus novaezelandiae* (Table 3).

Differences in fish assemblages between sampling periods

There were significant differences in fish assemblages observed across years at all three sites (p[perm <0.05, Table 2). Fish assemblages in 2024 had higher abundance of bluefin leatherjacket *T. degeni* (21.8–40.2 contribution to dissimilarity) *Pseudocaranx* spp. (11.3–21.9 contribution to dissimilarity), and yellowtail scad *Trachurus novaezelandiae* (5.4–17.5 contribution to dissimilarity) at all sites compared to previous years.

Fish assemblage herein provides a baseline assessment of fish assemblages at and around the proposed outfall in October 2021, May 2022, and March 2024 sampling periods. We found significant effects of sampling period on fish assemblages at all sites in Boston Bay. Regular assessments are recommended for ongoing monitoring throughout construction and operation of the desalination plant to identify the potential effects of the proposed outfall. Several standard ecological metrics can be derived from the data collected from BRUVS including diversity indices, abundance, community structure, and substrata where the BRUVS land. These metrics are commonly used to detect changes in marine communities, enabling information collected through ongoing monitoring to detect any potential impacts of hypersaline discharges on ecological communities in the area. Data collected here can act as a baseline for future assessments at different temporal and spatial scales within the Boston Bay area, allowing the assessment of seasonal variations in fish communities as part of ongoing monitoring programs.

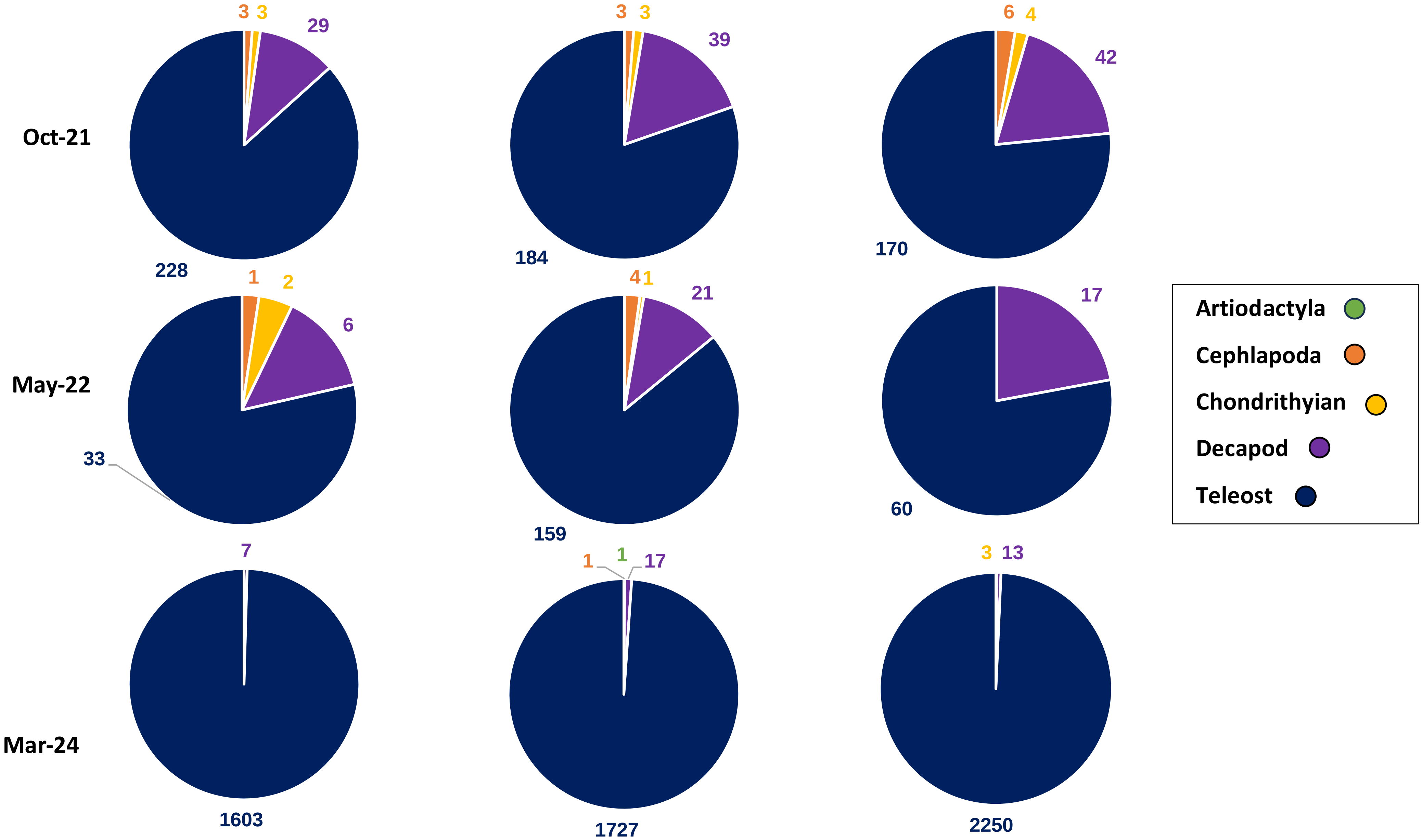

Figure 2. Number of individuals within each class observed by Baited Remote Underwater Video Stations (BRUVS) across three sites (northern control [left], proposed outfall [centre], southern control [right]) and years (October 2021 [top], May 2022 [centre], and March 2024 [bottom]) in Boston Bay, Port Lincoln.

Table 1. Sum of MaxN and taxa identified using Baited Remote Underwater Video Stations (BRUVS) from 72 deployments (24 each sampling year) across three sites (eight deployments at each the proposed outfall site, northern control site, and southern control site) in Boston Bay, Port Lincoln.

Family	**Species**	**Outfall**			**Southern**			**Northern**		
		Oct-21	**May-22**	**Mar-24**	**Oct-21**	**May-22**	**Mar-24**	**Oct-21**	**May-22**	**Mar-24**
Artiodactyla										
Delphinidae	*Tursiops sp.*			1						
Cephlapoda										
Loliginidae	*Sepioteuthis australis*	**3**	**1**	1	**6**			**2**		
Octopodidae	*Hapalochlaena sp.*		**1**							
Octopodidae	*Octopus sp.*		**2**					**1**	**1**	
Chondrithyian										
Dasyatidae	*Bathytoshia brevicaudata*	**3**			**4**		**2**	**2**		
Heterodontidae	*Heterodontus portusjacksoni*		**1**					**1**	**2**	
Trygonorrhinidae	*Trygonorrhina dumerilii*						**1**			
Decapod										
Majidae	*Leptomithrax gaimardii*	**12**	**3**	4	**10**	**4**	**1**	**12**		**1**
Parastacidae	*Ovalipes australianensis*	**1**			**1**	**2**				
Portunidae	*Nectocarcinus integrifrons*	**7**	**11**	7	**19**	**8**	**5**	**7**		
Portunidae	*Portunus armatus*	**19**	**7**	6	**12**	**3**	**6**	**10**	**6**	**6**
Portunidae	*Ovalipes australiensis*						**1**			
Teleost										
Apogonidae	*Siphamia cephalotes*				**14**					
Apogonidae	*Vincentia conspersa*	**1**								
Arripidae	*Arripis georgianus*			103				**60**		**5**
Arripidae	*Arripis truttaceus*	**2**		42			**2**			
Carangidae	*Pseudocaranx spp*	**38**	**107**	248	**3**		**424**	**1**		**113**
Carangidae	*Trachurus novaezelandiae*	**3**		122	**1**	**25**	**147**			**74**
Diodontidae	*Diodon nichthemerus*				**1**					
Gerreidae	*Parequula melbournensis*	**6**		13	**9**		**12**	**1**		
Gobiidae	*Nesogobius sp*	**2**	**1**		**2**					

Family	Species	Outfall			Southern			Northern		
		Oct-21	May-22	Mar-24	Oct-21	May-22	Mar-24	Oct-21	May-22	Mar-24
Teleost (cont.)										
Labridae	*Siphonognathus attenuatus*		1							
Monacanthidae	*Acanthaluteres spilomelanurus*	26		3	54	1	1	15		2
Monacanthidae	*Nelusetta ayraud*	3			1			2		
Monacanthidae	*Thamnaconus degeni*		5	1176		6	1624		6	1400
Mullidae	*Upeneichthys vlamingii*	1	1	3	4	6	15			
Odacidae	*Neoodax balteatus*	61	14	3	36	6	1	117	5	1
Pinguipedidae	*Parapercis haackei*	18	12	6	15	9	13	28	13	8
Pinguipedidae	*Parapercis ramsayi*	3				2			3	
Platycephalidae	*Platycephalus bassensis*	11	7	2	19		7	3	1	
Platycephalidae	*Platycephalus grandispinis*	1								
Platycephalidae	*Platycephalus speculator*	3	5	1	5	5	4		5	
Sillaginidae	*Sillaginodes punctatus*				5					
Sillaginidae	*Sillago bassensis*	5	6	2						
Tetraodontidae	*Omegophora armilla*							1		
Triglidae	*Lepidotrigla papilio*				1					
Rhombosoleidae	*Ammotretis elongatus*			1						
Labridae	*Siphonognathus beddomei*			1						
Sphyraenidae	*Sphyraena novaehollandiae*			1						

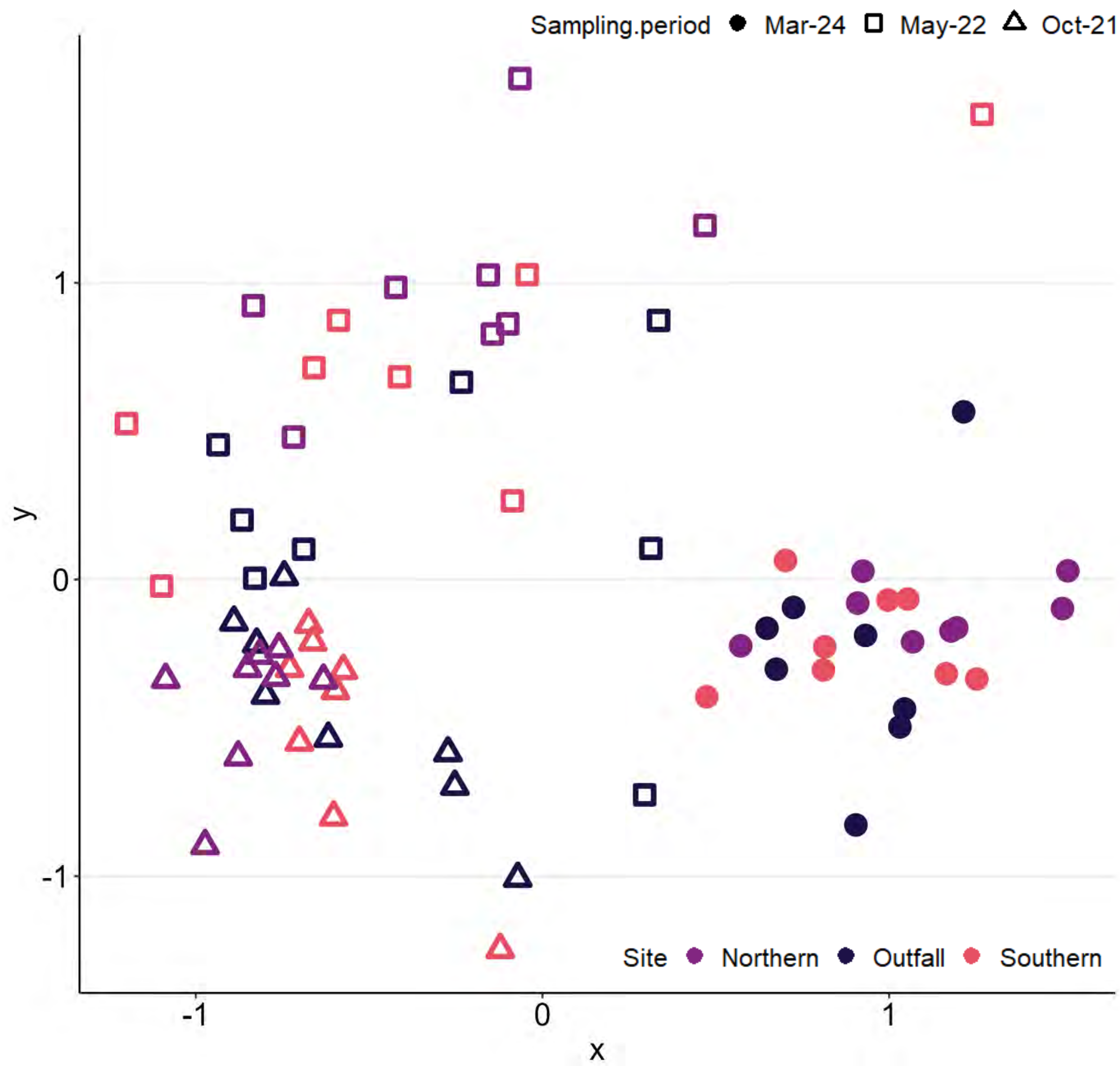

Figure 3. Non-metric multi-dimensional scaling (nMDS) ordination plot of fish assemblages observed by Baited Remote Underwater Video Stations (BRUVS) from three sites (northern control [purple], proposed outfall [blue], southern control [pink]) in Boston Bay, Port Lincoln across three sampling periods (October 2021 [empty triangle symbols], May 2022 [open square symbols], and March 2024 [filled circle symbols]).

Table 2. Output from PERMANOVA pair-wise tests of fish assemblages observed from BRUVS from the interaction between sampling sites and seasons. Significant results are shown in bold.

	Groups	**t**	**P(perm)**	**Unique perms**
Site comparison (within years)				
2024	Outfall Mar-24, Southern Mar-24	1.4	0.09	5055
	Outfall Mar-24, Northern Mar-24	**1.54**	**<0.05**	**5052**
	Southern Mar-24, Northern Mar-24	**1.74**	**<0.05**	**5082**
2022	Outfall May-22, Southern May-22	1.34	0.07	5067
	Outfall May-22, Northern May-22	**1.71**	**<0.05**	**5049**
	Southern May-22, Northern May-22	1.32	0.14	5058
2021	OutfallOct-21, SouthernOct-21	1.02	0.38	5046
	OutfallOct-21, NorthernOct-21	1.3	0.12	5058
	SouthernOct-21, NorthernOct-21	**1.99**	**<0.05**	**5070**
Year comparison (within sites)				
Outfall	**Outfall Oct-21, Outfall May-22**	**1.93**	**<0.05**	**5054**
	Outfall Oct-21, Outfall Mar-24	**3.71**	**<0.05**	**5058**
	Outfall May-22, Outfall Mar-24	**2.94**	**<0.05**	**5072**
Southern	**Southern Oct-21, Southern May-22**	**2.46**	**<0.05**	**5070**
	Southern Oct-21, Southern Mar-24	**4.74**	**<0.05**	**5071**
	Southern May-22, Southern Mar-24	**3.39**	**<0.05**	**5059**
Northern	**Northern Oct-21, Northern May-22**	**3.56**	**<0.05**	**5066**
	Northern Oct-21, Northern Mar-24	**7.41**	**<0.05**	**5043**
	Northern May-22, Northern Mar-24	**4.44**	**<0.05**	**5085**

Table 3. Similarity Percentage (SIMPER) analyses of fish assemblages observed by Baited Remote Underwater Video Stations (BRUVS) from across years from three sites (northern control, proposed outfall, southern control) in Boston Bay, Port Lincoln. Only top 5 contributing species are presented for clarity.

Species	Average abundance	Average abundance	Average dissimilarity	Average contribution/SD	Contribution %	Cumulative %
Outfall						
Oct-21 vs. May-22, Average dissimilarity = 62.78						
	Oct-21	**May-22**				
Pseudocaranx spp.	0.95	1	7.85	0.87	12.5	12.5
Neoodax balteatus	1.99	0.81	7.78	1.42	12.39	24.89
Acanthaluteres spilomelanurus	1.26	0	7.38	1.8	11.76	36.65
Portunus armatus	1.11	0.61	4.08	1.43	6.51	43.15
Nectocarcinus integrifrons	0.52	0.59	3.8	1.14	6.06	49.21
Oct-21 vs. Mar-24, Average dissimilarity = 77.09						
	Oct-21	**Mar-24**				
Thamnaconus degeni	0	4.35	16.83	2.71	21.83	21.83
Pseudocaranx spp.	0.95	2.68	8.77	1.5	11.38	33.2
Trachurus novaezelandiae	0.22	1.98	7.29	1.33	9.46	42.66
Neoodax balteatus	1.99	0.22	7.18	2.03	9.31	51.97
Acanthaluteres spilomelanurus	1.26	0.17	4.56	1.63	5.92	57.89
May-22 vs. Mar-24, Average dissimilarity = 77.02						
	May-22	**Mar-24**				
Thamnaconus degeni	0.35	4.35	18.68	2.45	24.25	24.25
Pseudocaranx spp.	1	2.68	11.15	1.53	14.48	38.73
Trachurus novaezelandiae	0	1.98	9.43	1.4	12.25	50.98
Arripis georgianus	0	1.15	5.39	0.75	6.99	57.97
Arripis truttaceus	0	0.91	3.94	0.86	5.12	63.09

Southern						
Oct-21 vs. May-22, Average dissimilarity = 70.97						
	Oct-21	**May-22**				
Acanthaluteres spilomelanurus	1.66	0.09	10.35	1.65	14.59	14.59
Neoodax balteatus	1.64	0.48	7.82	1.86	11.02	25.61
Platycephalus bassensis	1.08	0	7.02	1.81	9.89	35.5
Nectocarcinus integrifrons	1.11	0.51	5.58	1.33	7.86	43.36
Portunus armatus	0.88	0.26	4.32	1.3	6.08	49.44
Oct-21 vs. Mar-24, Average dissimilarity = 79.90						
	Oct-21	**Mar-24**				
Thamnaconus degeni	0	5.23	21.18	6.4	26.51	26.51
Pseudocaranx spp.	0.17	3.07	12.11	1.76	15.15	41.66
Acanthaluteres spilomelanurus	1.66	0.09	6.33	1.77	7.92	49.59
Neoodax balteatus	1.64	0.09	6.27	3.06	7.85	57.44
Trachurus novaezelandiae	0.09	1.17	4.32	0.74	5.41	62.85
May-22 vs. Mar-24, Average dissimilarity = 82.8						
	May-22	**Mar-24**				
Thamnaconus degeni	0.48	5.23	27.44	4.29	33.14	33.14
Pseudocaranx spp.	0	3.07	18.13	1.66	21.9	55.04
Trachurus novaezelandiae	0.41	1.17	6.57	0.8	7.93	62.97
Parapercis haackei	0.71	0.76	3.56	1.42	4.3	67.26
Upeneichthys vlamingii	0.24	0.5	3.39	0.7	4.09	71.36

Northern						
Oct-21 vs. May-22, Average dissimilarity = 75.98						
	Oct-21	**May-22**				
Neoodax balteatus	2.69	0.35	19.3	3.81	25.4	25.4
Acanthaluteres spilomelanurus	0.97	0	8.21	2.06	10.81	36.21
Leptomithrax gaimardii	0.9	0	7.48	3.66	9.85	46.06
Parapercis haackei	1.38	0.85	6.34	1.3	8.34	54.4
Nectocarcinus integrifrons	0.57	0	4.8	1.54	6.32	60.72
Oct-21 vs. Mar-24, Average dissimilarity = 88.45						
	Oct-21	**Mar-24**				
Thamnaconus degeni	0	5.06	26.03	5.29	29.43	29.43
Neoodax balteatus	2.69	0.09	13.34	4.7	15.09	44.51
Trachurus novaezelandiae	0	2.1	10.47	3.02	11.84	56.35
Pseudocaranx spp.	0.09	2.11	9.98	1.57	11.28	67.63
Parapercis haackei	1.38	0.51	5.33	1.54	6.02	73.65
May-22 vs. Mar-24, Average dissimilarity = 84.59						
	May-22	**Mar-24**				
Thamnaconus degeni	0.48	5.06	33.86	3.65	40.02	40.02
Trachurus novaezelandiae	0	2.1	14.77	3.15	17.46	57.48
Pseudocaranx spp.	0	2.11	14.09	1.53	16.66	74.14

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Appendix S Desalination Ecotoxicity Review

DESALINATION ECOTOXICITY REVIEW

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EYRE PENINSULA DESALINATION PLANT

B22030

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DECEMBER 2022

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DOCUMENT CONTROL INFORMATION

DATE PRINTED	JOB NUMBER	REPORT NUMBER
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PROJECT SUBTITLE	Eyre Peninsula Desalination Plant
PROJECT MANAGER	Dustin Hobbs
FILENAME	B22030 EP Desalination ecotoxicity review

STATUS	ORIGINATOR/S	REVIEWED	AUTHORISED	DATE
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V2.4	NR, DH	FA	DH	16/12/2022

DISTRIBUTION

FILENAME	DESCRIPTION	ISSUED TO	ISSUED BY
V1-0	Draft for Review	Hazel Vandeleur (SA Water)	Dustin Hobbs
V2-0	Draft	Hazel Vandeleur (SA Water)	Dustin Hobbs
V3-0	Draft for External Review	Hazel Vandeleur (SA Water)	Dustin Hobbs

EXECUTIVE SUMMARY

SA Water are proposing to build a 24 ML/day desalination plant in the vicinity of Port Lincoln on the Eyre Peninsula, to supplement the region's water supply which has historically been provided by the Uley South Basin bore field and the River Murray. As part of the approvals process an ecotoxicological assessment of the discharge from the proposed desalination plant needs to be undertaken. This report considers the available ecotoxicology information from other large scale seawater desalination plants built in Australia. Of particular interest is the now operating Adelaide Desalination Plant (ADP) and the proposed Olympic Dam Desalination Plant (ODDP) to supplement the data collection process for the Eyre Peninsula Desalination Plant (EPDP). The proposed EDPD intends to use the same chemicals that were assessed and approved for use by the ADP and will be designed to achieve a conservative 40:1 dilution of the discharge by the edge of the mixing zone.

All previous ecotoxicological assessments of discharges simulating operational desalination plant brine have indicated that salinity was the main driver of the observed toxicity, with a small effect being observed in some assessments from the addition of process chemicals such as antiscalant. The dilution required to protect the receiving environment from the effects of salinity was shown to be more than adequate to nullify this additional toxicity.

Ecotoxicity assessments indicated that some chemicals used to clean the membranes and other desalination infrastructure would require a higher rate of dilution than those achieved by the desalination plant under normal operating conditions. This is not unusual given that some of these chemicals are biological control agents that are used for antifouling purposes and are toxic by design. The toxicity associated with process and cleaning chemicals can be managed using standard procedures for their disposal into the waste stream at appropriate concentrations calculated as part of the ecotoxicology assessment. This can be achieved through appropriate plant design to ensure there is no effect on the receiving environment.

While there is a plethora of relevant ecotoxicology information available, it is recommended that a site-specific approach be taken. This approach uses a subset of regionally relevant organisms and intake water from the proposed site for chronic pre-operational ecotoxicity testing of the pilot plant saline concentrate. The results of this subset of tests can then be directly compared with the ADP results to ensure that any observed toxicity is within the bounds of that seen during the ADP assessment. This testing can also be supported by the results from the numerous tests undertaken on large seawater desalination plants around Australia for more toxicity context and robust results.

It is also recommended that a post operational ecotoxicity assessment of the brine discharge be undertaken as the plant is brought to operational capacity using the same subset of ecotoxicity tests employed in the pilot study, in a similar requirement to that placed upon the ADP (for example testing to be carried out at 50% of total production then 3 months and 6 months after full production has commenced).

Given the results of the ecotoxicological assessments for other large seawater desalination plants in Australia, the resultant discharge dilution ratios and the size and output volume of the proposed EPDP, it is expected that the proposed 40:1 dilution ratio to be achieved by the edge of the mixing zone will be adequate to protect the receiving environment. The recommended pre and post commissioning testing regime will ensure that this is achieved. The treatment of cleaning chemicals should be handled so that concentrations entering the discharge stream are low enough to present no risk to the receiving environment.

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1. INTRODUCTION

1.1 BACKGROUND

The Eyre Peninsula is a triangular peninsula in South Australia, bounded by the Spencer Gulf on the east, by the Great Australian Bight on the west, and by the Gawler Ranges on the north. Eyre Peninsula water sources have reduced over time due to the changing climate and salinisation and underground water resources are suffering from gradually increasing salinity. The Uley South Basin has provided water for drinking supply since 1976 and currently provides 75% of all water used on the Eyre Peninsula, with the majority of the balance coming from the River Murray. Presently, water is pumped several hundred kilometres from the Murray River to the town of Whyalla through the Morgan-Whyalla pipeline.

Working together with the Eyre Peninsula community, SA Water has investigated potential locations to establish seawater desalination plants to address Eyre Peninsula's future water security concerns. The desalination plant is required by 2025 to prevent permanent damage to Uley South Basin and the flow-on impacts to water availability across the Eyre Peninsula. The plant will provide a new reliable, climate-independent source of drinking water to supplement existing groundwater sources and water from the River Murray and is critical to maintaining a long term supply of safe, clean drinking water for around 35,000 people on the Eyre Peninsula. Four sites have now been shortlisted as possible locations for the Eyre Peninsula Desalination Plant: Sleaford West, Point Boston, Uley South Shoal Point, and Sleaford North.

1.2 ECOTOXICOLOGICAL ASSESSMENTS OF POTENTIAL DISCHARGES

Contaminants that enter the natural environment can affect the flora and fauna of the ecosystem into which they are released. The science of studying these effects is called ecotoxicology and it investigates the impacts of contaminants on individuals, populations, natural communities, and ecosystems, as well as determining what happens to the contaminant as it breaks down in the environment, typically referred to as its 'fate' (Newman & Unger, 2003). Ecotoxicology is a complex field of study and draws on a range of scientific disciplines including ecology, toxicology, physiology, analytical chemistry, molecular biology and mathematics.

An ecotoxicological assessment can be used to assess the potential impact of a complex mixture such as a proposed discharge, on the environment. This is usually done by exposing a number of organisms to a sample that best represents the potential discharge and recording the effects on the different species. The ecotoxicity assessments that have been carried out on the majority of large seawater desalination plants in Australia used this method. These studies typically obtain representative discharge samples for assessments by processing intake water from the proposed site through a small scale benchtop reverse osmosis plant or obtaining discharge from an already established desalination plant. The additional factors that determine the chemical composition of the discharge, including the level of recovery, (i.e. how much freshwater is to be extracted from the seawater), the process treatment chemicals and cleaning chemicals can all be managed to replicate those expected for the proposed desalination plant.

Several different species are required for toxicity testing, currently recommendations suggest five species from four trophic levels. However, it is strongly encouraged to increase the number of species tested where possible to eight in order to produce more reliable and robust results (ANZG, 2018; Warne et al., 2018). It is also ideal to use local species as part of the testing regime, but this needs to be weighed against the practicality of procuring the test species in adequate numbers and keeping them successfully in a laboratory setting for testing purposes as well as the potential for the application of standardised toxicity test methods.

The chosen species are exposed to a dilution series of the discharge to understand at what point the discharge negatively affects the organism(s), referred to as an ‘endpoint’. A chronic endpoint is desired as the measure of toxicity for each species, i.e., a measurable non-lethal indicator such as number of brood, growth or successful germination. It is also often useful to understand the potential effects on acute endpoints such as immobilsation and death, which provide data for plant process disruptions where the receiving environment may experience short exposures of the discharge at higher concentrations.

Data collected during these experiments are used to statistically derive an ‘effective concentration’, the concentration at which a certain percentage of the test organisms are affected. An effective concentration of 10% is typically used in ecotoxicological assessments of this nature, i.e., the concentration at which 10% of the population experience the test endpoints, known as the EC10. A chronic EC10 value will be calculated for each test species based on the results of the ecotoxicology testing. These EC10 values for each species are then used to calculate a guidelines value based on a species sensitivity distribution (SSD), using BurrliOz 2.0 software (Barry and Henderson 2014). This is a statistical approach whereby the concentration of discharge that is hazardous to no more than a pre-defined percentage of organisms in the receiving environment is calculated. An SSD is a cumulative distribution function that describes the variation in sensitivity of species to a chemical or discharge. An example of an SSD is shown in Figure 4-1 for the Olympic Dam ecotoxicology assessment. While BurrliOz 2.0 does it have its limitations, it does allow for standardisation of distribution fitting across SSDs. From the SSD protective concentrations can be estimated for different levels of protection. For example, ANZG (2018) default guidelines are based on a slightly to moderately disturbed level or the concentration that will protect 95% of species in a receiving environment. This is also known as the PC95 and is the most common protective concentration used when assessing a discharge unless the discharge will occur into a high environmental value zone, where the PC99 would be adopted, or the receiving environment is considered highly disturbed where the PC90 or PC80 may be recommended.

The process of deriving site-specific guideline values and dilution ratios using the SSD method from a number of single-species toxicity tests is deliberately conservative. This ensures that the receiving environment will be adequately protected when taking into consideration the inherent associated single-species ecotoxicity testing and the many variables that exist when undertaking a testing regime based on a synthetic discharge under laboratory conditions.

1.3 STUDY OBJECTIVES

The following report has been prepared for SA Water to provide technical information relating to the ecotoxicity of seawater desalination discharges of the proposed Eyre Peninsula Desalination Plant (EPDP) as part of the development assessment process.

The objectives of this study are to:

- Review relevant available information on seawater desalination plant discharge ecotoxicology assessments with a particular focus on information generated as part of the Adelaide Desalination Plant (ADP) development process and the information available from the Olympic Dam Desalination Plant (ODDP) Environmental Impact Statement.
- Assess the applicability of the ADP ecotoxicity data and any other relevant information for the assessment of the potential ecotoxicity of the proposed EPDP discharge.
- Derive a protective concentration and corresponding safe dilution from the available ecotoxicity data deemed relevant to the EPDP discharge.

The following sections have been divided into:

- Salinity and its potential effects;
- Chemical additives used in both the desalination process and membrane cleaning;
- Utility and applicability of previous ecotoxicity assessments for the proposed EPDP;
- Literature review of relevant desalination ecotoxicity studies; and
- Recommendations.

2.SALINITY EFFECTS

It is generally accepted that salinity is the main driver of the observed toxicity of seawater desalination plant discharge. The importance of understanding the tolerance of species that may experience elevated salinity associated with the brine discharge is paramount to ensuring no significant impacts result from plant operations. Marine organisms have varying sensitivity in response to changes in salinity. Osmotic conformers are organisms that have no mechanism to control the salinity within their bodies and therefore their cells conform to the same salinity as their environment (Voutchkov, 2011). Large increases in salinity in the surrounding marine environment cause the water to flow out of the cells of these organisms, which could lead to cell dehydration and ultimately death. Organisms that can only survive in a narrow salinity range are referred to as “stenohaline”. On the contrary, osmotic regulators can control the salt content within their cells despite variations in external salinity (Voutchkov, 2011). Most marine fish, reptiles, birds and mammals are osmotic regulators. Salinity tolerances of marine organism vary, but some shellfish (scallops, clams, oysters, mussels or crabs) and reef building corals are able to tolerate very high salinities (Voutchkov, 2011). An additional factor when considering environmental impacts of concentrate discharges is the mobility of the organisms. Mobile organisms may simply move away from areas of higher salinity without adverse impacts. Sessile organisms (e.g. plants and corals) are more vulnerable to salinity changes (Missimer & Maliva, 2018). Many marine organisms are naturally adapted to the changes in seawater salinity that occur seasonally and are mostly driven by the evaporative rate from the ocean surface, by rain deposition and runoff events and by surface water discharges. Typically, the range of natural salinity fluctuation is at least ± 10% of the average annual ambient seawater salinity concentration. The “10% increment above ambient ocean salinity” threshold is considered a conservative measure of aquatic life tolerance to elevated salinity. The actual salinity tolerance (the point at which organisms can survive) of most marine organisms is usually significantly higher than this level and often exceeds 40 ppt (Voutchkov, 2011).

The toxicity assessments undertaken on the large seawater desalination plants that have been built in Australia since the turn of the century have all indicated that the main driver of the observed toxicity was the salinity of the brines. Table 2-1 shows the characteristics of those plants and the dilution ratios calculated to ensure that the discharge would have little to no effect after diffusion.

Table 2-1 Australian desalination plants and calculated little to no effect dilution ratios

Study site	Treatment	Safe dilution/ protective factor	Note/comment
ADP pilot plant	Brine	PC 95: 21:1	
Penneshaw	Brine	PC 95: 12:1	Most relevant to EPDP
Olympic Dam	Brine with Nalco anti-scalant PC1020T at a dosing rate of 3.6 mg/L.	PC 99: 60:1 (60 x dilution, 1.66% effluent). Recalculated using NOEC: 26.3:1 (3.8% with a corresponding safe dilution of 26.3)	Second value uses recommended process when salinity is the main toxicity driver.
ADP post commissioning	Discharge effluent	3 months after fully operational: 15.1:1 6 months after fully operational: 27.4:1	
Adelaide Desalination Plant (ADP) **Pilot plant saline concentrate study**	Ambient saline concentrate without antiscalant	PC 95: 16:1 PC 99: 23:1	EC10 concentrations used but NOEC used when a gradual reduction in effect was not seen.
	Ambient saline concentrate with antiscalant	PC 95: 12:1 PC 99: 14:1	EC10 concentrations used but NOEC used when a gradual reduction in effect was not seen.
	pH adjusted saline concentrate without antiscalant	PC 95: 13:1 PC 99: 15:1	EC10 concentrations used but NOEC used when a gradual reduction in effect was not seen.
	pH adjusted saline concentrate with antiscalant	PC 95: 12:1 PC 99: 14:1	EC10 concentrations used but NOEC used when a gradual reduction in effect was not seen.
Olympic Dam desalination plant discharge	Return water for Point Lowly [b]	Best dataset PC 99: 45:1 PC 95: 30:1	A mixture of EC10 and NOEC concentrations used.
Sydney desalination plant	Concentrated seawater	Stream 1 PC 95: 27:1 PC 99: 20:1	Ecological trigger values calculated from EC10 data.

Study site	Treatment	Safe dilution/ protective factor	Note/comment
	Concentrated seawater with anti-scalent	Stream 4 PC 95: 13:1 PC 90: 12:1	Ecological trigger values calculated from EC10 data
Perth Seawater Desalination Plant	Seawater concentrate discharge	PC 95: 13:1	Based on EC10 toxicity data
Victorian Desalination Plant **Round 1: April 2008**	Salinity adjusted intake water from the Perth Seawater Desalination Plant.	PC 99 (ACR 2.5): 39:1	Calculated from EC10 based species sensitivity distributions.
	Case 2 brine concentrate and pre-treatment supernatant waste	PC 99 (ACR 2.5): 29:1	Calculated from EC10 based species sensitivity distributions.
Victorian Desalination Plant **Round 2: June 2008**	Case 1 Brine concentrate plus pre-treatment waste	PC 99 (ACR 2.5): 17.8	Calculated from EC10 based species sensitivity distributions.
	Case 2 Brine concentrate plus pre-treatment supernatant waste	PC 99 (ACR 2.5): 22.6	Calculated from EC10 based species sensitivity distributions
	Case 3 Brine concentrate	PC 99 (ACR 2.5): 18.3	Calculated from EC10 based species sensitivity distributions
	Salinity adjusted intake water	PC 99 (ACR 2.5): 16.7	Calculated from EC10 based species sensitivity distributions
Gold Coast Desalination Plant (GCDP)	Short-term concentrated effluent pulse exposure	<1 hour: salinity concentration up to 42.0 ppt Up to 4 hours: salinity concentration up to 41.9 ppt	

3. DESALINATION CHEMICAL EFFECTS

Reverse Osmosis Desalination is a method of water purification that uses a membrane to separate particles in solution and remove the salt. A number of processes typically occur in the desalination of seawater that may affect discharge characteristics. Table 3-1 provides a generic overview of these processes. There are a range of process chemicals available for use in the various stages of desalination, and the final selection of chemicals will be dependent upon desalination process design, environmental and engineering performance requirements, and regulatory requirements for the discharge of the final waste stream.

Information on water treatment chemicals used in desalination plant operation is often too broad to be useful in a toxicological assessment context. While the same broad class of chemical may be used to perform a particular function as part of the desalination process, the various products on the market that perform those functions can have subtly different chemical characteristics or recommended dosage rates; this, in turn, affects their potential toxicity. The following sections outline the broad chemical classes used as part of the desalination process, typical dosing rates used for each and their potential toxicity to organisms in receiving waters.

Table 3-1 Summary of processes in desalination, their purposes and the chemicals that are added

	Process	Purpose	Approach
1	Chlorination	Control biological growth in intake and pre-treatment; Reduce rate of biofouling	Chlorine (NaOCl)
2	Dechlorination	Protect chlorine-sensitive RO membranes	Sodium metabisulfite
3	Antiscalant dosing	Minimise rate of scale formation on RO membranes.	Sequestering agent dispersants
4	pH adjustment	Minimise rate of scale formation in RO membranes. To achieve optimum pH for boron removal	Acid (H_2SO_4) Base (NaOH)
5	Membrane cleaning	To periodically clean the membranes to restore RO performance	Acids, bases and surfactants

3.1 CHLORINATION

Intermittent chlorination is typically performed at the marine intake structures and at the seawater pump station to control marine growth. Chlorine, either as chlorine solution (generated using chlorine gas) or commercial liquid sodium hypochlorite is normally employed at concentrations below 10 mg/L as Cl_2 equivalent (active chlorine). The toxicity of sodium hypochlorite has been determined for a wide variety of aquatic organisms. Free chlorine and bromine will be removed in the process due to its potential to harm the reverse osmosis membranes and will therefore, not be part of the discharge and is not relevant from a toxicity perspective.

3.2 DECHLORINATION

As stated previously, feed seawater is chlorinated for marine biofoulant control. However, as chlorine can cause irreversible damage to RO membranes, the seawater must be dechlorinated prior to entering the RO membrane system. This is achieved by adding sodium metabisulfite when chlorine dosing is active.

As part of the process to ensure complete removal of free chlorine and free bromine, a slight overdose of sodium bisulfite is used. As sodium bisulfite is an oxygen scavenger, the discharge will have lower levels of dissolved oxygen associated with it. Dissolved oxygen could have a significant impact on the receiving environment and, therefore, tight control of the dechlorination process will be needed. The toxicity data available for sodium bisulfite is limited.

3.3 ANTISCALANT DOSING

Antiscalants are used to minimise or prevent the accumulation of sparingly soluble salts on the RO membrane surface, as the seawater is concentrated in the RO process. This ensures maximum performance (with respect to water quality and energy consumption) from the system. The following are some of the chemicals that are commonly used in the de-scaling process.

Sodium polyacrylate is used as an antiscalant – it prevents the deposition of calcium salts. As the purpose of dosing polycarboxylates into the waste stream is to bind calcium and inhibit scale formation, this process is likely to dominate the environmental fate of polycarboxylates, both within the desalination plant and the discharge receiving stream. The concentration of polycarboxylates expected in the desalination plant discharge is expected to be negligible.

Polyphosphates are also used as antiscalants in desalination plants. These compounds inhibit the formation of inorganic scale precipitates on the membranes. The main environmental risk associated with polyphosphates is the degradation of the compound to phosphate, a nutrient associated with eutrophication. Elevated concentrations of phosphate may lead to eutrophication and possible algal blooms, although it should be noted that it is generally considered that nitrogen is the limiting nutrient in marine water, while phosphorus is the limiting factor in freshwater.

Antiscalant active ingredients may include phosphonates, which are used to prevent metal hydroxides/oxides and compounds, such as calcium carbonate, calcium sulfate and silicates from precipitating onto the RO membranes and other equipment. As for the polyphosphates, the degradation products of the phosphonates include phosphate, which in high concentrations could lead to eutrophication.

3.4 MEMBRANE CLEANING

Over time, the permeability of the RO membranes declines due to fouling and scaling of the membrane surface, leading to higher feed pressures being required to maintain a constant permeate flux. RO performance is restored using various cleaning chemicals: high pH for biofilm and organics; low pH for inorganic precipitates. Chemical cleaning requires the shutdown of the RO train. Chemicals are batched to the correct strength, pH and temperature, prior to circulation through an RO train. The amount and type of chemicals required varies depending on the degree and nature of membrane fouling.

Acids such as citric and hydrochloric are often used to clean the alkaline scale and metal oxides from RO membranes. The acids are added to lower the pH to approximately 2-3 in RO systems. There are few marine toxicity data available for citric acid. However, it should be noted that often it is the amount of acidity that is more important than the type of acid. i.e. pH is most important. However, as the solutions used in membrane cleaning are neutralised before disposal these acids, providing the neutralisation is done correctly, will not contribute to toxicity.

Ethylenediamine tetraacetic acid (EDTA) is a chelating agent that is often used for sequestration of metals in freshwater. In the desalination process EDTA may be employed in acidic or alkaline chemical cleaning solutions to sequester metallic scale from the RO membranes and pipes. The toxicity of EDTA to organisms in seawater has not been widely investigated, although it is a common constituent of synthetic seawater mixes used in the aquarium industry.

Alkyl glucoside surfactants or alkyl polyglucosides are often used in household products like cleaning agents, dishwashing detergent and laundry detergents. They are composed of a linear fatty alcohol which is bound to the C-1 carbon of the glucose molecule by a glycosidic bond. The alkyl chain usually contains either 8-10 or 12-14 carbon atoms. Toxicity data for marine organisms could not be sourced for these products but data for freshwater organisms indicated low toxicity.

2,2-dibromo-3-nitriloproprionamide (DBNPA) is used as a non-oxidising biocide. Therefore, it is expected to exert toxic effects on aquatic organisms.

3.5 DESALINATION PLANT SPECIFIC CHEMICALS

Each desalination plant will have an approved set of chemicals that will be used in the desalination process and for membrane cleaning. The ecotoxicological assessments undertaken as part of the approval process in Australia has included an assessment for the proposed chemicals as part of the operational discharge and the membrane cleaning process. A summary of the dilution ratios required for discharges from the different desalination plants can be seen in Table 3-2.

Pre-treatment processes such as chlorination/dechlorination, pH adjustment and antiscalant addition tend to cancel each other out, as is their intention in the desalination process, or with regard to the antiscalant, be at concentrations low enough that they are contributing little or no toxicity in the discharge. It should be noted that where an antiscalant is thought to be contributing to the toxicity of a discharge, the required dilution for salinity as the main driver of the observed toxicity is more than adequate to meet the dilution requirements for the antiscalant.

Membrane cleaning chemicals have often been found to have a high level of toxicity, which is expected given that some of the chemicals used are intentionally toxic, such as biocide. Membrane cleaning is never undertaken when a desalination plant is operational and all material used in this process is collected and stored for appropriate disposal. For some sites, this has involved shipping the material off-site for treatment and disposal or slowly releasing safe concentrations into the operational waste stream at a concentration calculated to cause little to no environmental harm.

Table 3-2 Australian desalination plant-specific chemicals and calculated little to no effect dilution ratios

Study	Treatment	Safe dilution /protective factor	Note/comment
Adelaide Desalination Plant (ADP) **Pilot plant backwash DTA**	Backwash supernatant	PC 95: 5:1 PC 99: 12:1	EC10 values used to derive protective concentrations
	Dechlorinated membrane pre-treatment chemically enhanced backwash	PC 95: 6:1 PC 99: 14:1	EC10 values used to derive protective concentrations
Adelaide Desalination Plant **Process chemicals DTA**	Acidified and neutralised permeate	IC10 PC 95: 47 PC 99: 371 IC10 Best data [a] PC 95: 21 PC 99: 106	EC10 values used to derive protective concentrations

Study	Treatment	Safe dilution /protective factor	Note/comment
	DBNPA treated and neutralised permeate	IC10 PC 95: 13 PC 99: 23 IC10 Best data [a] PC 95: 11 PC 99: 19	EC10 values used to derive protective concentrations
	Permeate treated with NaOH/Na4-EDTA/neutralised	IC10 PC 95: 715 PC 99: 5000 IC10 Best data [a] PC 95: 770 PC 99: 5000	EC10 values used to derive protective concentrations
	Permeate treated with NaOH/sodium laurel sulphate/neutralised	IC10 PC 95: 2500 PC 99: 5000 IC10 Best data [a] PC 95: 2500 PC 99: 5000	EC10 values used to derive protective concentrations
	Polyelectrolyte treated feedwater	An environmental concern level of 10% sample concentration was calculated which would require at least a ten times dilution to protect the majority of species in the receiving environment.	EC10 values used to derive protective concentrations
Sydney desalination plant	Concentrated seawater with backwash liquid and antiscalent	Stream 2 PC 95: 40:1 PC 90: 31:1	Ecological trigger values calculated from EC10 data
	Concentrated seawater with antiscalent and membrane cleaning	Stream 5 PC 95: 14:1 PC 90: 13:1	Ecological trigger values calculated from EC10 data

Study	Treatment	Safe dilution /protective factor	Note/comment
	Concentrated seawater with antiscalent, backwash liquid and membrane cleaning	Stream 6 PC 95: 16:1 PC 90: 14:1	Ecological trigger values calculated from EC10 data

4.TOXICITY CONSIDERATIONS FOR EPDP

4.1 UTILITY OF AVAILABLE ECOTOXICITY DATA

There is a large amount of ecotoxicity information available on the potential toxicity of waste brines discharged to the ocean from large scale seawater desalination plants from a number of Australian states as well as internationally. However, as shown in the following literature review and discussed in earlier sections, the ecotoxicity data that was generated for the Adelaide Desalination Plant is highly relevant for the assessment of the proposed EPDP, as is the work that was undertaken for the proposed Olympic Dam seawater desalination plant that was to be located in the Upper Spencer Gulf.

The fundamental questions that are of importance with regards to the understanding of ecotoxicity data and defining a safe discharge dilution that will protect the receiving environment are:

1. Are the samples that are being tested appropriate with regards to their representativeness of the scenario in question?
2. Are the species that have been tested as part of the evaluation process relevant to the proposed discharge point?
3. Are the results from the testing adequate to understand the discharge characteristic that is the main driver of the observed toxicity?
4. Will the proposed discharge process offer an adequate level of dilution to ensure the protection of the receiving ecosystem?

4.2 UTILITY OF CURRENTLY AVAILABLE ECOTOXICITY DATA FOR EPDP ASSESSMENT

4.2.1 ADELAIDE DESALINATION PLANT ECOTOXICITY ASSESSMENT

As part of the ADP assessment, brine samples tested were generated using different reverse osmosis plants:

- Port Stanvac seawater processed through Kangaroo Islands Penneshaw desalination plant.
- Port Stanvac seawater processed through a benchtop pilot plant.
- Port Stanvac seawater processed through the pilot plant that was set up at the site of the proposed ADP.

The feed-in water was collected from Port Stanvac, the proposed site for the ADP, for each of the studies with a brine then generated for the ecotoxicity regime. The water quality characteristics of the Port Stanvac feed water is considered to have similar composition to that which will be used for the EPDP and can therefore be considered representative.

The species that were used as part of the ADP ecotoxicity assessment included a number that were relevant to the coast of the Gulf St Vincent, were generic with regard to their ubiquitous distribution or were the best available surrogate offered by the ecotoxicity testing laboratories. The species that were used during the ADP assessment included:

- *Pagrus auratus* (fish)
- *Seriola lalandi* (fish)
- *Allorchestes compressa* (amphipod)
- *Nitzschia closterium* (microalga)
- *Heliocidaris tuberculata* (sea urchin)
- *Mimaclamys asperrima* (scallop)
- *Ecklonia radiata (macroalga)*
- *Diopatra dentata* (polychaete)
- *Mytilus edulis* (mussel)

All these species would also be considered locally or regionally relevant regarding the assessment of the EPDP.

The results of the ecotoxicity assessment for the ADP indicated that salinity is the main driver of the observed toxicity for an operational brine discharge, which has been confirmed by other large seawater desalination plant discharge studies undertaken in Australia. As presented in the literature review, the chemicals that are potentially toxic to the receiving environment are either not discharged with the brines (due to needing a much greater dilution rate than could not be met) or are in such low concentrations that they have little to no toxic effect and are considered negligible given the required dilution to reduce the toxicity of the salinity to acceptable levels.

To derive the minimum dilution needed to protect the receiving environment from a brine discharge, the species sensitivity distribution (SSD) method is recommended as per the (ANZG, 2018). This method was used to derive the protective concentrations in the assessment of ADP brine. The outcomes of the ecotoxicity assessment using brine generated from Penneshaw and the ADP pilot plant indicated that dilutions of approximately 12:1 and 21:1 would be needed, respectively. The reason for the observed difference in the required dilution was the increased salinity of the brine produced by the ADP pilot plant which was operating at a greater recovery rate than the Penneshaw plant, which increased the salinity of the ADP's discharge and hence the toxicity.

Further testing undertaken for the ADP investigated two different proposed Clean in Place (CIP) chemicals mixtures:

1. Permeate sample with sodium hydroxide added to reach a pH of 12.5 with 0.35% Na_4-EDTA and then neutralised with sulphuric acid until a pH of 8.0 was reached;
2. Permeate sample with sodium hydroxide added to reach a pH of 12.5 with 0.01% laurel sulphate and then neutralised with sulphuric acid until a pH of 8.0 reached.

The same set of species were used in the assessment of the CIP chemicals that were used previously for the ADP ecotoxicity assessment.

The resulting safe dilution to protect 95% of receiving environment species from toxicity effects, CIP mixture 1 was calculated to need a 770:1 dilution and CIP mixture 2 would need a dilution of 2500:1.

It should be noted that the ecotoxicity assessment undertaken using the brines generated by the Penneshaw desalination plant as the most relevant for the assessment of the proposed EPDP. The brines assessed had a salinity of approximately 60 PSU, the same as the proposed salinity of the brine discharge from the EPDP. The pre-treatment chemicals are also those that were approved for use at the ADP. The safe dilution for this brine was derived to be 12:1, well within the proposed 40:1

4.2.2 OLYMPIC DAM DESALINATION PLANT ECOTOXICITY ASSESSMENT

As summarised in Section 2.3, tests were undertaken as part of the assessment of the discharge from the proposed Olympic Dam Desalination Plant (ODDP) during 2006, 2007 and 2008.

The samples that were tested as part of the ODDP assessment ranged from 35 ppt to 45 ppt salinity. The ecotoxicity testing that was undertaken in 2006 was at a salinity that would be comparable with that measured at the proposed EPDP discharge area, while tests done in 2007 and 2008 were undertaken at higher salinities to better match salinities in the Upper Spencer Gulf and would not be suitable for assessing the EPDP.

The brine generated for use in the ecotoxicity testing for ODDP used Nalco anti-scalant PC1020T at a dosing rate of 3.6 mg/L. This anti-scalant will be used in the EPDP and is therefore relevant to the EPDP ecotoxicity assessment.

The species tested in 2006 for the ODDP ecotoxicity assessment are presented in Table 4-1. Only three of the tested species, *Nitzshia closterium*, *Horosira banksii* and *Seriola lalandi*, would be considered regionally relevant to the proposed EPDP.

Table 4-1 Species tested as part of the 2006 Olympic Dam Desalination Plant ecotoxicity assessment

Species	Regionally relevant to EPDP	Notes
***Nitzschia closterium* (microalga)**	Yes	Widely distributed in Australian waters
***Hormosira banksii* (macroalga)**	Yes	Widely distributed throughout SA waters
***Penaeus monodon* (crustacean)**	No	
***Saccostrea commercialis* (bivalve)**	No	
***Heliocidaris tuberculata* (sea urchin)**	No	Distributed on rocky reefs from Southern Queensland to central New South Wales

Species	Regionally relevant to EPDP	Notes
***Seriola lalandi* (fish)**	Yes	An important aquaculture species in the Spencer Gulf

The main toxicity observed in the ODDP ecotoxicity assessment was attributed to the increased salinity of the brine samples. The brines that were tested were approximately 78 PSU, which is higher than that tested for the APD (72 PSU) and higher than that proposed for the EPDP (~60 PSU). Toxicity not explained by salinity alone was observed for the microalga which was thought to be due to the added anti-scalant.

The protective levels calculated for the ODDP data generated in 2006 to protect 95% of species was a concentration of 1.66% effluent and 60 times dilution. Upon recalculation using chronic and sub-chronic no observed effect concentration (NOEC) values and chronic converted acute values using an acute to chronic ratio of 2 (recommended when salinity is considered the main driver of toxicity), the 95% protective dilution was calculated to be 3.8% with a corresponding safe dilution of 26.3. Percentage concentrations of discharge brines and values used in the recalculation are presented in Table 4-2 and the corresponding SSD is presented in Figure 4-1.

Table 4-2 Concentrations of 2006 ODDP brine discharge used in recalculation of protective concentration

Species	NOEC (% sample)	NOEC used (% sample)
***Nitzschia closterium* (microalga)**	11	11
***Hormosira banksii* (macroalga)**	16.5	16.5
***Penaeus monodon* (crustacean)**	16.5	8.25
***Saccostrea commercialis* (bivalve)**	8.3	8.3
***Heliocidaris tuberculata* (sea urchin)**	4.1	4.1
***Seriola lalandi* (fish)**	12.5	6.25

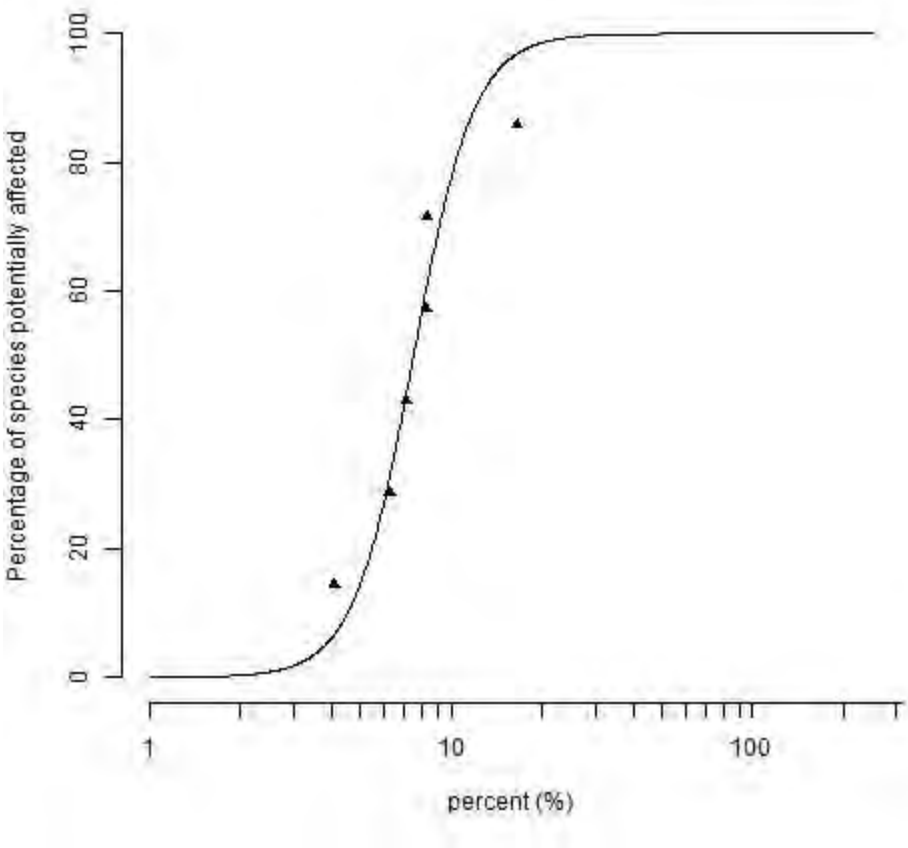

Figure 4-1 Species sensitivity distribution for 2006 ODDP brine discharge concentrations

4.2.3 ADP POST PLANT COMMISSIONING ASSESSMENT

As part of the Adelaide Desalination Plant EPA licence compliance conditions, post commissioning ecotoxicity testing was required to assess the performance of the plant regarding the toxicity of the discharge effluent. This licence condition was imposed after following the initial pre-commissioning ecotoxicity testing results, where a safe dilution to protect the receiving ecosystem was derived. The post-commissioning ecotoxicity testing involved the collection of discharge samples for ecotoxicity testing, as the plant increased its output from mid-2011 up to October 2013. Samples were collected at specific points as the plant increased output as per Table 4-3. Each of the five samples were submitted to a NATA accredited laboratory for ecotoxicity testing. Over the program, three species were used due to the unavailability of the polychaete, *Diopatra aciculata*, for testing of the 3-month after operation and 6-month after operation samples, where the sea urchin, *Helicidaris tuberculata*, was used instead. The regionally relevant mussel, *Mytilus galloprovincialis*, was the only species that was exposed to all five samples. Table 4-3 gives the 10% inhibition concentration (IC10) and the corresponding safe dilution needed to protect the receiving ecosystem. The safe dilutions were derived by dividing the chronic IC10 value by a safety factor of 2 (the safety factor used when salinity is the driver of the observed toxicity). The resultant safe dilution was then deemed to be acceptable if it was within the minimum 50-fold diffusion that occurs within the designated mixing zone.

Table 4-3 Plant production, date of sample collection and IC10/safe dilutions for each discharge scenario

Sample	Target value	10% of total production	20% of total production	30% of total production	3 months after fully operational	6 months after fully operational
Data of sample collection		12/10/2011	15/05/2012	17/05/2012	25/03/2013	19/08/2013
Plant production at the time		30ML/d	60ML/d	90ML/d	165ML/d	90ML/d
***Mytilus galloprovincialis* 48-h larval dev**	IC10	12.9 (12.8-12.9)	10.9 (8.9-13.4)	12.5 (8.2-13.0)	6.4*	6.3*
	Safe Dilution	15.5	18.4	16	31.3	31.8
***Diopatra aciculata* 14-d growth**	IC10	19.5 (2.4-76.3)	4.1^ (0.5-38.9)	2.1^ (0.6-11.9)	NA	NA
	Safe Dilution	10.3	48.8	95.3	NA	NA
***Heliocidaris tuberculata* 72-h larval dev**	IC10	NA	NA	NA	12.9 (12.6-13.1)	7.3 (6.7-7.8)
	Safe Dilution	NA	NA	NA	15.5	27.4

* Confidence intervals not reliable
^ Below lowest test concentration (<6.3% sample concentration)

The results showed that the majority of the resultant safe dilutions were within the safe minimum diffusion that would be achieved in the mixing zone with the exception of the *D. aciculata* 14-d growth test when exposed to the sample collected at the 30% of total production stage of commissioning. Upon investigation of the results of the testing for both the 20% and 30% of total production discharge for this endpoint, it was observed the test results had high variability around each of the concentrations tested, including the control, with the overall result affected by the standard deviation oscillating above and below the level of significance for these tests. It was decided that these weight endpoint results would not be considered in the interpretation of the discharges. Results for the mussel, *M. galloprovincialis*, were the most complete set for the assessment of the discharges, given that it was the only species that was tested against all five samples. The levels of toxicity measured for this species were all below the level of dilution expected to be achieved within the mixing zone around the discharge point. This outcome was corroborated by the results for the sea urchin, *H. tuberculata,* for the 3 months and 6 months discharges where the level of toxicity measured was within the expected dilution of the mixing zone. These results indicated that the ADP was operating within the required performance criteria.

5.LITERATURE REVIEW

Hydrobiology has conducted several desalination plant ecotoxicity assessment projects in Australia, for example, Adelaide, Sydney, Melbourne, and Gold Coast large seawater desalination projects to assess ecotoxicity of seawater desalination discharges and its utility to assist in the calculation of dilution criteria. The outcomes of these studies have been provided in previous sections as summaries but we have included here a more in-depth review of those studies.

5.1 ECOTOXICITY EVALUATION FOR ADELAIDE DESALINATION PILOT PLANT SALINE CONCENTRATE AND BACKWASH

Hydrobiology was commissioned by SA Water in July 2008 to undertake an ecotoxicity program aimed to investigate the toxicity of a saline concentrate representative of the Adelaide Desalination Plant (ADP) to determine the protective concentrations necessary to minimise environmental harm and to calculate the corresponding dilutions to achieve this.

The testing of a pilot plant saline concentrate, and backwash products was undertaken in the second phase of ecotoxicity testing. The samples that were tested are listed below:

- Backwash supernatant, which may include small concentrations of insoluble iron and manganese (in the form of ferric hydroxide and manganese dioxide), as well as very low concentrations of unreacted polymer used in the solids clarification/thickening process. Contributing streams to the backwash supernatant include UF membrane pre-treatment backwash and conventional media filter backwash;
- Dechlorinated membrane pre-treatment chemically enhanced backwash: this involved dosing filtered seawater with approximately 200 mg/L of chlorine (in the form of sodium hypochlorite) and increasing the pH to 10 (using sodium hydroxide). This was followed by a low pH clean (pH 2, using sulphuric acid). The combined waste contained residual free chlorine (typically less than 20 mg/L) at a pH between 6.5 and 7.5. This solution was then batch dechlorinated using sodium metabisulphite;
- Reverse osmosis concentrate (45% recovery rate) with no added antiscalant at ambient pH;

- Reverse osmosis concentrate (45% recovery rate) with added antiscalant (the applied concentration at this pH was ~ 2.8 mg/L, corresponding to ~ 5 mg/L antiscalant in the saline concentrate) at ambient pH;
- Reverse osmosis concentrate (45%) with no added antiscalant at an adjusted pH of 7.1
- Reverse osmosis concentrate (45% recovery rate) with added antiscalant (the applied concentration at this pH was ~ 1.2 mg/L, corresponding to ~ 2.2 mg/L in the saline concentrate) at an adjusted pH of 7.1

Saline concentrate was pH adjusted by adding an amount of sulphuric acid to the feed water before the reverse osmosis process while the feedwater for the ambient concentrate did not receive any acidic pre-filtering treatment.

The following toxicity tests were selected - with the pilot plant saline concentrate and backwash samples:

Acute tests:

- 96-h fish imbalance test using *Pagrus auratus* (acute); and,
- 96-h amphipod survival test using *Allorchestes compressa* (acute).

Sub-chronic tests:

- 72-h microalga growth inhibition test using *Nitzschia closterium* (sub-chronic);
- 1-h sea urchin fertilisation success using *Heliocidaris tuberculata* (sub-chronic);
- 72-h sea urchin larval development test using *Heliocidaris tuberculata* (sub-chronic);
- 48-h scallop larval development test using *Mimaclamys asperrima* (sub-chronic); and,
- 72-h macroalga germination assay using *Ecklonia radiata* (sub-chronic).

Chronic tests:

- 14-d macroalga gametophyte growth test using *Ecklonia radiata* (chronic);
- 14-d polychaete survival test using *Diopatra dentata* (chronic);
- 14-d polychaete biomass test using *Diopatra dentata* (chronic);
- 14-d amphipod survival test using *Allorchestes compressa* (chronic);
- 14-d amphipod biomass test using *Allorchestes compressa* (chronic); and,
- 7-d fish growth test using *Pagrus auratus* (chronic).
- 16-d sea urchin metamorphosis test using *Heliocidaris erthyrogramma* (chronic);

5.1.1.1 TOXICITY TESTING RESULTS

AMBIENT PILOT PLANT SALINE CONCENTRATE

Results of the direct toxicity assessment (DTA) testing of the ambient saline concentrate and ambient saline concentrate with added antiscalant are presented in Table 5-1. The most sensitive organism to the ambient saline concentrate both with and without the antiscalant added was the sea urchin and scallop while the least sensitive organism was the amphipod.

An EC10 was not calculable for a number of the tests due to the response of the organisms being all or nothing where a gradual reduction in effect was not seen between test concentrations. The TOXCALC (Tidepool Scientific Software) software used by the laboratory is unable to derive a point estimate for the EC10 in these circumstances but does indicate that the value was between the no observed effect concentration (NOEC) and the lowest observed effect concentration (LOEC). For the purposes of deriving trigger values (TVs) a conservative approach was taken and the NOEC value was used in the species sensitivity distributions. It should also be noted that some of the calculated EC/IC10 values were imprecise with 95% confidence intervals either large or not calculable.

The EC10/NOEC values used in species sensitivity distributions to derive ecological TVs for ambient saline concentrate both with and without antiscalant are greyed out in Table 5-1.

Table 5-1 Results of DTA of ambient pilot plant saline concentrate with and without antiscalant.

	QA/QC criteria met	EC10/NOEC values (% sample)	
		Ambient saline concentrate with antiscalant	Ambient saline concentrate without antiscalant
Microalgal Cell Yield	Yes	8.6	5.8
Sea Urchin Fertilisation Success (*H. tuberculata*)	Yes	22.1 (16.8 – 26.9)	20.6 (17.9 – 23.2)
Sea Urchin Larval Development (*H. tuberculata*)	Yes	13.3 (12.8 – 13.0)	13.5 (13.0 – 13.8)
Sea Urchin Metamorphosis (*H. erythrogramma*)	Yes	>12.5	>12.5
Scallop Larval Development	Yes	12.8 (12.3 – 13.0)	12.9 (12.7 – 13.0)
Macro-algal Germination	Yes	93.4	>100
Macroalgal Gametophyte Growth	Yes	27.2 (15.9 – 37.8)	59.2 (52.6 – 63.7)
Amphipod Survival (96-h)	Yes	54.1 (49.0 – 71.8)	65.2
Amphipod Survival ((14-d)	Yes	47.1 (27.6 – 56.4)	28.8 (9.4 – 38.6)
Amphipod biomass (14-d)	Yes	42.3 (0.0 – 62.6)	28.3 (0.0 – 33.7)
Polychaete Survival (14-d)	Yes	31.3 (21.2 – 51.7)	19.4 (2.1 – 36.6)
Polychaete Biomass (14-d)	Yes	>50	>50
Fish Growth (7-d)	Yes	13.8 (13.5 – 13.8)	13.8 (13.3 - 13.8)

* greyed out cells were used in calculation of species sensitivity distributions. Values in brackets are 95% confidence intervals

Figure 5-1 and Figure 5-2 display the Species sensitivity distributions (SSDs) derived from the EC10/NOEC data and the fit of the data by the BurrliOZ (ANZECC and ARMCANZ, 2000) software.

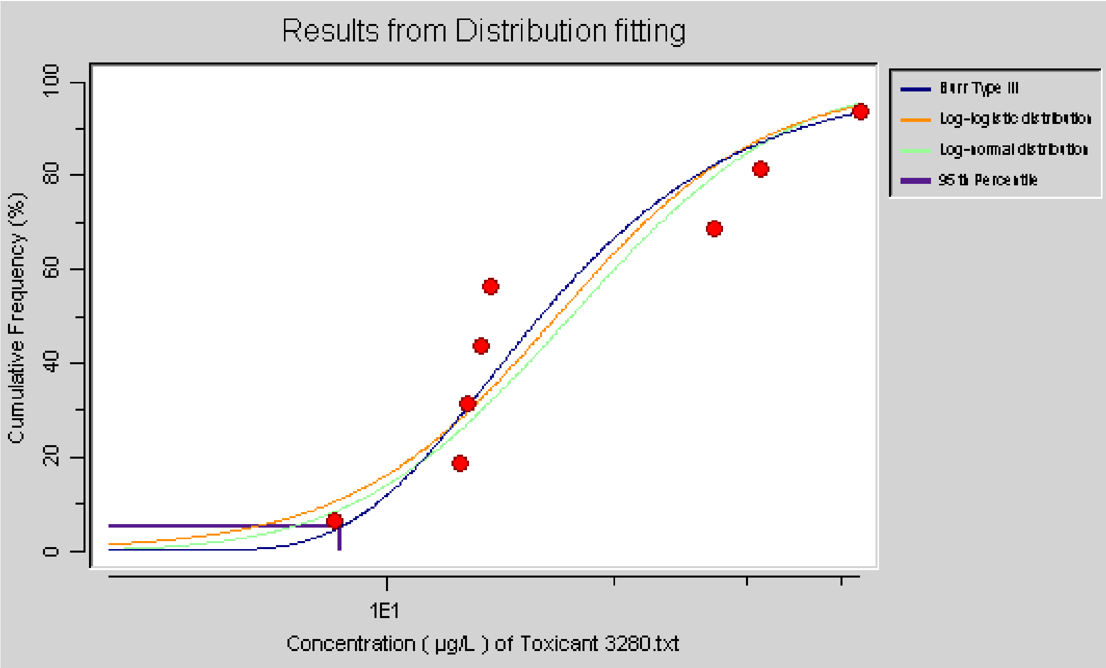

Figure 5-1 Species sensitivity distribution for pilot plant ambient saline concentrate with antiscalant

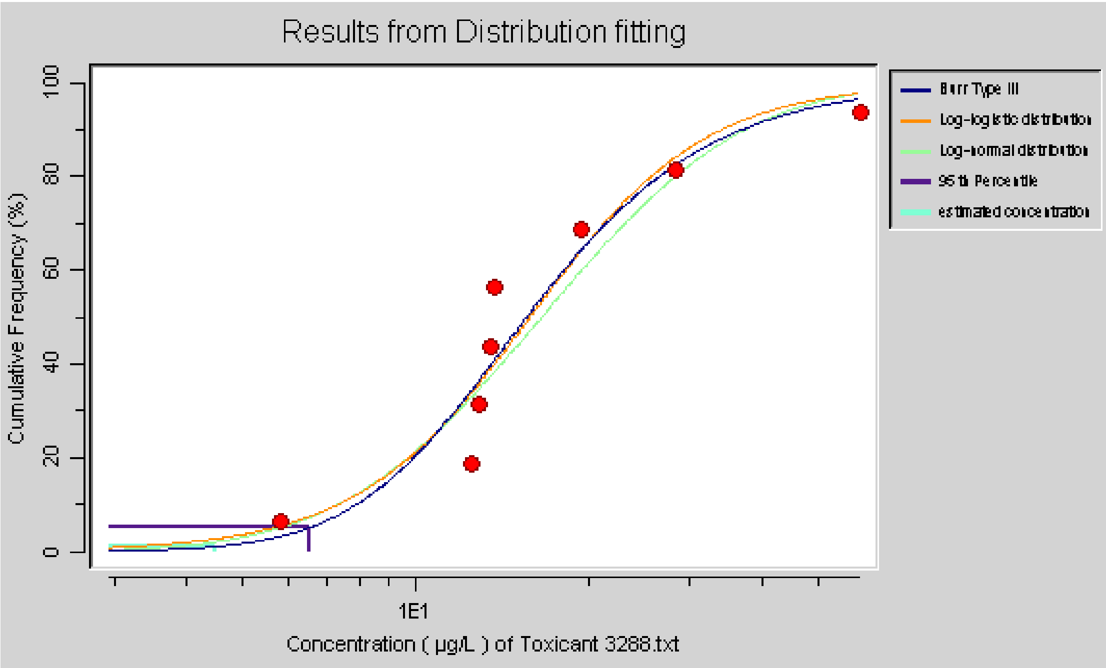

Figure 5-2 Species sensitivity distribution for pilot plant ambient saline concentrate without antiscalant

The fit of the Burr Type III distribution to each of the above sets of data was acceptable for the number of data points available for curve derivation with the goodness of fit values in the range of 20 to 25. The values obtained for the above SSDs were in the same range as those obtained for trigger values in the Australian and New Zealand water quality guidelines (ANZECC and ARMCANZ, 2000) that were based on a similar number of data points.

The concentrations of the ambient saline concentrate with and without antiscalant that must be achieved in order to protect 95% of species and corresponding safe dilution factors are presented in Table 5-2.

Table 5-2 Concentrations of the ambient pH saline concentrate that would need to be met to ensure the protection of 95% of species and their corresponding safe dilution factors

	PC95 (% sample) and safe dilution factor for ambient pH	
	Ambient saline concentrate with antiscalant	Ambient saline concentrate without antiscalant
PC 95	8.67	6.52
Safe Dilution Factor	12:1	16:1
PC 99	7.25	4.47
Safe Dilution Factor	14:1	23:1

The calculated safe dilutions indicate that the toxicity of the ambient saline concentrate without the added antiscalant was slightly more toxic than the saline concentrate with added antiscalant.

PH-ADJUSTED PILOT PLANT SALINE CONCENTRATE

Results of the DTA testing of the pH adjusted saline concentrate both with and without antiscalant are presented in Table 5-3. For the concentrate with the antiscalant the polychaete (biomass endpoint) was the most sensitive followed by the microalgae, sea urchin, fish and scallop, while the macroalgal germination endpoint was the least sensitive. The concentrate without the antiscalant was most toxic to the microalgae followed by the polychaete (survival endpoint), sea urchin and scallop, while the macroalgal germination test was the least sensitive.

The EC10/NOEC values used in species sensitivity distributions to derive ecological TVs for ambient saline concentrate both with and without antiscalant are highlighted in Table 5-3.

Table 5-3 Results of DTA of pH adjusted pilot plant saline concentrate with and without antiscalant

Direct Toxicity Assessment Test	QA/QC criteria met	EC10/NOEC values (% sample)	
		pH adjusted saline concentrate with antiscalant	pH adjusted saline concentrate without antiscalant
Microalgal Cell Yield	Yes	10.6	7.9
Sea Urchin Fertilisation Success (*H. tuberculata*)	Yes	22.5 (15.8 – 27.3)	21.1 (16.8 – 27.5)
Sea Urchin Larval Development (*H. tuberculata*)	Yes	13.6 (13.4 – 13.9)	13.3 (12.7 – 13.9)
Sea Urchin Metamorphosis (*H. erythrogramma*)	Yes	>12.5	>12.5

Scallop Larval Development	Yes	12.9 (12.6 – 13.0)	12.8 (12.5 – 12.9)
Macro-algal Germination	Yes	>100	>100
Macroalgal Gametophyte Growth	Yes	>12.5	53.5 (37.3 – 62.7)
Amphipod Survival (96-h)	Yes	78.1 (57.4 – 79.8)	52.2 (45.4 – 72.9)
Amphipod Survival ((14-d)	Yes	38.9 (0.0 – 58.9)	33.5 (0.0 – 42.8)
Amphipod Biomass (14-d)	Yes	50.0 (0.0 – 58.0)	28.5 (0.0 – 35.9)
Polychaete Survival (14-d)	Yes	41.1 (36.7 – 44.1)	11.4
Polychaete Biomass (14-d)	Yes	8.4	>50
Fish Growth (7-d)	Yes	13.8 (13.3 – 13.8)	13.8 (13.5 – 13.8)

* greyed out cells were used in calculation of species sensitivity distributions. Values in brackets are 95% confidence intervals

Figure 5-3 and Figure 5-4 display the SSDs derived from the EC10/NOEC data and the fit of the data by the BurrliOZ software.

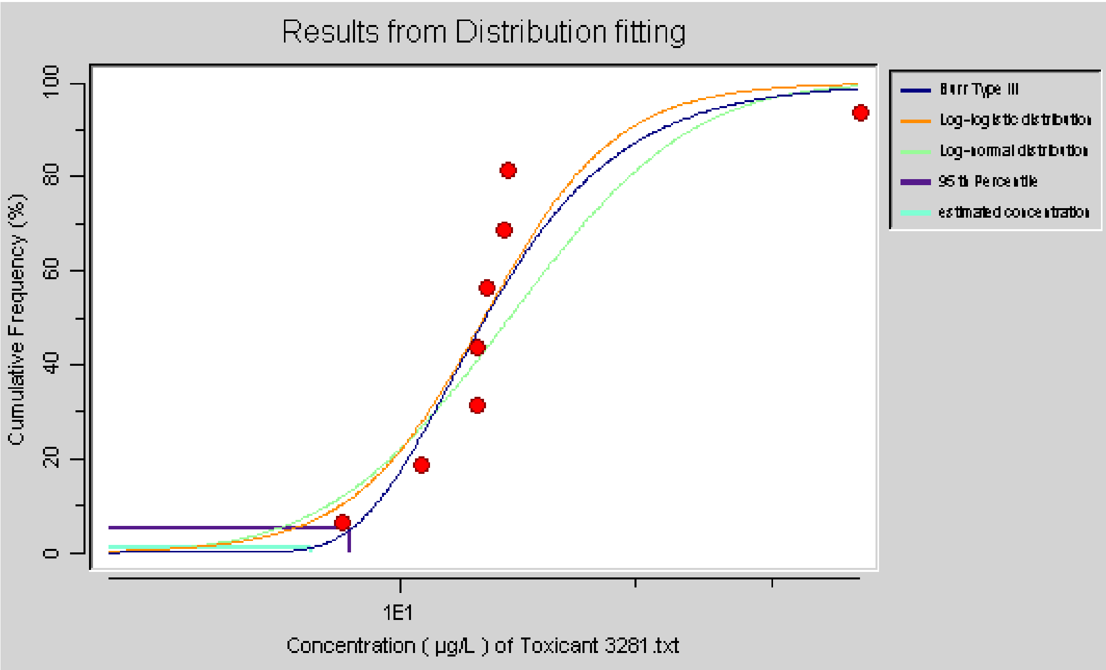

Figure 5-3 Species sensitivity distribution for pH adjusted pilot plant saline concentrate with antiscalant

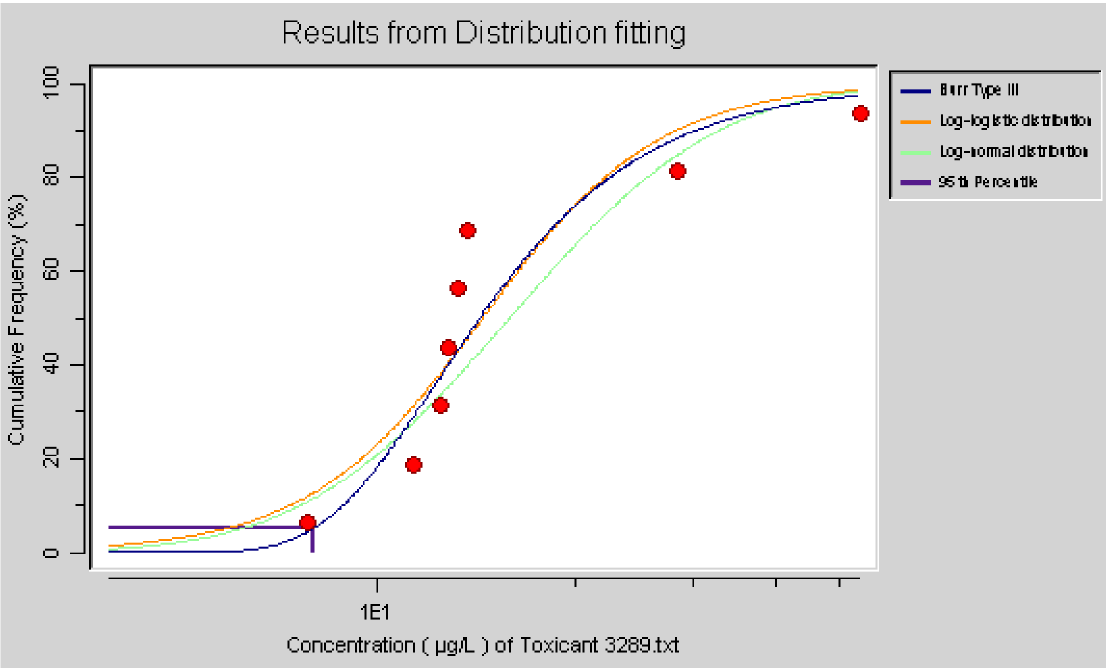

Figure 5-4 Species sensitivity distribution for pH adjusted pilot plant saline concentrate without antiscalant

The fit of the Burr Type III distribution to each of the above sets of data was acceptable for the number of data points available for curve derivation with the goodness of fit values in the range of 20 to 25. The values obtained for the above SSDs were similar to those obtained for trigger values in the Australian and New Zealand water quality guidelines (ANZECC and ARMCANZ, 2000) that were based on a similar number of data points.

The concentrations of the pH-adjusted saline concentrate with antiscalant and without antiscalant that must be achieved in order to protect 95% of species and corresponding safe dilution factors are presented in Table 5-4.

Table 5-4 Concentrations of the pH-adjusted discharge that would need to be met to ensure the protection of 95% of species and their corresponding safe dilution factors

	PC95 (% sample) and safe dilution factor for pH-adjusted	
	pH adjusted saline concentrate with antiscalant	pH adjusted saline concentrate without antiscalant
PC 95	8.61	8.00
Safe Dilution Factor	12:1	13:1
PC 99	7.66	6.75
Safe Dilution Factor	14:1	15:1

The safe dilutions calculated indicate that the pH adjusted saline concentrate without antiscalant needs a higher rate of dilution, but the inherent assumptions involved with calculating protective concentrations and safe dilutions the difference can be considered negligible.

BACKWASH

Results of the DTA testing of the backwash supernatant and dechlorinated membrane pre-treatment chemically enhanced backwash are presented in Table 5-5 For the backwash supernatant the most sensitive organism was the microalga while the sea urchin fertilisation test, the macroalgal gametophyte growth test and the amphipod biomass test were the only other bioassays to detect toxicity. Similarly, the dechlorinated membrane pre-treatment chemically enhanced backwash caused the greatest toxicity in the microalgal test with toxicity also recorded in the sea urchin larval development test, the sea urchin fertilisation success test, the macroalgal gametophyte growth test and the scallop larval development test in order of decreasing sensitivity.

The EC10/NOEC values used in species sensitivity distributions to derive ecological TVs for both backwash samples are highlighted in Table 5-5.

Table 5-5 Results of DTA for pilot plant backwash supernatant and dechlorinated membrane pre-treatment chemically enhanced backwash

Direct Toxicity Assessment Test	QA/QC criteria met	EC10/NOEC values (% sample)	
		Backwash supernatant	Dechlorinated membrane pre-treatment chemically enhanced backwash
Microalgal Cell Yield	Yes	4.4 (1 – 24.9)	3.1 (0.9 – 12.5)
Sea Urchin Fertilisation Success (*H. tuberculata*)	Yes	51.6 (50.6 – 52.7)	60.4
Sea Urchin Larval Development (*H. tuberculata*)	Yes	>100	57.1 (52.4 – 60.3)
Sea Urchin Metamorphosis (H. erythrogramma)	Yes	>100	>100
Scallop Larval Development	Yes	>100	89.5
Macro-algal Germination	Yes	>100	>100
Macroalgal Gametophyte Growth	Yes	72.8 (55.4 – 79.1)	64.5 (11.0 – 84.9)
Amphipod Survival (96-h)	Yes	>100	>100
Amphipod Survival ((14-d)	Yes	>100	>100
Amphipod Biomass (14-d)	Yes	87.5	>100
Polychaete Survival (14-d)	Yes	>100	>100
Polychaete Biomass (14-d)	Yes	>100	>100
Fish Growth (7-d)	Yes	>100	>100

* greyed out cells were used in calculation of species sensitivity distributions. Values in brackets are 95% confidence intervals

Figure 5-5 and Figure 5-6 display the SSDs derived from the EC10 data and the fit of the data by the BurrliOZ software.

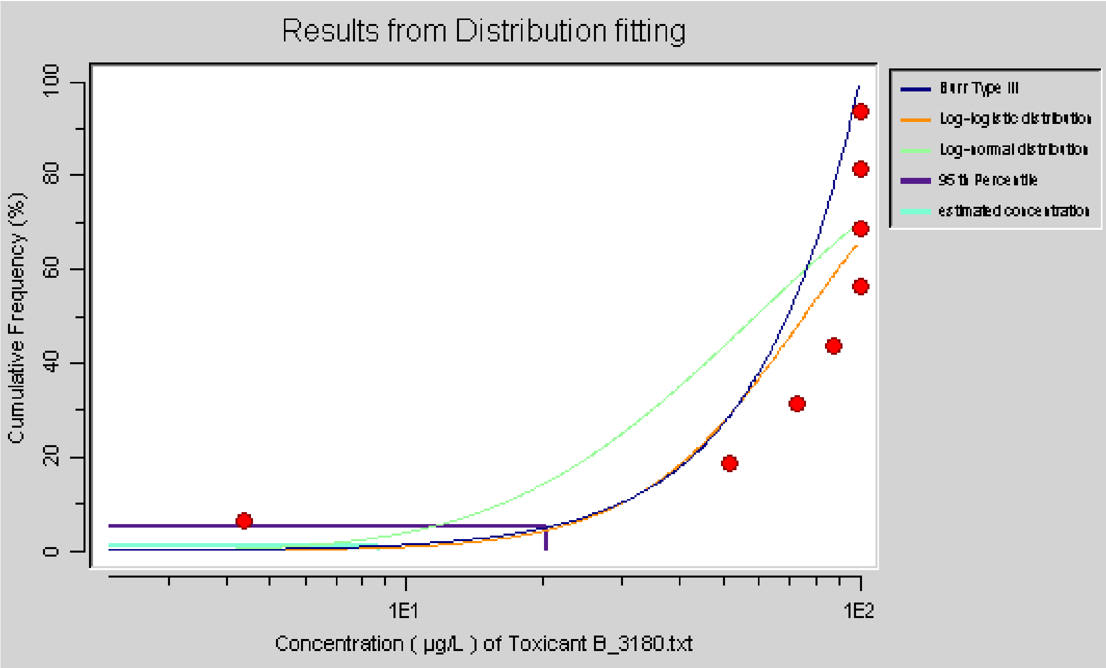

Figure 5-5 Species sensitivity distribution for pilot plant backwash supernatant

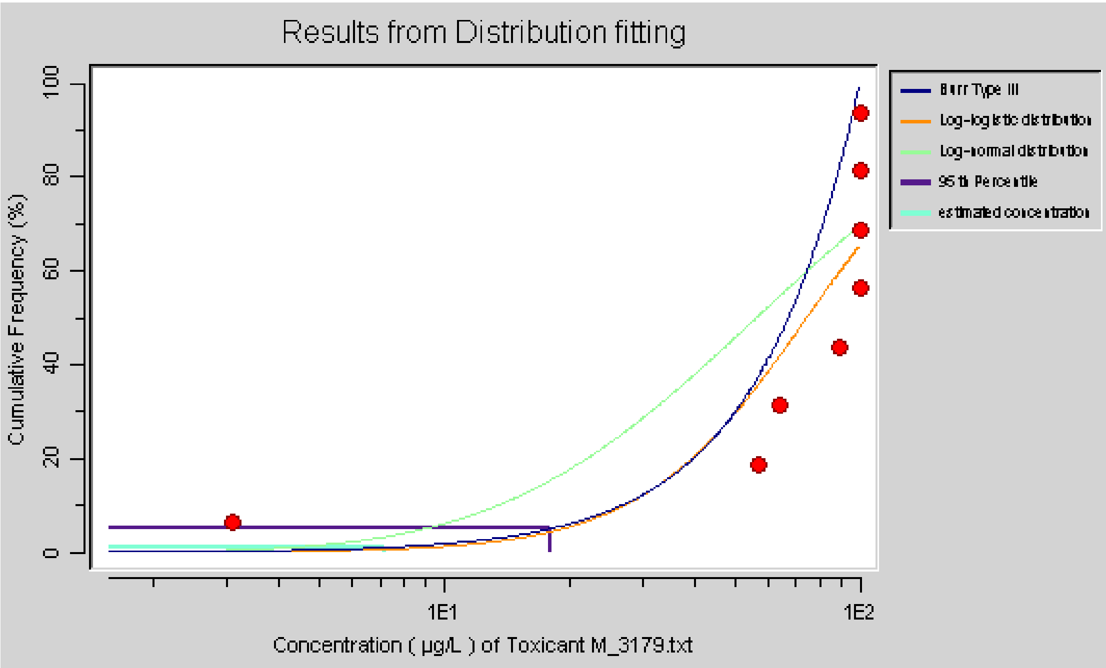

Figure 5-6 Species sensitivity distribution for dechlorinated membrane pre-treatment chemically enhanced backwash

The fit of the Burr Type III distribution to each of the above sets of data was acceptable for the number of data points available for curve derivation with the goodness of fit values in the range of 30 to 31. The values obtained for the above SSDs were similar to those obtained for trigger values in the Australian and New Zealand water quality guidelines (ANZECC and ARMCANZ, 2000) that were based on a similar number of data points.

The concentrations of the backwash supernatant and the dechlorinated membrane pre-treatment chemically enhanced backwash that must be achieved in order to protect 95% of species and corresponding safe dilution factors are presented in Table 5-6.

Table 5-6 Concentrations of the backwash supernatant and dechlorinated membrane pre-treatment chemically enhanced backwash that would need to be met to the protection of 95% of species and their corresponding safe dilution factors

	PC95 (% sample) and safe dilution factor for backwash	
	Backwash supernatant	Dechlorinated membrane pre-treatment chemically enhanced backwash
PC 95	20.47	17.97
Safe Dilution Factor	5:1	6:1
PC 99	8.73	7.15
Safe Dilution Factor	12:1	14:1

The toxicity of both backwash samples was low and would require low levels of dilution to achieve concentrations that will not harm 95% of the endemic marine species.

5.1.2 ECOTOXICITY EVALUATION OF ADELAIDE DESALINATION PLANT EFFLUENT AND PROCESS CHEMICALS

Hydrobiology was commissioned by Adelaide Aqua in year 2009 to undertake an ecotoxicological testing program on a range of possible effluents that may be part of the discharge from the Adelaide desalination plant to the marine environment at Port Stanvac. Samples were obtained from the pilot plant located at Port Stanvac. These samples included sea water obtained directly from the seawater pump, brine obtained from the operating reverse osmosis membranes at a recovery rate of 50% and the freshwater permeate obtained from the operating reverse osmosis membranes at a recovery rate of 50%.

Ecotoxicity testing was undertaken on samples derived from the operational pilot plant located at Port Stanvac and also on a poly-electrolyte. The samples tested were prepared by Adelaide Aqua personnel at ESA laboratories and were as follows:

- A brine sample that had not been treated chemically;
- A brine sample with 15 mg/l free chlorine produced by adding sodium hypochlorite to the brine. The free chlorine is then neutralised by adding 26 mg/L of sodium metabisulphite;
- A permeate sample that had been treated with 1 g/L of sulphuric acid and 2.5 g/L citric acid and then neutralised to pH 6.5 with caustic soda;
- A permeate sample with 30 mg/L of the biocide DBNPA (dibromonitrilopropionamide) added which was then neutralised with 29.5 mg/L sodium metabisulphite, ensuring that the dissolved oxygen levels were greater than 6.5 mg/L;
- There were two samples tested for sample 5:
  - ➢ permeate sample with sodium hydroxide added to reach a pH of 12.5 with 0.35% Na_4-EDTA and then neutralised with sulphuric acid until a pH of 8.0 was reached;
  - ➢ permeate sample with sodium hydroxide added to reach a pH of 12.5 with 0.01% laurel sulphate and then neutralised with sulphuric acid until a pH of 8.0 reached; and

- An intake seawater sample treated with a polyelectrolyte flocculent.

Permeate samples salinity was manipulated to approximately 35‰ using artificial sea salts before testing.

Below is a list of test species used in the DTA tests:

- 72-h *Nitzschia closterium* algal growth inhibition test (sub-chronic);
- 72-h sea urchin larval development test using *Heliocidaris tuberculata* (sub-chronic);
- 48-h larval development using the blue mussel *Mytilus edulis* (sub-chronic);
- 14-d macroalgal (*Ecklonia radiata*) gametophyte growth test (chronic);
- 14-d polychaete (*Diopatra dentata*) biomass test (chronic);
- 14-d amphipod (*Allorchestes compressa*) biomass test (chronic); and
- 7-d fish (*Seriola lalandi* and *Pagrus auratus*) growth and imbalance test (chronic).

5.1.2.1 TESTING RESULTS

BRINE RESULTS

Results of the DTA of the pilot plant brine are presented in Table 5-7

Table 5-7 Results of DTA of pilot plant brine

	% sample		Salinity (‰)		
	IC10	NOEC	Diluent	IC10	NOEC
Microalgal Cell Yield	12.7 (8.0-14.1)	12.5	37.6	43.1	43
Sea Urchin Larval Development	6.6 (6.4-6.7)	6.3	38.1	40.9	40.8
Mussel Larval Development	7.7 (7.2-8.7)	6.3	38.1	41.4	40.8
Macroalgal Gametophyte Growth	44.8 (27.7-55.0)	50	38.1	57.3	59.6
Amphipod Biomass (14-d)	20 (0-72.0)	50	37.6	46.3	59.3
Amphipod Survival (14-d)	11.8 (0-75.1)	50	37.6	42.7	59.3
Polychaete Biomass (14-d)	1.1 (0.04-43.3)	25	37.5	38	48.4
Polychaete Survival (14-d)	26.1 (4.3-36.5)	25	37.5	48.9	48.4
Snapper Growth (7-d)	0.4 (0.3-0.4)	<1.6	35	35.2	35.6
Snapper Imbalance (7-d)	0.7 (0.2-2.5)	<1.6	35	35.3	35.6
Kingfish Growth (7-d)	1.4 (0.4-9.6)	12.5	37.7	38.3	43.1
Kingfish Imbalance (7-d)	6.6 (0-9.0)	12.5	37.7	40.6	43.1

The larval fish tests were the most sensitive to the brine sample followed by the sea urchin and mussel larval development tests. The macroalgae proved to be the least sensitive of all the organisms tested. The corresponding salinity indicated that the snapper where very sensitive to an increase in salinity with a 0.2 ‰ increase causing a 10% decrease in the growth of the larval snapper while a 0.3‰ increase caused an imbalance to 10% of the larval snapper. For the larval kingfish an increase in salinity of 0.5‰ saw a 10% reduced growth rate and 0.7‰ increase caused 10% of the larval kingfish to become imbalanced. A salinity of 57.3‰ was observed to cause a 10% reduction in gametophyte growth.

BRINE PROTECTIVE CONCENTRATIONS

Protective concentrations for the brine were derived using IC10 and NOEC data as well as an "IC10 Best Data" set. An IC10 result was included in the best data set if the upper and lower confidence limits were within 3 times the IC10 % sample concentration. Table 5-8 displays the data that have been used to calculate the protective concentrations for all three sets of data with those values shaded in the table.

Table 5-8 Values used for the derivation of protective concentrations for brine sample

	% sample		
	IC10	IC10 Best Data	NOEC
Microalgal Cell Yield	12.7 (8.0-14.1)	12.7 (8.0-14.1)	12.5
Sea Urchin Larval Development	6.6 (6.4-6.7)	6.6 (6.4-6.7)	6.3
Scallop Larval Development	7.7 (7.2-8.7)	7.7 (7.2-8.7)	6.3
Macroalgal Gametophyte Growth	44.8 (27.7-55.0)	44.8 (27.7-55.0)	50
Amphipod Biomass (14-d)	20 (0-72.0)	20 (0-72.0)	50
Amphipod Survival (14-d)	11.8 (0-75.1)	11.8 (0-75.1)	50
Polychaete Biomass (14-d)	1.1 (0.04-43.3)	1.1 (0.04-43.3)	25
Polychaete Survival (14-d)	26.1 (4.3-36.5)	26.1 (4.3-36.5)	25
Snapper Growth (7-d)	0.4 (0.3-0.4)	0.4 (0.3-0.4)	1.6
Snapper Imbalance (7-d)	0.7 (0.2-2.5)	0.7 (0.2-2.5)	1.6
Kingfish Growth (7-d)	1.4 (0.4-9.6)	1.4 (0.4-9.6)	12.5
Kingfish Imbalance (7-d)	6.6 (0-9.0)	6.6 (0-9.0)	12.5

Figure 5-7 and Figure 5-8 display the SSDs derived from the IC10, IC10 Best Data and NOEC data respectively, and the goodness of fit of the data by the BurrliOZ (ANZECC and ARMCANZ, 2000) software.

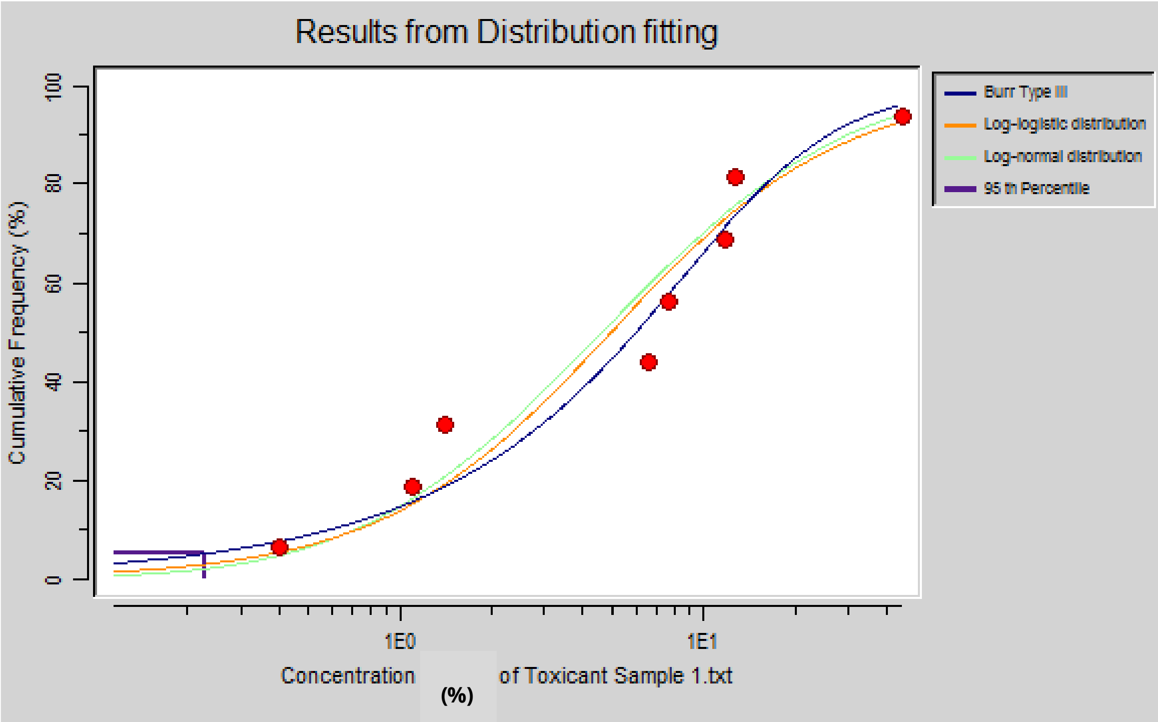

Figure 5-7 Species sensitivity distribution for pilot plant brine IC10 data

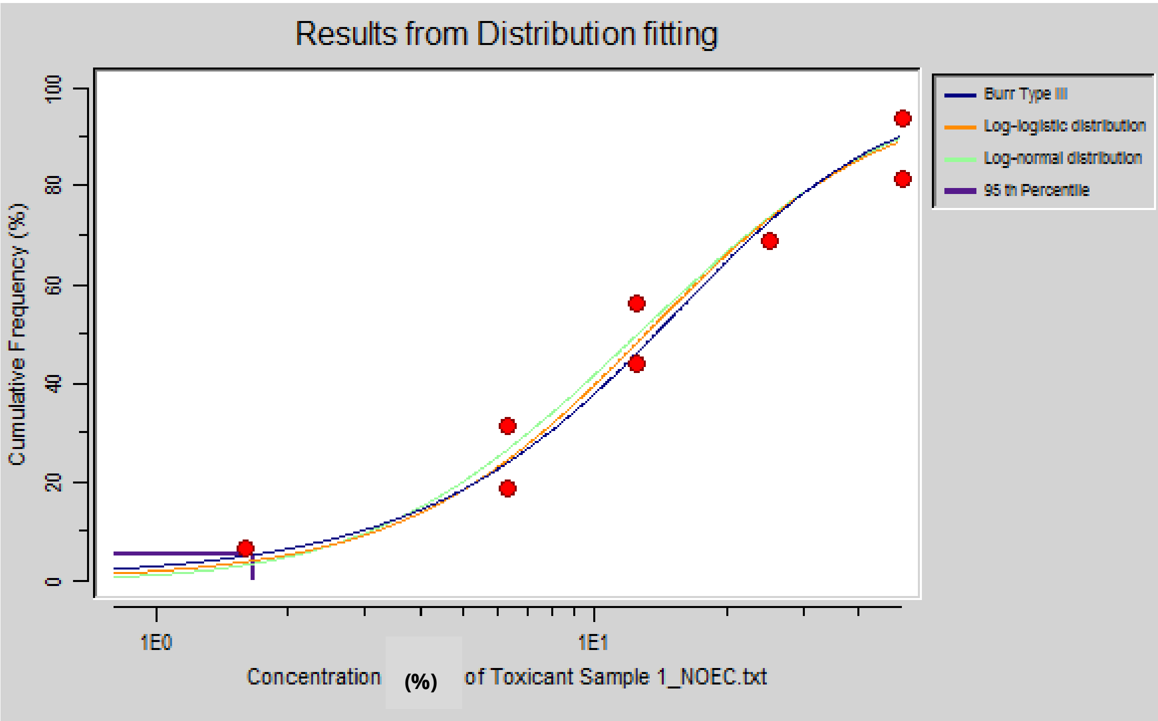

Figure 5-8 Species sensitivity distribution for pilot plant brine NOEC data

The resultant protective concentrations and safe dilutions for the three sets of brine data are presented in Table 5-9.

Table 5-9 Protective concentrations and safe dilutions for the brine sample (but see further discussion of IC10 Best Data set below).

	% sample		
PC	IC10	IC10 Best Data	NOEC
95%	0.23	0.55	1.66
Safe Dilution	435	182	61
99%	0.02	0.07	0.44
Safe Dilution	5000	1429	228
Goodness of Fit	26.7	21.3	32.5

CHLORINATED/DECHLORINATED BRINE RESULTS

Results of the DTA of the pilot plant brine that underwent a chlorination/dechlorination process prior to testing are presented in Table 5-10.

Table 5-10 Results of DTA of pilot plant chlorinated/dechlorinated brine

	% sample		Salinity (‰)		
	IC10	NOEC	Diluent	IC10	NOEC
Microalgal Cell Yield	13.1 (10.5-14.8)	12.5	37.6	43.3	43
Sea Urchin Larval Development	6.4 (6.2-6.6)	3.1	38.1	40.9	39.4
Mussel Larval Development	7.5 (6.4-8.3)	6.3	38.1	41.3	40.8
Macroalgal Gametophyte Growth	32.1 (31-33.0)	25	38.1	51.9	48.8
Amphipod Biomass (14-d)	24.0 (0.6-73.6)	50	37.6	48.0	59.3
Amphipod Survival (14-d)	50.1 (0-53.5)	50	37.6	59.3	59.3
Polychaete Biomass (14-d)	7.6 (0-38.3)	25	37.5	40.8	48.4
Polychaete Survival (14-d)	7.4 (0-36.3)	25	37.5	40.7	48.4
Snapper Growth (7-d)	0.4 (0.3-0.5)	<1.6	35	35.2	35.6
Snapper Imbalance (7-d)	0.9 (0.4-2.3)	<1.6	35	35.3	35.6
Kingfish Growth (7-d)	2.0 (0.2-12.1)	12.5	37.7	38.6	43.1
Kingfish Imbalance (7-d)	6.4 (0.4-9.7)	12.5	37.7	40.5	43.1

The larval fish were the most sensitive to the chlorinated/dechlorinated brine sample followed by the sea urchin and mussel larval development tests. As was seen with the brine sample an increase of 0.2‰ was enough to reduce the growth of the snapper by 10% and an increase of 0.3‰ cause 10% of the larval snapper to experience imbalance. For the larval kingfish an increase of 0.9‰ reduced growth by 10% and an increase of 1.2‰ caused 10% of the larval kingfish to experience imbalance. The macrophyte survival endpoint was the least sensitive of the organisms tested where a 10% reduction in gametophyte length was observed after salinity increase of 21.7‰.

CHLORINATED/DECHLORINATED BRINE PROTECTIVE CONCENTRATIONS

Protective concentrations for the chlorinated/dechlorinated brine were derived using IC10 and NOEC data as well as an "IC10 Best Data" set. An IC10 result was included in the best data set if the upper and lower confidence limits were within 3 times the IC10 % sample concentration. The snapper data was also excluded from the IC10 Best Data due to the unusual results of the testing. Table 5-11 displays the data that has been used to calculate the protective concentrations for all three sets of data with those values shaded in the table.

Table 5-11 Values used for the derivation of protective concentrations for the chlorinated/dechlorinated brine sample

	% sample		
	IC10	IC10 Best Data	NOEC
Microalgal Cell Yield	13.1 (10.5-14.8)	13.1 (10.5-14.8)	12.5
Sea Urchin Larval Development	6.4 (6.2-6.6)	6.4 (6.2-6.6)	3.1
Scallop Larval Development	7.5 (6.4-8.3)	7.5 (6.4-8.3)	6.3
Macroalgal Gametophyte Growth	32.1 (31-33.0)	32.1 (31-33.0)	25
Amphipod Biomass (14-d)	24.0 (0.6-73.6)	24.0 (0.6-73.6)	50
Amphipod Survival (14-d)	50.1 (0-53.5)	50.1 (0-53.5)	50
Polychaete Biomass (14-d)	7.6 (0-38.3)	7.6 (0-38.3)	25
Polychaete Survival (14-d)	7.4 (0-36.3)	7.4 (0-36.3)	25
Snapper Growth (7-d)	0.4 (0.3-0.5)	0.4 (0.3-0.5)	<1.6
Snapper Imbalance (7-d)	0.9 (0.4-2.3)	0.9 (0.4-2.3)	<1.6
Kingfish Growth (7-d)	2.0 (0.2-12.1)	2.0 (0.2-12.1)	12.5
Kingfish Imbalance (7-d)	6.4 (0.4-9.7)	6.4 (0.4-9.7)	12.5

Figure 5-9, Figure 5-10 and Figure 5-11 displays the SSDs derived from the IC10, IC10 Best Data and NOEC data respectively, and the fit of the data by the BurrliOZ (ANZECC and ARMCANZ 2000) software.

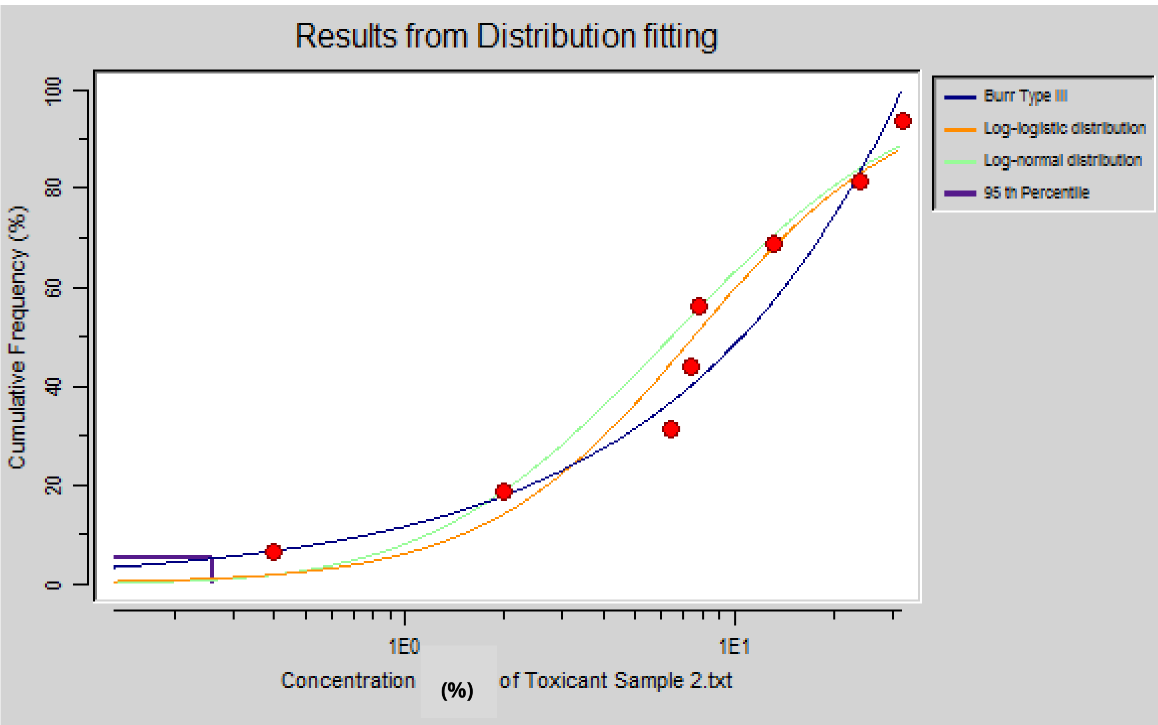

Figure 5-9 Species sensitivity distribution for pilot plant chlorinated/dechlorinated brine IC10 data

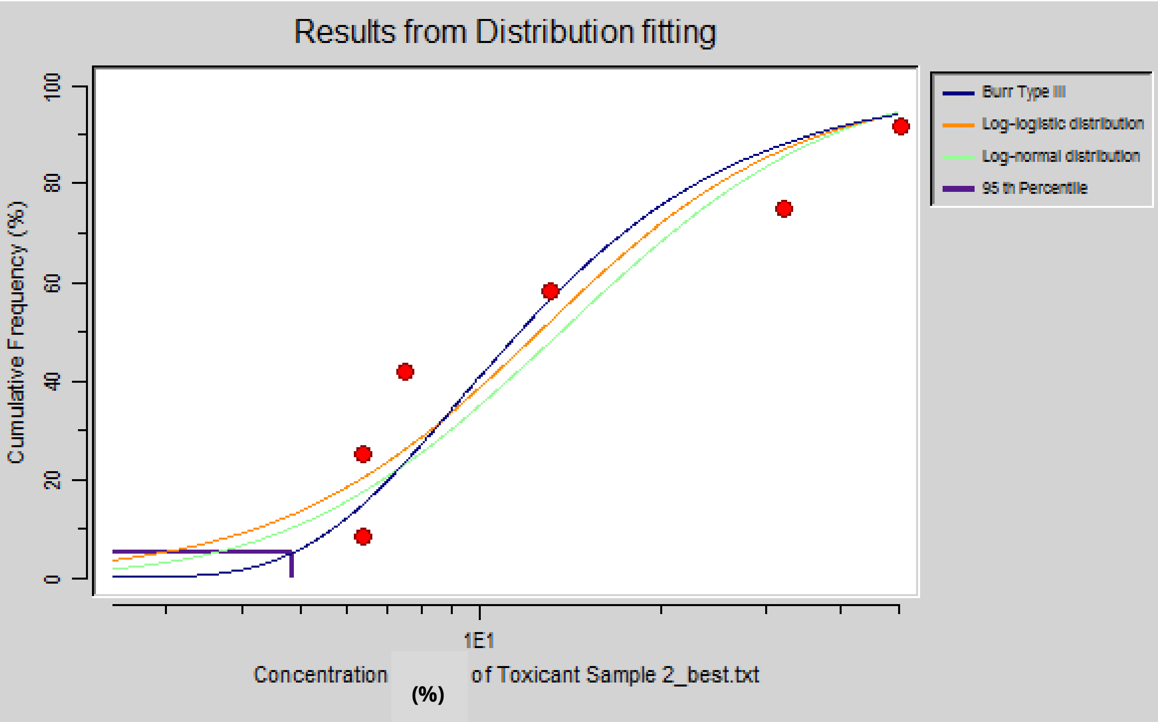

Figure 5-10 Species sensitivity distribution for pilot plant chlorinated/dechlorinated brine IC10 Best Data

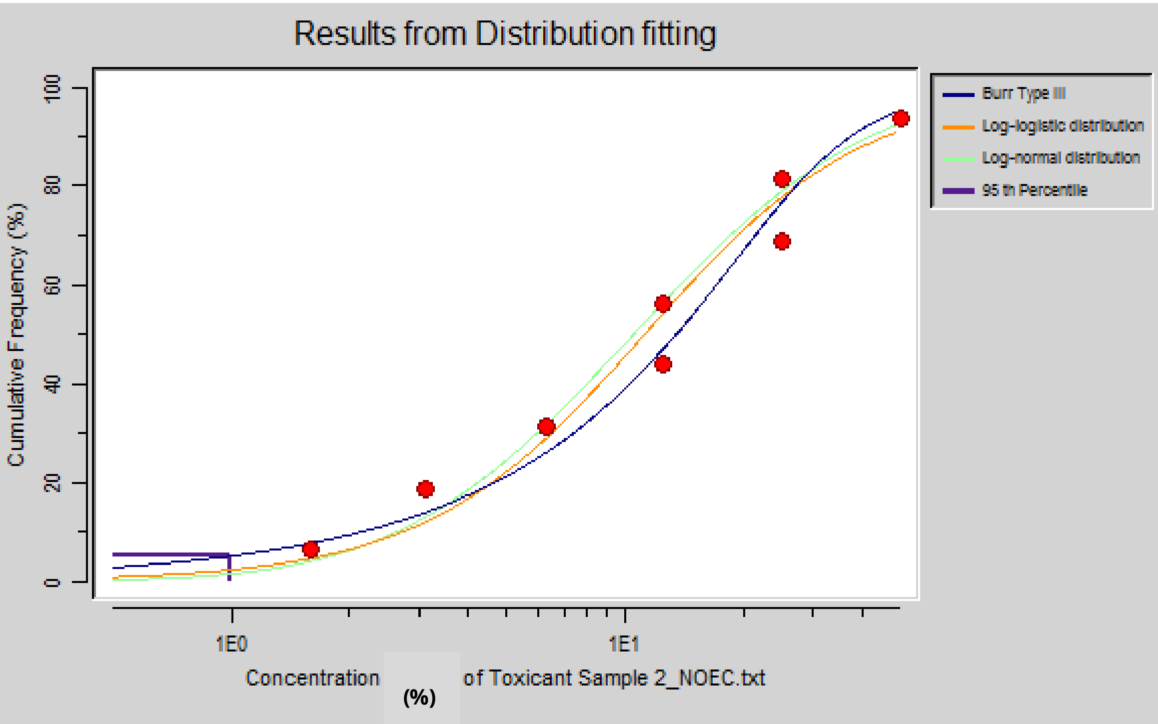

Figure 5-11 Species sensitivity distribution for pilot plant chlorinated/dechlorinated brine NOEC data

The resultant protective concentrations and safe dilutions for the three sets of chlorinated/dechlorinated brine data are presented in Table 5-12.

Table 5-12 Protective concentrations and safe dilutions for the chlorinated/dechlorinated brine sample

% sample

PC	IC10	IC10 Best Data	NOEC
95%	0.26	4.87	1
Safe Dilution	385	21	100
99%	0.02	3.77	0.16
Safe Dilution	5000	27	625
Goodness of Fit	26.7	26.8	27.2

ACIDIFIED/NEUTRALISED PERMEATE RESULTS

Results of the DTA of the pilot plant permeate that underwent acidification and neutralisation prior to testing are presented in Table 5-13.

Table 5-13 Results of DTA of pilot plant acidified and neutralised permeate

	% sample	
	IC10	NOEC
Microalgal Cell Yield	100	100
Sea Urchin Larval Development	25.5 (23.8-26.3)	25
Mussel Larval Development	25.7 (24.9-25.8)	25
Macroalgal Gametophyte Growth	62.6 (0-67.1)	50
Amphipod Biomass (14-d)	100	100
Amphipod Survival (14-d)	100	100
Polychaete Biomass (14-d)	4.2 (0-46.6)	50
Polychaete Survival (14-d)	14.3 (NC)	50
Snapper Growth (7-d)	55.4 (48.6-59.1)	50
Snapper Imbalance (7-d)	62.4 (45.1-71.8)	50
Kingfish Growth (7-d)	4.4 (0-9.7)	50
Kingfish Imbalance (7-d)	3.7 (0-11.5)	50

The sea urchin and mussel larval development tests proved to be the most sensitive of the routine tests used while the fish imbalance and polychaete biomass endpoints were also sensitive to the brine. The microalgae and the snapper proved to be the least sensitive of all the organisms tested.

ACIDIFIED/NEUTRALISED PERMEATE PROTECTIVE CONCENTRATIONS

Protective concentrations for the acidified/neutralised permeate were derived using IC10 estimates as well as an "IC10 Best Data" set. An IC10 result was included in the best data set if the upper and lower confidence limits were within 3 times the IC10 % sample concentration. Table 5-14 displays the values that have been used to calculate the protective concentrations for the two sets of data with those values shaded in the table. The NOEC values were not used as only three of the test concentrations could be used to calculate the PC's.

Table 5-14 Values used for the derivation of protective concentrations for the acidified/neutralised permeate sample

	% sample	
	IC10	IC10 Best Data
Microalgal Cell Yield	100	100
Sea Urchin Larval Development	25.5 (23.8-26.3)	25.5 (23.8-26.3)
Scallop Larval Development	25.7 (24.9-25.8)	25.7 (24.9-25.8)
Macroalgal Gametophyte Growth	62.6 (0-67.1)	62.6 (0-67.1)
Amphipod Biomass (14-d)	100	100
Amphipod Survival (14-d)	100	100
Polychaete Biomass (14-d)	4.2 (0-46.6)	4.2 (0-46.6)
Polychaete Survival (14-d)	14.3 (NC)	14.3 (NC)
Snapper Growth (7-d)	55.4 (48.6-59.1)	55.4 (48.6-59.1)
Snapper Imbalance (7-d)	62.4 (45.1-71.8)	62.4 (45.1-71.8)
Kingfish Growth (7-d)	4.4 (0-9.7)	4.4 (0-9.7)
Kingfish Imbalance (7-d)	3.7 (0-11.5)	3.7 (0-11.5)

Figure 5-12 and Figure 5-13 display the SSDs derived from the IC10 and IC10 Best Data estimates respectively, and the goodness of fit of the data by the BurrliOZ (ANZECC and ARMCANZ, 2000) software.

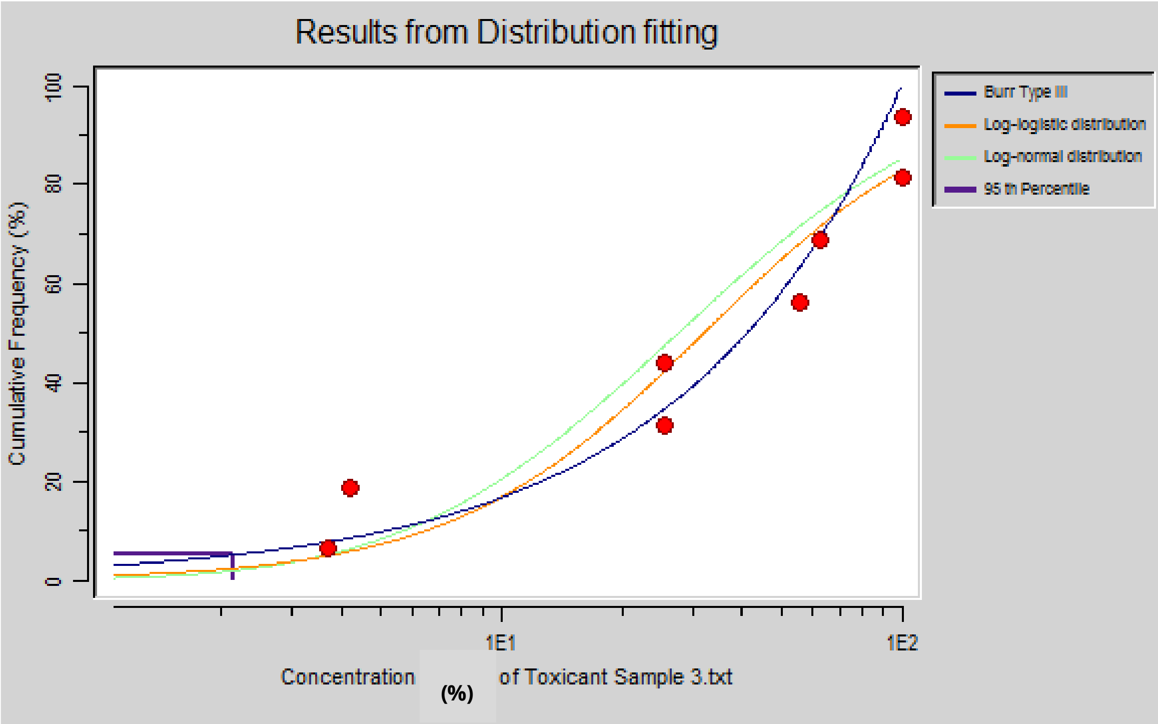

Figure 5-12 Species sensitivity distribution for pilot plant acidified/neutralised permeate IC10 data

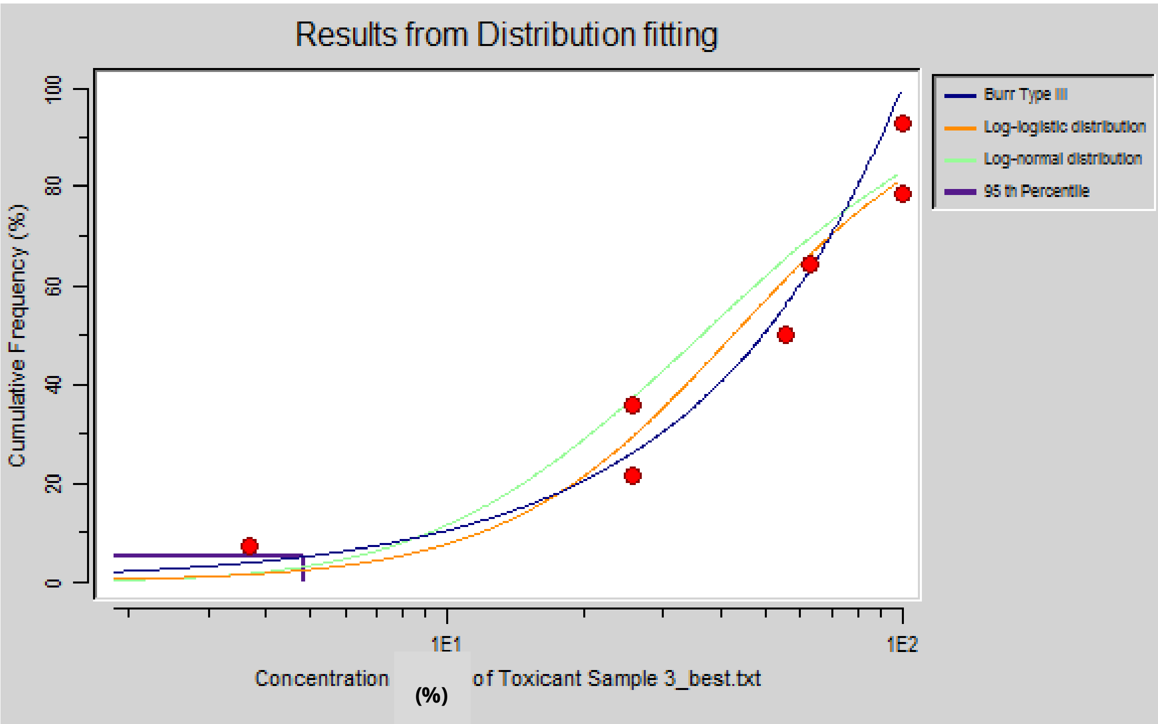

Figure 5-13 Species sensitivity distribution for pilot plant acidified/neutralised permeate IC10 Best Data

The resultant protective concentrations and safe dilutions for the three sets of chlorinated/dechlorinated brine data are presented in Table 5-15. The exclusion of the polychaete data from the calculation of the PC's in the IC10 Best Data reduced the required dilution by just over half for the 95% PC and by three times for the 99% PC. This indicates that the calculation of the PC's was sensitive to the inclusion of the polychaete data.

Table 5-15 Protective concentrations and safe dilutions for the acidified/neutralised permeate sample

	% sample	
PC	IC10	IC10 Best Data
95%	2.16	4.83
Safe Dilution	47	21
99%	0.27	0.95
Safe Dilution	371	106
Fit of Data	36.6	32.2

DBNPA TREATED/NEUTRALISED PERMEATE RESULTS

Results of the DTA of the pilot plant permeate that underwent DBNPA treatment and neutralisation prior to testing are presented in Table 5-16.

Table 5-16 Results of DTA of pilot plant DBNPA treated and neutralised permeate

	% sample	
	IC10	NOEC
Microalgal Cell Yield	18.0 (11.0-23.0))	25
Sea Urchin Larval Development	19.7 (17.1-25.6)	12.5
Mussel Larval Development	25.5 (24.8-25.8)	25
Macroalgal Gametophyte Growth	18.9 (14.4-31.5)	25
Amphipod Biomass (14-d)	20.1 (0-75.9)	50
Amphipod Survival (14-d)	9.1 (0-20.6)	12.5
Polychaete Biomass (14-d)	29 (NC)	100
Polychaete Survival (14-d)	27.6 (0-64.0)	50
Snapper Growth (7-d)	27.5 (25.4-28.8)	25
Snapper Imbalance (7-d)	40.8 (37.7-44.3)	25
Kingfish Growth (7-d)	28.8 (2.4-58.7)	50
Kingfish Imbalance (7-d)	11.6 (1.0-65.6)	50

The sea urchin and mussel larval development tests proved to be the most sensitive of the routine tests used while the fish imbalance and polychaete biomass endpoints were also sensitive to the brine. The microalgae proved to be the least sensitive of all the organisms tested.

DBNPA TREATED/NEUTRALISED PERMEATE PROTECTIVE CONCENTRATIONS

Protective concentrations for the DBNPA treated/neutralised permeate were derived using IC10 data as well as an "IC10 Best Data" set. An IC10 result was included in the best data set if the upper and lower confidence limits were within 3 times the IC10 % sample concentration. Table 5-17 displays the data that has been used to calculate the protective concentrations for the two sets of estimates with those values shaded in the table. PC's for the NOEC data were not calculated due to only three concentrations being able to be used for the calculations.

Table 5-17 Values used for the derivation of protective concentrations for the DBNPA treated/neutralised permeate sample

	% sample	
	IC10	IC10 Best Data
Microalgal Cell Yield	18.0 (11.0-23.0))	18.0 (11.0-23.0))
Sea Urchin Larval Development	19.7 (17.1-25.6)	19.7 (17.1-25.6)
Scallop Larval Development	25.5 (24.8-25.8)	25.5 (24.8-25.8)
Macroalgal Gametophyte Growth	18.9 (14.4-31.5)	18.9 (14.4-31.5)
Amphipod Biomass (14-d)	20.1 (0-75.9)	20.1 (0-75.9)
Amphipod Survival (14-d)	9.1 (0-20.6)	9.1 (0-20.6)
Polychaete Biomass (14-d)	29 (NC)	29 (NC)
Polychaete Survival (14-d)	27.6 (0-64.0)	27.6 (0-64.0)
Snapper Growth (7-d)	27.5 (25.4-28.8)	27.5 (25.4-28.8)
Snapper Imbalance (7-d)	40.8 (37.7-44.3)	40.8 (37.7-44.3)
Kingfish Growth (7-d)	28.8 (2.4-58.7)	28.8 (2.4-58.7)
Kingfish Imbalance (7-d)	11.6 (1.0-65.6)	11.6 (1.0-65.6)

Figure 5-14 and Figure 5-15 display the SSDs derived from the IC10, and IC10 Best Data estimates respectively, and the goodness of fit of the data by the BurrliOZ (ANZECC and ARMCANZ, 2000) software.

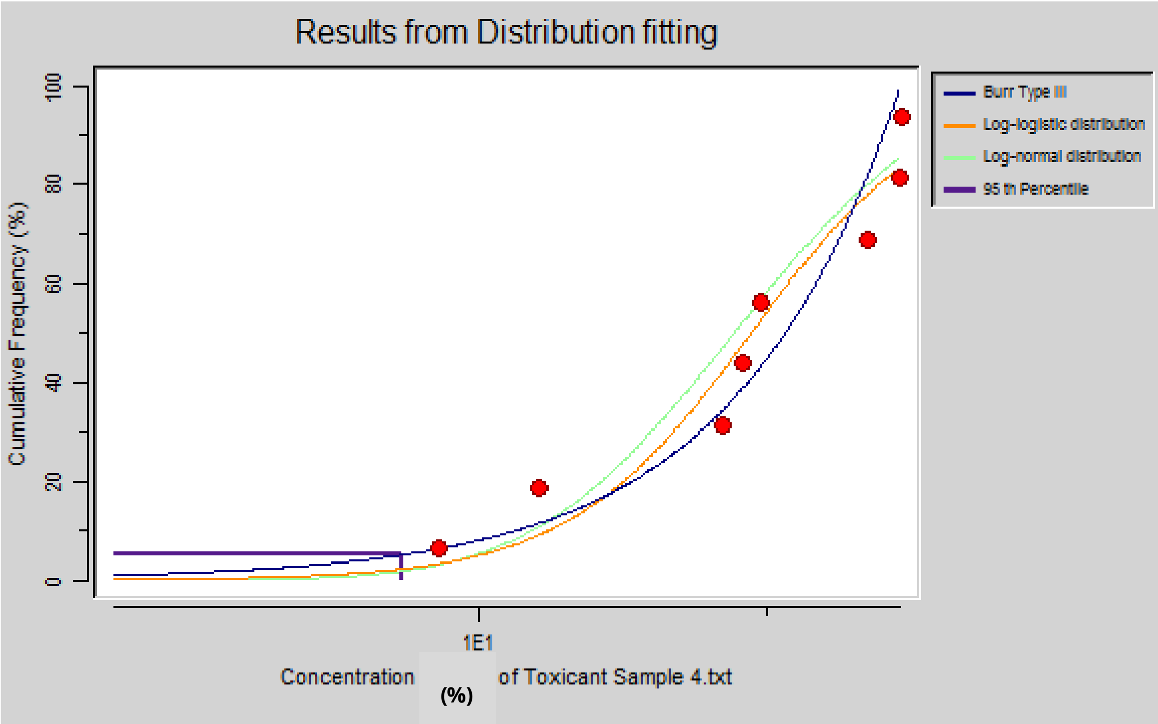

Figure 5-14 Species sensitivity distribution for pilot plant DBNPA treated/neutralised permeate IC10 data

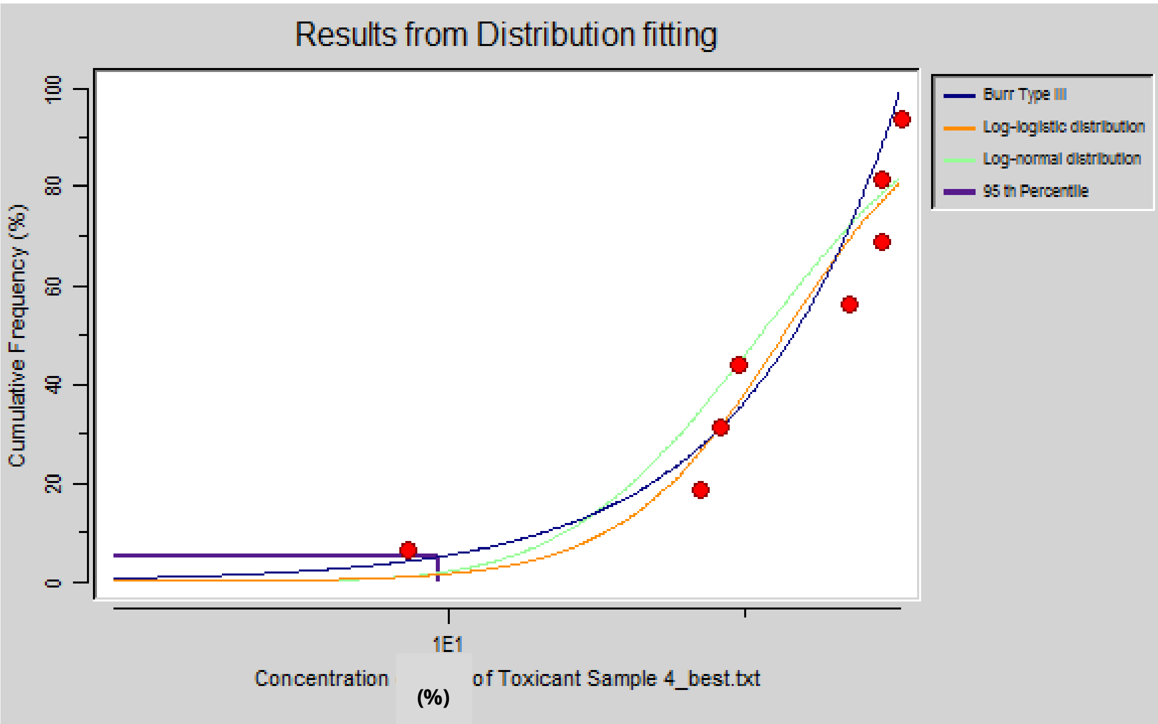

Figure 5-15 Species sensitivity distribution for pilot plant DBNPA treated/neutralised permeate IC10 Best Data

The resultant protective concentrations and safe dilutions for the three sets of DBNPA treated/neutralised permeate data are presented in Table 5-18. The use of the kingfish growth test data instead of the kingfish imbalance test for the IC10 Best Data PC's did not significantly alter the safe dilutions needed from those calculated using the IC10 data.

Table 5-18 Protective concentrations and safe dilutions for the DBNPA treated permeate sample

	% sample	
PC	IC10	IC10 Best Data
95%	8.32	9.73
Safe Dilution	13	11
99%	4.37	5.43
Safe Dilution	23	19
Goodness of Fit	24	23.4

NAOH/NA4-EDTA/NEUTRALISED PERMEATE RESULTS

Results of the DTA of the pilot plant permeate that underwent NaOH/Na4-EDTA treatment and neutralisation prior to testing are presented in Table 5-19.

Table 5-19 Results of DTA of pilot plant permeate treated with NaOH/Na4-EDTA/neutralised

	% sample	
	IC10	NOEC
Microalgal Cell Yield	0.9 (0.7-1.4)	<3.1
Sea Urchin Larval Development	4.0 (3.6-4.3)	3.1
Mussel Larval Development	4.5 (0.1-5.3)	3.1
Macroalgal Gametophyte Growth	26.0 (21.1-28.8)	25
Amphipod Biomass (14-d)	1.0 (0.5-10.1)	6.3
Amphipod Survival (14-d)	2.6 (1.1-3.4)	3.1
Polychaete Biomass (14-d)	4.5	100
Polychaete Survival (14-d)	100	100
Fish Imbalance (7-d)	0.15 (0-0.24)	<3.1

The microalgae test proved to be the most sensitive of the standard tests used while the fish imbalance endpoint was also sensitive to the treated permeate. The macroalgae proved to be the least sensitive of all the organisms tested.

PERMEATE TREATED WITH NAOH/NA4-EDTA/NEUTRALISED PROTECTIVE CONCENTRATIONS

Protective concentrations for the NaOH/Na4-EDTA/neutralised permeate were derived using IC10 and NOEC data as well as an "IC10 Best Data" set. An IC10 result was included in the best data set if the upper and lower confidence limits were within 3 times the IC10 % sample concentration. Table 5-20 displays the values that were used to calculate the protective concentrations for all three sets of data with those values shaded in the table. PC's for the NOEC data were not calculated due to only four concentrations being able to be used for the calculations.

Table 5-20 Values used for the derivation of protective concentrations for the NaOH/NA_4-EDTA/neutralised permeate sample

	% sample		
	IC10	IC10 Best Data	NOEC
Microalgal Cell Yield	0.9 (0.7-1.4)	0.9 (0.7-1.4)	<3.1
Sea Urchin Larval Development	4.0 (3.6-4.3)	4.0 (3.6-4.3)	3.1
Scallop Larval Development	4.5 (0.1-5.3)	4.5 (0.1-5.3)	3.1
Macroalgal Gametophyte Growth	26.0 (21.1-28.8)	26.0 (21.1-28.8)	25
Amphipod Biomass (14-d)	1.0 (0.5-10.1)	1.0 (0.5-10.1)	6.3
Amphipod Survival (14-d)	2.6 (1.1-3.4)	2.6 (1.1-3.4)	3.1
Polychaete Biomass (14-d)	4.5	4.5	100
Polychaete Survival (14-d)	100	100	100
Fish Imbalance (7-d)	0.15 (0-0.24)	0.15 (0-0.24)	<3.1

Figure 5-16 and Figure 5-17 display the SSDs derived from the IC10 and IC10 Best Data estimates respectively, and the goodness of fit of the data by the BurrliOZ (ANZECC and ARMCANZ, 2000) software.

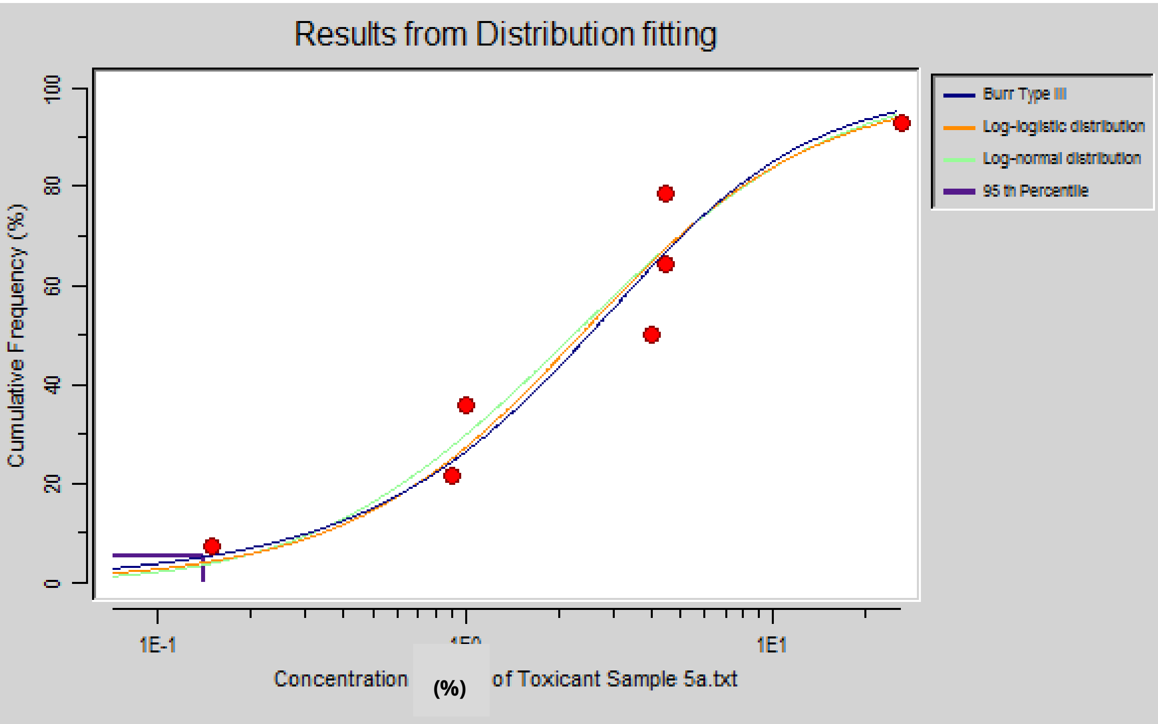

Figure 5-16 Species sensitivity distribution for pilot plant NaOH/Na4-EDTA/neutralised permeate IC10 data

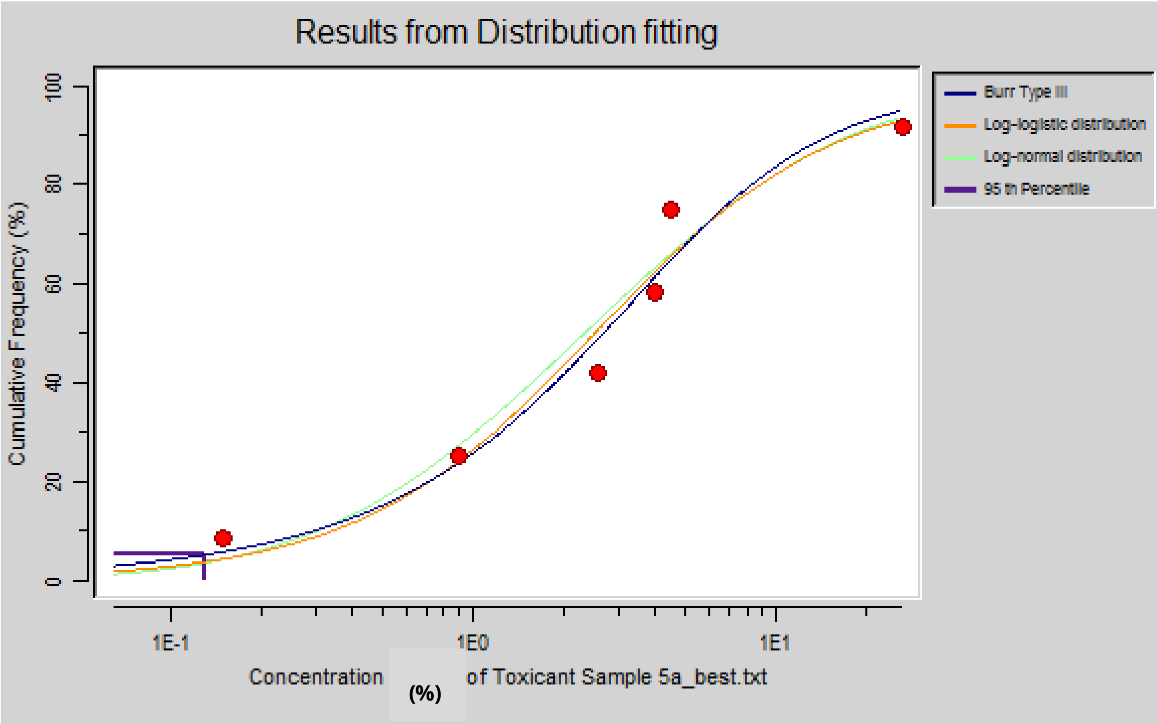

Figure 5-17 Species sensitivity distribution for pilot plant NaOH/Na4-EDTA/neutralised permeate IC10 Best Data

The resultant protective concentrations and safe dilutions for the two sets of NaOH/Na4-EDTA/neutralised permeate data are presented in Table 5-21. The exclusion of the polychaete data and the use of the amphipod survival data instead of the biomass data did not significantly alter the calculated PC's.

Table 5-21 Protective concentrations and safe dilutions for the NaOH/Na4-EDTA/neutralised permeate sample

	% sample	
PC	IC10	IC10 Best Data
95%	0.14	0.13
Safe Dilution	715	770
99%	0.02	0.02
Safe Dilution	5000	5000
Goodness of Fit	18.3	16.4

NAOH/SODIUM LAUREL SULPHATE/NEUTRALISED PERMEATE RESULTS

Results of the DTA of the pilot plant permeate that underwent NaOH/sodium laurel sulphate/neutralisation prior to testing are presented in Table 5-22.

Table 5-22 Results of DTA of pilot plant permeate treated with NaOH/sodium laurel sulphate/neutralised

	% sample	
	IC10	NOEC
Microalgal Cell Yield	0.3 (0.32-0.35)	<3.1
Sea Urchin Larval Development	0.2 (0.1-0.2)	<3.1
Mussel Larval Development	0.08 (0.07-0.08)	<3.1
Macroalgal Gametophyte Growth	6.7 (2.5-7.4)	6.3
Amphipod Biomass (14-d)	6.8 (2.7-7.0)	6.3
Amphipod Survival (14-d)	6.0 (0.8-7.0)	6.3
Polychaete Biomass (14-d)	2.4 (0.4-9.7)	6.3
Polychaete Survival (14-d)	10.1 (7.1-12.2)	12.5
Fish Imbalance (7-d)	0.05 (0.04-0.06)	<3.1

The mussel larval development test proved to be the most sensitive of the routine tests used while the fish imbalance endpoint was also sensitive to the treated permeate. The macroalgae proved to be the least sensitive of all the organisms tested.

NAOH/SODIUM LAUREL SULPHATE/NEUTRALISED PERMEATE PROTECTIVE CONCENTRATIONS

Protective concentrations for the NaOH/sodium laurel sulphate/neutralised permeate were derived using IC10 data as well as an "IC10 Best Data" set. An IC10 result was included in the best data set if the upper and lower confidence limits were within 3 times the IC10 % sample concentration. Table 5-23 displays the values that were used to calculate the protective concentrations for the two sets of data with those values shaded in the table. As there NOEC results only included two concentrations the PC's were not calculated based on those values.

Table 5-23 Values used for the derivation of protective concentrations for the NaOH/sodium laurel sulphate/neutralised permeate sample

	% sample	
	IC10	IC10 Best Data
Microalgal Cell Yield	0.3 (0.32-0.35)	0.3 (0.32-0.35)
Sea Urchin Larval Development	0.2 (0.1-0.2)	0.2 (0.1-0.2)
Scallop Larval Development	0.08 (0.07-0.08)	0.08 (0.07-0.08)
Macroalgal Gametophyte Growth	6.7 (2.5-7.4)	6.7 (2.5-7.4)
Amphipod Biomass (14-d)	6.8 (2.7-7.0)	6.8 (2.7-7.0)
Amphipod Survival (14-d)	6.0 (0.8-7.0)	6.0 (0.8-7.0)
Polychaete Biomass (14-d)	2.4 (0.4-9.7)	2.4 (0.4-9.7)

Polychaete Survival (14-d)	10.1 (7.1-12.2)	10.1 (7.1-12.2)
Fish Imbalance (7-d)	0.05 (0.04-0.06)	0.05 (0.04-0.06)

Figure 5-18 and Figure 5-19 display the SSDs derived from the IC10 and IC10 Best Data estimates respectively, and the goodness of fit of the data by the BurrliOZ (ANZECC and ARMCANZ, 2000) software.

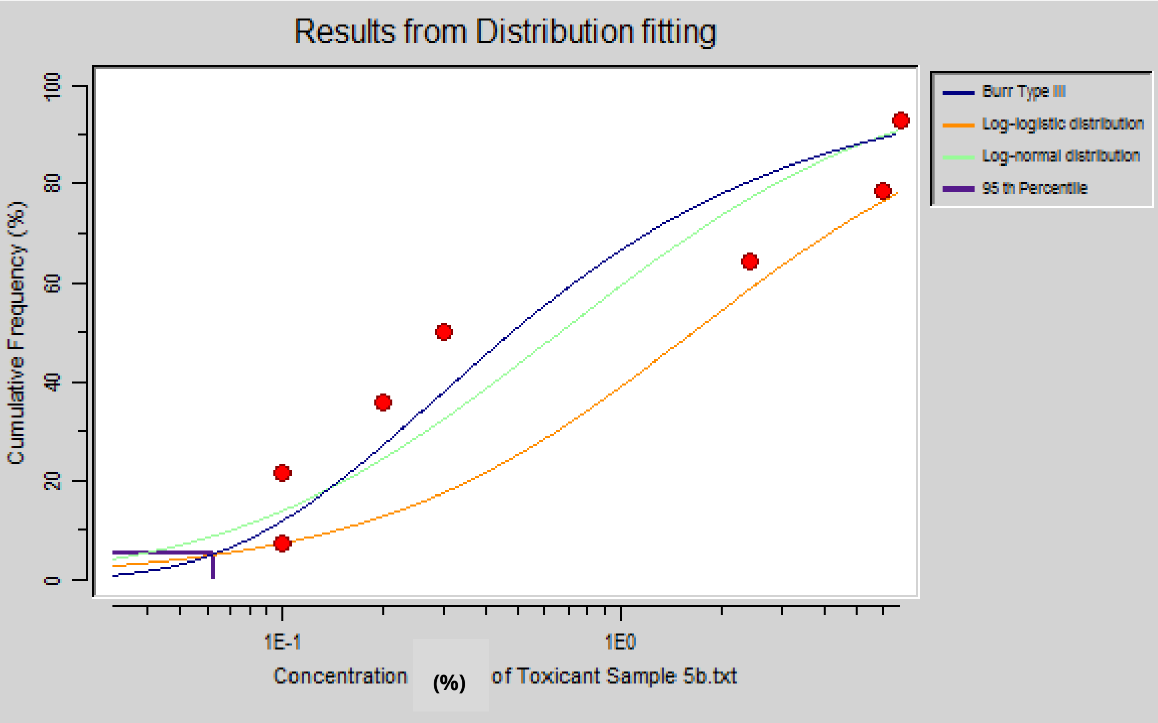

Figure 5-18 Species sensitivity distribution for pilot plant NaOH/sodium laurel sulphate/neutralised permeate IC10 data

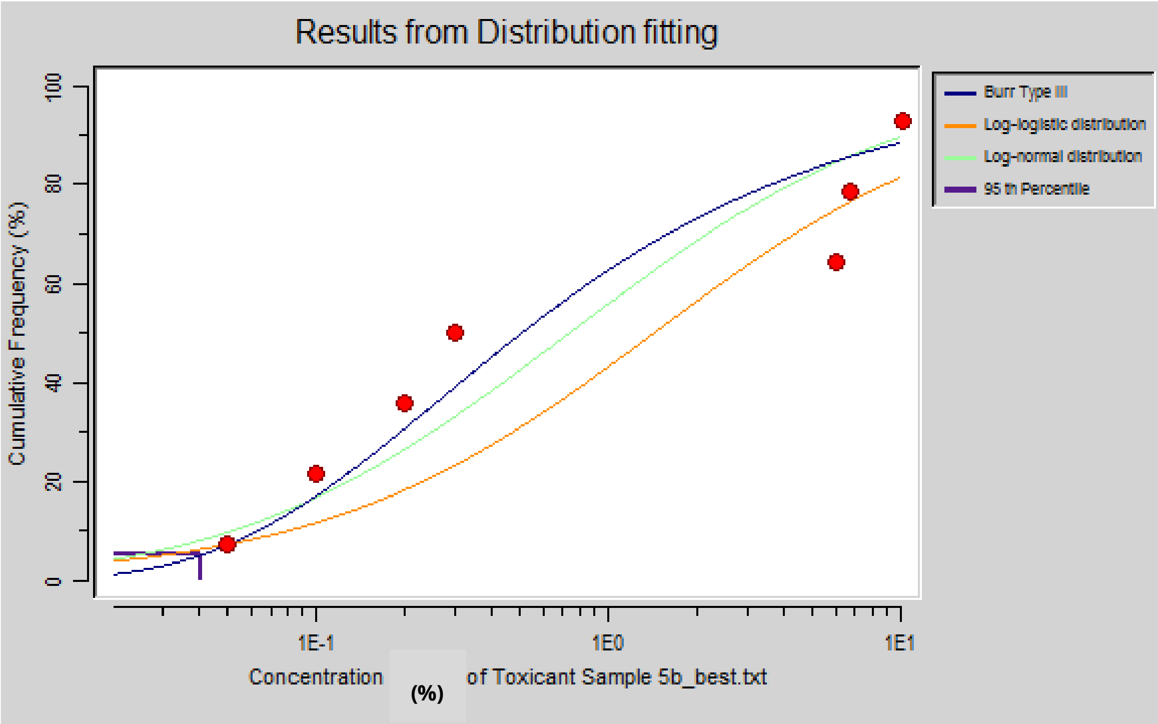

Figure 5-19 Species sensitivity distribution for pilot plant NaOH/sodium laurel sulphate/neutralised permeate IC10 Best Data

The resultant protective concentrations and safe dilutions for the two sets of NaOH/sodium laurel sulphate/neutralised permeate data are presented in Table 5-24. The use of the polychaete survival data instead of the biomass data in the IC10 Best Data set did not significantly alter the calculated PC's.

Table 5-24 Protective concentrations and safe dilutions for the NaOH/sodium laurel sulphate/neutralised permeate sample

	% sample	
PC	IC10	IC10 Best Data
95%	0.04	0.04
Safe Dilution	2500	2500
99%	0.02	0.02
Safe Dilution	5000	5000
Fit of Data	10.7	12.8

POLYELECTROLYTE TREATED FEEDWATER

Results of the DTA of the polyelectrolyte treated feedwater are presented in Table 5-25. The toxicity exhibited by the polyelectrolyte to the selected test organisms was low. From the results, the most sensitive organism to the sample was the macroalgae, while the amphipod indicating moderate toxicity and all other tests did not exhibit any sensitivity to the concentrations tested. By using the application factor approach recommended by ANZECC and ARMCANZ, (2000) (Section 8.3.3.2) for data sets that do not meet the requirements for calculating PCs using the SSD method, an environmental concern level can be calculated by dividing the lowest chronic NOEC value by 10. For the polyelectrolyte treated feedwater a environmental concern level of 10% sample concentration was calculated which would require at least a ten times dilution to protect the majority of species in the receiving environment.

Table 5-25 Results of DTA of polyelectrolyte treated feedwater

	% sample	
	IC10	NOEC
Microalgal Cell Yield	>100	100
Macroalgal Gametophyte Growth	14.4	100
Amphipod Biomass (14-d)	18.3	100
Amphipod Survival (14-d)	61.7	100
Polychaete Biomass (14-d)	>100	100
Polychaete Survival (14-d)	>100	100

5.2 OLYMPIC DAM DESALINATION PLANT DISCHARGE ECOLOGICAL TRIGGER VALUE DERIVATION

5.2.1 A REFINED ASSESSMENT OF THE SELECTION OF SPECIES AND OTHER FACTORS THAT AFFECT DILUTION FACTORS FOR THE PROPOSED DESALINATION PLANT AT POINT LOWLY, SOUTH AUSTRALIA

In 2006 BHP Billiton planned to put a 280 million litre a day, Reverse Osmosis desalination plant, onto the Point Lowly peninsula, South Australia. Dr Warne (CSIRO) reviewed two years of studies undertaken as part of the Draft Environmental Impact Statement (EIS) for the proposed desalination plant at Point Lowly and provided his expert opinion on a number of issues related to the toxicity tests.

Sixteen organisms were tested and evaluated as part of the Environmental Impact Statement for the proposed desalination plant at Point Lowly for their appropriateness to calculate dilution factors for the return water. The ambient salinity at Point Lowly (40-43 g/L) is greater than the majority of Australian marine waters (34- 37 g/L), with the return water salinity approximating 78 g/L. Dr Warne's report provided an assessment of all the direct toxicity assessment (DTA) results, and the species protection values presented use the most appropriate dataset available and superseded all previous calculated values.

5.2.1.1 DIRECT TOXICITY ASSESSMENT (DTA)

There are two different approaches that can be used to conduct direct toxicity assessment (DTA) which is also called whole effluent toxicity testing (WET).

- to use generic species that occur in that environmental media. For example, a DTA test at Point Lowly would use species that occur within Australian marine waters. This is also called the Standard DTA approach (Van Dam and Chapman, 2001).
- to use endemic organisms that actually occur in the ecosystem that is being assessed. For example, a DTA test at Point Lowly would use species that are found in the marine waters

around Point Lowly or closely related organisms. This is also called the Site-specific DTA approach (Van Dam and Chapman, 2001).

The initial toxicity testing undertaken to assess the toxicity of the return water for Point Lowly followed the generic species approach with the exception of the Giant Australian Cuttlefish, *Sepia apama*. The species used were *S. apama* - cephalopod, *Penaeus monodon* – crustacean; *Seriola lalandi* – fish; *Nitzschia closterium* – diatom; *Hormosira banksii* – brown macroalga; *Heliocidaris tuberculata* – echinoid; and *Saccostrea commercialis* – bivalve. The use of these generic organisms caused some problems mainly as they were acclimated to normal salinity marine water (i.e. 35 – 36 ppt), while the salinity of the Point Lowly region varies between 40 and 43 ppt. At the salinities that naturally occur at Point Lowly, two of the tested species (i.e. the oyster and the sea urchin) died – thus highlighting their unsuitability as test organisms. Also, neither of these species was endemic to the Point Lowly region. Given the above, Dr Warne recommended that it would be desirable to (1) conduct further toxicity tests, preferably using species found in Upper Spencer Gulf, (2) increase the number of species for which there are toxicity data and (3) increase the relevance of the resulting dilution factors.

As a result of Dr Warne's previous recommendation subsequent toxicity testing was undertaken to follow the endemic species approach. A list of all the species that have been used to determine the toxicity of return water and whether they are endemic to Upper Spencer Gulf (USG) (where Point Lowly is located) is presented in Table 5-26.

Table 5-26 Information on the test organisms used in the direct toxicity assessment of return water for the proposed Point Lowly desalination plant

Species	Present in USG	Notes	Phase[a]
Microalga - *Nitzschia closterium*	Yes	Widely distributed in Australian waters	1
Microalga - *Isochrysis galbana*	Genus yes, species unknown		2
Microalga - *Ecklonia radiata*	No	Widely distributed throughout SA waters, but not recorded to occur north of Arno Bay (which is to the south of Point Lowly)	2
Macroalga - *Hormosira banksii*	Yes	Widely distributed throughout SA waters	1
Copepod - *Gladioferens imparipes*	Unknown		2
Tiger Prawn - *Penaeus monodon*	No		1
Western King Prawn - *Melicertus latisulcatus*	Yes		2
Blue Swimmer Crab - *Portunus armatus*	Yes		2
Pacific Oyster - *Crassostrea gigas*	Yes	In aquaculture	2

Sydney Rock Oyster - *Saccostrea commercialis*	No		1
Sea urchin - *Heliocidaris tuberculata*	No	Distributed on rocky reefs from Southern Queensland to central New South Wales	1
Yellowtail Kingfish - *Seriola lalandi*	Yes	Also an important aquaculture species	1, 2 & 3
Snapper - *Chrysophrys auratus*	Yes		2
Mulloway - *Argyrosomus japonicus*	Yes		2
Giant Australian Cuttlefish - *Sepia apama*	Yes	Important breeding habitat at Point Lowly	1 & 2
Sponge - *Aplysina* sp.	Yes	This is a newly developed toxicity test.	3

[a]**Phases 1, 2 and 3 refer to testing conducted in 2006, 2007 and 2008 respectively.**

5.2.1.2 RECOMMENDED SPECIES FOR THE CALCULATION OF DILUTION FACTORS AND THE RATIONALE

Some of the DTA tests were conducted using diluent water with salinity outside the range found at Point Lowly, that some of the DTA tests only use acute exposure and QAQC issues. According to Dr Warne's opinion, the most internally consistent dataset which permits the largest number of species should be used to derive the dilution factors. By internally consistent it is meant that:

- toxicity data for only one type of exposure (i.e. chronic or acute or pulse) and
- data determined using diluent water with a single salinity within the range of Point Lowly (i.e. 40 – 43 ppt).

Based on these criteria, the best dataset was that using chronic toxicity data measured in diluent water with a salinity of 41.2 ppt (Table 5-27). An a priori decision was made to use, whenever possible, the concentration that causes a 10 % effect (EC10) rather than no observed effect concentration (NOEC) data to derive the PC99 and safe dilution factors. For the Giant Australian Cuttlefish there were limitations associated with the toxicity data for both phases I and II. Given the selection criteria the toxicity data from phase II were used to calculate the safe dilution factors.

The second-best dataset was considered to be that which permitted the most species to be used to derive the dilution factors even if some acute, chronic, and pulse values measured in different salinity diluent water were combined (Table 5-27). In addition to the chronic toxicity values measured at 41.2 ppt the best toxicity values for *H. banksii, G. imparipes* and *S. lalandi* were included in the second-best dataset. In the case of *S. lalandi* the toxicity values from phases I, II and III were deemed not ideal (see previous explanation). The lowest EC10 value was 1.48 % return water however, this was determined in diluent water with a salinity of 44.3 ppt which is higher than the highest reliably measured salinity at Point Lowly (i.e. 43 ppt). The EC10 and NOEC values from phases I (conducted using diluent water with a salinity of 41.2 ppt) and II (where the diluent water had a salinity of 35 ppt) were 12.5 (10.6% when recalculated by the author) and 11.1 % return water, respectively. The close agreement of the EC10 values from phase I and II tends to indicate that the phase III result was atypical and therefore as the recalculated phase II EC10 of 10.6% return water was the lower of the two value it was adopted.

The best dataset contains toxicity data for seven species that belong to six taxonomic groups of organisms. The second-best dataset contains toxicity data for ten species that belong to six taxonomic groups of organisms. Both datasets exceed the minimum data requirements of the BurrliOZ method (Campbell et al., 2000) and the Australian and New Zealand water quality guidelines (ANZECC and ARMCANZ, 2000) to derive site-specific trigger values (i.e. at least five species that belong to at least four taxonomic groups of organisms).

Table 5-27 The species and the toxicity values for the two preferred datasets used to derive the dilution factors.

Test species	Taxonomic group	EC10 and NOEC values (% return water)	
		Best dataset	2nd best dataset
H. banksii	Macroalga		16[a]
I. galbana	Diatom	84.4	84.4
E. radiata	Macroalga	27.6	27.6
C. gigas	Bivalve	3.3	3.3
G. imparipes	Crustacean		10.9[b]
C. auratus	Fish	22.2	22.2
S. lalandi	Fish		10.6[c]
A. japonicus	Fish	11.0[d]	11.0[d]
M. latisulcatus	Crustacean	7.5[e]	7.5[e]
S. apama	Cephalopod	6.3	6.3

[a]the NOEC for *H. banksii* was measured in diluent water with a salinity of 37 ppt. [b] the EC10 for *G. imparipes* is an acute toxicity value. [c] the EC10 value for *S. lalandi* was measured in diluent water with a salinity of 35 ppt and calculated by the author using data generated by Geotechnical Services (2008) (Appendix O10.4 of the Draft EIS, BHP Billiton, 2009). The method used fits a log-logistic distribution to the data (Barnes et al., 2003).[d] in Warne (2008a) the reported value was 11.6 % return water. The reason for the change is discussed in the text on this species that following this table. [e.]the EC10 value for *M. latisulcatus* was calculated by the author using data generated by Geotechnical Services (2008) (Appendix O10.4 of the Draft EIS, BHP Billiton, 2009). The method of Barnes et al (2003) was used.

5.2.1.3 DERIVATION OF PROTECTIVE CONCENTRATION VALUES AND SAFE DILUTION FACTORS

The suite of organisms tested as part of the Draft Environmental Impact Statement for the proposed desalination plant at Point Lowly were evaluated for their appropriateness to calculate safe dilution factors for the return water.

The PC99 and safe dilution factor for the best dataset were 2.35 % return water and 45 (rounded up from 42.6) respectively. The PC95 and safe dilution factor for the best dataset were 3.37 % return water and 30 (rounded up from 29.6) respectively. The PC99 value and dilution factor for the second-best dataset were 2.51 % return water and 40 (rounded up from 39.8) respectively. The PC95 value and dilution factor for the second-best dataset were 3.91 % return water and 26 (rounded up from 25.6) respectively. The SSD plots used to generate these PC values and safe dilution factors for the best and second-best datasets are presented in Figures 1 and 2 respectively.

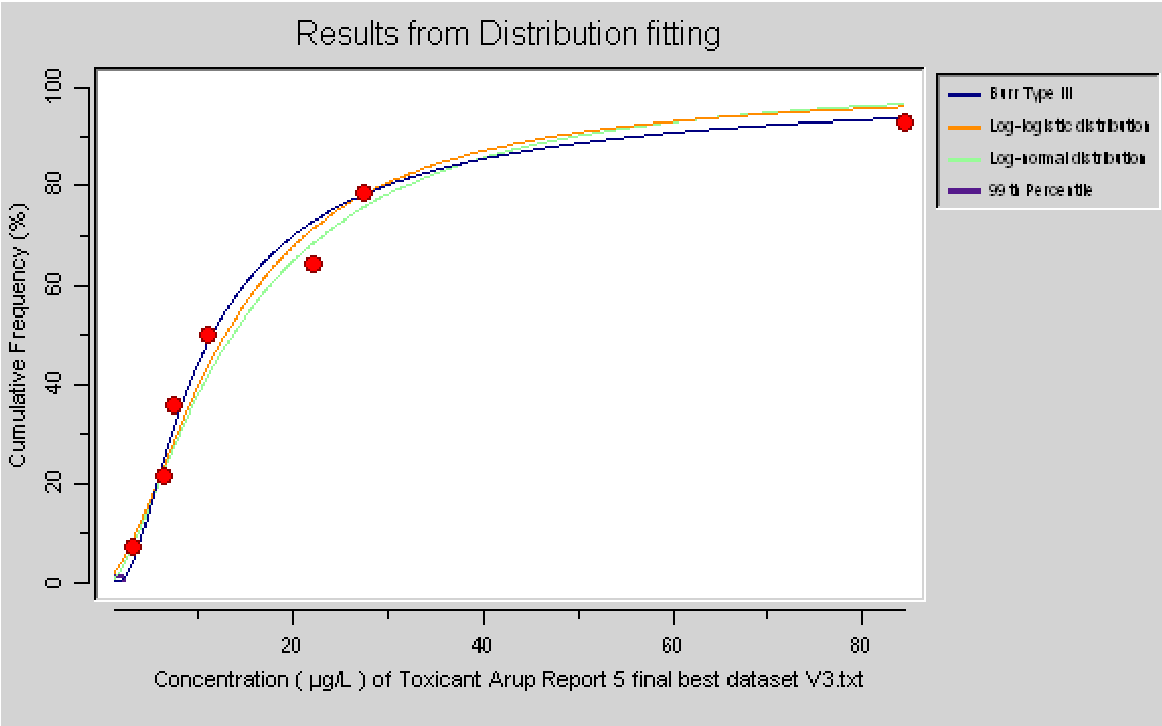

Figure 5-20 The species sensitivity distribution plot of the concentrations of return water that cause a 10% effect (EC10) for the best dataset

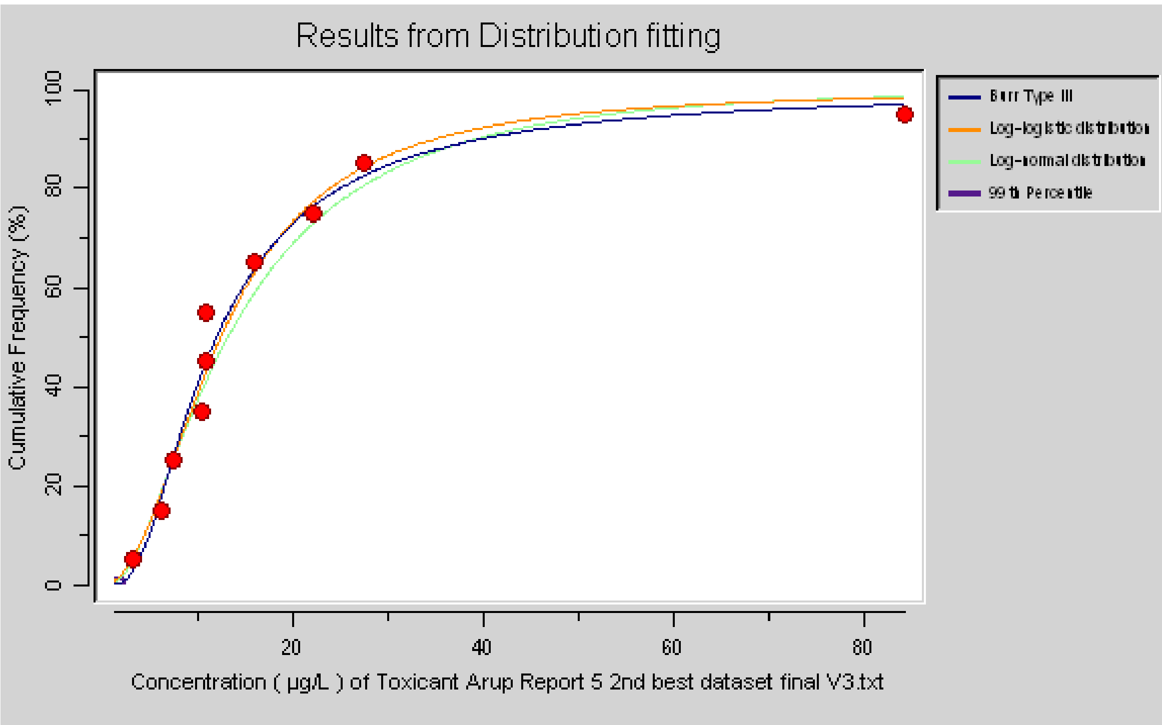

Figure 5-21 The species sensitivity distribution plot of the concentrations of return water that cause a 10% effect (EC10) for the second best dataset

It is worth noting that the PC99 and safe dilution factors derived using the best dataset (even though they are based on toxicity data for fewer species) are more conservative (i.e. requiring a greater dilution of the return water) than those derived using the second best dataset. Therefore, in order to be conservative, the PC99 and safe dilution factor of the best dataset are preferred. The close agreement of the PC99 and safe dilution factors generated by the two datasets increases the confidence associated with using the values from the best dataset.

If the PC99 and dilution factor for the best dataset are achieved, then theoretically 99% of marine organisms typical of Upper Spencer Gulf should be protected from experiencing sub- chronic or chronic toxic effects of greater than 10% magnitude caused by the discharge of return water into water with a salinity of 41.2 ppt. It is important to note however, that the salinity of the diluent water used in the preceding calculations (41.2 ppt) is slightly below the mean of the range of salinities experienced at Point Lowly. Therefore, it is likely that the PC99 and safe dilution factor underestimate those that would be derived using toxicity data generated using diluent water with a salinity of 43 ppt (the maximum salinity reached at Point Lowly).

5.3 ECOLOGICAL TRIGGER VALUE DERIVATION OF SYDNEY WATER DESALINATION PLANT EFFLUENT

Hydrobiology was commissioned by Sydney Water in 2007 to undertake an ecotoxicity program aimed to investigate the toxicity of a saline concentrate representative of the sydney Desalination Plant to derive ecological trigger values for each stream of desalination plant effluent using direct toxicity assessment (DTA) data and ANZECC/ARMCANZ (2000) methods necessary to minimise environmental harm and derive 'safe' dilutions for each stream of desalination plant effluent to achieve this. Samples of seawater concentrate were collected from the pilot desalination plant at Kurnell on a number of occasions in the period mid-May to late June 2007. The following seawater concentrate streams were sampled by Sydney Water from the desalination plant:

- Stream 1 – Concentrated seawater
- Stream 2 – Concentrated seawater with backwash liquid and antiscalent
- Stream 4 – Concentrated seawater with antiscalent
- Stream 5 – Concentrated seawater with antiscalent and membrane cleaning
- Stream 6 – Concentrated seawater with antiscalent, backwash liquid and membrane cleaning
- Stream 8 – Concentrated Seawater with Antiscalent, Backwash Liquid and Membrane Cleaning with Biocide

Samples for each of the above streams were collected from the pilot plant on three separate days to ensure independence of the samples and to capture any variations in plant operations that could result in alterations in properties of the test streams. It should be noted that Stream 8 results were discarded due to ambiguity in the original method and dosage of its neutralisation.

The effluent from each stream was then subjected to direct toxicity assessment using a suite of organisms including:

- The sea urchin, Haliocidaris tuberculata;
- The oyster, Saccostrea commercialis;
- The macro-algae, *Hormisira banksii*;
- The fish, *Latris lineata* (Striped Trumpeter), *Lates calcarifer* (Barramundi) or *Macquaria novaemaculeata* (Australian Bass) depending on availability; and,
- The prawn, Penaeus monodon.

5.3.1.1 DIRECT TOXICITY RESULTS

Results for direct toxicity assessment of effluent from Streams 1, 2, 4, 5 and 6 of the desalination process are presented in Table 5-28. It should be noted that the availability of fish resulted in three different species being used for the fish imbalance testing of the effluent streams. The three fish species used for the testing will have differing tolerances to salinity as the Barramundi and Bass both have life stages in estuarine and freshwater ecosystems while the striped trumpeter spends its life cycle in marine conditions. Whilst using fish with differing salinity tolerances is not ideal and will affect the results to some degree the overall outcome after calculation of the trigger values and dilution factors will not be overly different due to the fish only representing one data point in the species sensitivity distribution.

Table 5-28 Results of direct toxicity assessment of effluent collected from streams 1, 2, 4, 5 and 6 of the desalination process

Test		Stream 1 (% effluent)				Stream 2 (% effluent)				Stream 4 (% effluent)				Stream 5 (% effluent)				Stream 6 (% effluent)			
	Sample	NOEC	LOEC	EC_{50}	EC_{10}	NOEC	LOEC	EC_{50}	EC_{10}	NOEC	LOEC	EC_{50}	EC_{10}	NOEC	LOEC	EC_{50}	EC_{10}	NOEC	LOEC	EC_{50}	EC_{10}
Sea Urchin Fertilisation	1	2.5	5	6.4	4.4	1.25	2.5	3.1	2	10	50	54.1	22.3	10	50	28	14.2	10	50	22.7	11.7
	2	5	10	16.7	7.1	1.25	2.5	6.6	1.8	10	50	55.5	26.7	10	50	26.7	12.8	10	50	48	19.5
	3	2.5	5	12	5.3	5	10	8.7	4.7	5	10	16.7	6.7	10	50	22.4	11.3	10	50	22.4	11.2
Sea Urchin Larval Development	1	10	50	22.1	11.6	2.5	5	6.3	3.7	10	50	21.6	11.5	5	10	20.8	10.8	10	50	21.5	5
	2	5	10	7.9	5.8	5	10	17.2	8.4	10	50	21.6	11.4	5	10	20.8	5	10	50	21.5	9.7
	3	5	10	13.3	6.5	5	10	19.2	10	10	50	21.1	12.4	2.5	5	19.8	10.4	5	10	20.4	11.2
Rock Oyster Larval Development	1	10	50	22.4	10.7	5	100	10.7	9.9	10	50	21.2	10.2	10	50	20.7	18.1	10	50	20.1	11.5
	2	5	10	6.9	5.1	5	100	16.9	6.8	10	50	21.7	10	10	50	19.8	10.8	10	50	21	10.3
	3	5	10	16.1	6.6	5	100	16.9	10	10	50	21.9	10.5	5	10	17.4	10	10	50	20.6	10.7
Macro-algal germination	1	10	50	35.4	18.5	50	100	>100	108.4	10	50	61.6	40.8	5	10	26.8	11.6	50	100	69.3	52.9
	2	10	50	40.5	15.8	50	100	>100	69.5	10	50	34.6	16.6	10	50	55.1	26.7	50	100	77.2	64.9
	3	10	50	22.4	10.7	50	100	>100	98.6	10	50	45.4	20.2	10	50	58.2	32.5	10	50	>100	50.9
Fish Imbalance	1	10	50	38.1	14.5	10	50	21.3	10.9	10	50	53	40.4	50	100	63.8	52.2	50	100	66.8	54.1
	2	10	50	39.6	15	5	10	10	5.6	10	50	50.1	38.8	50	100	63.8	52.2	50	100	70.7	65.2
	3	10	50	30.8	9.5	10	50	32.1	13.8	10	50	17	6.1	50	100	78.5	55.7	50	100	90	14.5
Prawn Survival	1	10	50	38.4	19.1	10	50	34	15.1	10	50	18.6	8.5	10	50	19.9	9.6	10	50	21	11.3
	2	10	50	31.7	15	10	50	26.1	15.6	10	50	16.6	7.5	10	50	19.5	10.7	10	50	17.6	8.8
	3	10	50	19.4	13.5	10	50	20.5	14.9	10	50	21.1	11.1	10	50	18.8	9.6	10	50	15.8	9

ECOLOGICAL TRIGGER VALUES

The main component of the toxicity seen in desalination plant discharges is salinity and with this in mind it was decided to derive trigger values and dilution factors as a measure of salinity above the background salinity of the discharge area. This involves calculating the salinity that was tested at each dilution series and calibrating this to salinity above that of the background salinity. A background salinity of 35.54 ppt was calculated from data collected by Sydney Water at the site of the proposed intake pipe between January and September 2006. The difference between the actual salinity and the background salinity of the discharge area along with the % effluent was then used to develop SSDs and derive trigger values. The values used to derive the ecological trigger values in terms of salinity (ppt) above background and % effluent of each stream using EC10 data and NOEC data are presented in Table 5-29 and Table 5-30 respectively.

Table 5-29 EC10 data used in SSDs for derivation of ecological trigger values

Effluent Stream	Stream 1		Stream 2		Stream 4		Stream 5		Stream 6	
	% eff	ppt ↑ ambient	% eff	ppt ↑ ambient	% eff	ppt ↑ ambient	% eff	ppt ↑ ambient	% eff	ppt ↑ ambient
Sea Urchin Fertilisation	5.49	2	2.57	1.03	-	-	-	-	-	-
Sea Urchin Larval	-	-	-	-	11.76	3.64	8.25	2.06	8.15	2.69
Rock Oyster Larval	7.12	2.43	8.76	2.15	10.23	3.24	12.5	2.84	10.82	3.39
Macro-algal Germination	14.62	4.39	90.57	17.04	23.92	6.83	21.6	4.49	55.91	15.21
Fish Imbalance	12.74	3.9	9.44	2.28	21.23	6.12	53.34	10.27	37.12	10.29
Prawn Survival	15.7	4.67	15.2	3.33	8.91	2.89	9.95	2.37	9.64	3.09

Table 5-30 NOEC data used in SSDs for derivation of ecological trigger values

Effluent Stream	Stream 1		Stream 2		Stream 4		Stream 5		Stream 6	
	% eff	ppt ↑ ambient	% eff	ppt ↑ ambient	% eff	ppt ↑ ambient	% eff	ppt ↑ ambient	% eff	ppt ↑ ambient
Sea Urchin Fertilisation	3.2	1.4	1.98	0.92	7.94	2.64	-	-	-	-
Sea Urchin Larval	-	-	-	-	-	-	3.97	1.28	7.94	2.64
Rock Oyster Larval	6.3	2.21	5	1.47	10	3.18	7.94	2.01	10	3.18
Macro-algal Germination	10	3.18	50	9.66	10	3.18	7.94	2.01	29.24	8.22
Fish Imbalance	10	3.18	7.94	2.01	10	3.18	50	9.66	50	13.66
Prawn Survival	10	3.18	10	2.38	10	3.18	10	2.38	10	3.18

The concentrations for each stream effluent to protect 95 and 90% of species, derived from the Burr type III distribution, are presented in Table 5-31 for EC10 data and Table 5-32 for NOEC data along with their corresponding 'safe' dilutions.

As the salinity for both the desalination discharge and the diluents water was different for each stream the direct comparison of trigger values cannot be done. But with the derivation of the safe dilutions, which standardises the toxicity of the sample to the background salinity, we can see that Stream 2 was the most toxic to the suite of organisms using both EC10 and NOEC data. This stream would require a dilution of 40:1 to reduce toxicity to the 95% protective concentration while a dilution of 31:1 would be needed to reduce the toxicity to the 90% protective concentration when using EC10 data and 53:1 to reduce toxicity to 95% protective concentration while a dilution of 42:1 would be needed to reduce toxicity to the 90% protective concentration when using NOEC data. Stream 1, 4, 5 and 6 was calculated to require dilutions of between 27:1 and 13:1 to reduce the toxicity to the 95% protective concentration and 20:1 to 12:1 to reduce the toxicity to 90% protective concentration with stream 4 being the least toxic and needing the least dilution to achieve the desired 95% protective concentration when using EC10 data. Stream 1, 4, 5 and 6 were calculated to require dilutions of between 30:1 and 12:1 to reduce the toxicity to the 95% protective concentration and 24:1 to 12:1 to reduce the toxicity to 90% protective concentration with stream 4 being the least toxic and needing the least dilution to achieve the desired 95% protective concentration when using NOEC data.

Table 5-31 Ecological trigger values calculated from EC_{10} data for each desalination plant effluent stream with corresponding safe dilutions.

Effluent Stream	Stream 1		Stream 2		Stream 4		Stream 5		Stream 6	
	% eff	ppt ↑ ambient	% eff	ppt ↑ ambient	% eff	ppt ↑ ambient	% eff	ppt ↑ ambient	% eff	ppt ↑ ambient
PC95 50	3.78	1.55	2.49	1.01	8.21	2.71	7.15	1.86	6.48	2.26
Safe Dilution	27:1		40:1		13:1		14:1		16:1	
PC90 50	5.26	1.94	3.21	1.14	8.92	2.9	8.11	2.04	7.55	2.54
Safe Dilution	20:1		31:1		12:1		13:1		14:1	

Table 5-32 Ecological trigger values calculated from NOEC data for each desalination plant effluent stream with corresponding safe dilutions.

Effluent Stream	Stream 1		Stream 2		Stream 4		Stream 5		Stream 6	
	% eff	ppt ↑ ambient	% eff	ppt ↑ ambient	% eff	ppt ↑ ambient	% eff	ppt ↑ ambient	% eff	ppt ↑ ambient
PC95 50	3.34	1.44	1.9	0.91	8.71	2.84	3.71	1.24	6.54	2.27
Safe Dilution	30:1		53:1		12:1		27:1		16:1	
PC90 50	4.31	1.69	2.4	1	8.99	2.92	4.35	1.35	7.52	2.53
Safe Dilution	24:1		42:1		12:1		23:1		14:1	

From the trigger values for each stream the percentage of species that are protected could be calculated for desired dilution factor of 30:1 and are presented in

Table 5-33. When using the EC10 data Stream 2 is the only stream that will not offer a level of protection for 95% of species after 30 times dilution. All other streams offered a level of protection for more than 95% of species with stream 4 predicted to display no toxicity to any species in the ecosystem. The same is true when using NOEC data, where the only stream that does not offer 95% of species protection is Stream 2.

Table 5-33 Percentage of species protected for each stream after 30 times dilution calculated from both EC10 and NOEC data.

Effluent Stream	Stream 1	Stream 2	Stream 4	Stream 5	Stream 6

	NOEC	EC_{10}	NOEC	EC_{10}	NOEC	EC_{10}	NOEC	EC_{10}	NOEC	EC_{10}
% Species Protected	95.05	96.17	79.64	89.13	100	100	97.21	100	100	99.99

5.4 PERTH SEAWATER DESALINATION PLANT

The PSDP is owned by the Western Australian Water Corporation and has been in operation since late 2006. Twelve months after being commissioned, a DTA study was undertaken by Geotechnical Services to determine the toxicity of the seawater concentrate discharge, as required under the Ministerial conditions of the operation licence. The report (Geotechnical Services 2008) was made publicly available in April 2008.

The species selected by Geotechnical Services for the toxicity assessment of the seawater concentrate were mostly endemic to the marine ecosystem surrounding the discharge of the PSDP. The species selected and the tests undertaken were:

- 72-h *Isochrysis galbana* microalgal growth test;
- 72-h *Ecklonia radiata* macroalgal germination test;
- 48-h *Mytilus edulis* mussel larval development test;
- 24-h pulse exposure *Gladioferens imparipes* copepod reproduction test; and
- 7-day *Pagrus auratus* larval fish growth test.

All of these tests were undertaken at Geotechnical Services ecotoxicology laboratories. The dilutions that were used for assessing the sensitivity of each organism to the seawater concentrate are presented in Table 5-34.

Table 5-34 Concentrations of the PSDP RO saline concentrate used in the 2007 direct toxicity assessment

Test	Conc 1 (% saline concentrate)	Conc 2 (% saline concentrate)	Conc 3 (% saline concentrate)	Conc 4 (% saline concentrate)	Conc 5 (% saline concentrate)	Conc 6 (% saline concentrate)	Conc 7 (% saline concentrate)	Conc 8 (% saline concentrate)
Microalgae	0.7	1.3	2.6	5.2	10.4	20.8	41.6	83.3
Macroalgae	0.8	1.6	3.1	6.3	12.5	25	50	100
Mussel	0.8	1.6	2.6	6.3	12.5	25	50	100
Copepod	0.7	3.1	6.3	12.5	25	50		
Fish	1.5	1.6	3.1	6.3	12.5	25	50	100

From the dilution data, Geotechnical Services calculated the Protective Concentration (PC) for each species. Protective concentrations were separately derived by Geotechnical Services using Australian and New Zealand Water Quality Guidelines (ANZECC and ARMCANZ 2000) methods, with assessments of the concentrations that caused a 10% effect (i.e. EC10) and the no observed effect concentration (NOEC). Safe dilution factors were then determined. PC values (PC99, PC95, PC90 and PC80) and corresponding safe dilution factors derived for samples collected in 2007 from the PSDP are presented in Table 5-35.

Table 5-35 The protective concentrations for 99, 95, 90 and 80% of species based on EC10 and NOEC toxicity data and the corresponding safe dilution factors for the PSDP RO saline concentrate in the 2007 direct toxicity assessments.

Test	EC10 (% saline concentrate)	NOEC (% saline concentrate)
PC 99	6.6	7.9
Safe dilution factor	16:1	13:1
PC 95	8.2	9.0
Safe dilution factor	13:1	12:1
PC 90	9.2	9.8
Safe dilution factor	11:1	11:1
PC 80	10.9	10.9
Safe dilution factor	10:1	10:1

Values obtained from Geotechnical Services (2008).

Under the terms imposed by the Western Australian Government there were two zones to be considered, each with its own level of protection. The mixing zone was classed as a low environment protection area (LEPA) within which 80% of species must be protected (i.e. PC80 values applied). Outside the mixing zone was classed as a high environment protection area (HEPA) where 90% of species had to be protected (i.e. PC90 values applied). The results of the toxicity testing undertaken in 2007 indicated that the diffuser in use at the plant, which has been shown to achieve a minimum dilution of 45:1, provided a greater protection for more than 80% and 90% of marine species (Table 5-35).

5.5 TOXICITY ASSESSMENT FOR THE VICTORIAN DESALINATION PLANT

The Victorian Government proposed to construct a seawater desalination plant to supply water to the Melbourne Water supply system and possibly other regional supply systems. DTA testing program was undertaken for the Victorian Desalination Plant (VDP) project, using samples of salinity adjusted intake water and discharge samples of the Perth Seawater Desalination Plant. The samples were collected in two separate rounds (April and June 2008) and represented various waste discharge (or concentrate) scenarios including those available to the Project. Comparisons of the intake water quality, desalination processes and estimated concentrate characteristics indicated that the concentrate samples from the PSDP would be comparable to those for the VDP.

The DTA testing program consisted of exposing a suite of organisms that were either locally relevant to the southern coast of Victoria or generic species where a locally relevant species could not be used. The species and tests used are outlined below:

- Microalgal (*Nitzschia closterium*) 72-h growth rate test (chronic);
- Sea Urchin (*Heliocidaris tuberculata*) 1-h fertilisation success test (sub-chronic);
- Sea Urchin (*Heliocidaris tuberculata*) 72-h larval development test (sub-chronic);
- Scallop (*Mimaclamys asperrima*) 72-h larval development test (sub-chronic);
- Macroalgal (*Hormosira banksii*) 72-h germination success test (sub-chronic);

- Amphipod (*Allorchestes compressa*) 96-h mortality test (acute); and
- Fish (the sand whiting *Sillago ciliata* for round one and the Australian bass *Macquaria novamaculeata* for round two samples) 96-h fish imbalance test (acute).

All the above tests were conducted using standardised published protocols and adhering to Ecotox Services Australasia and CSIRO internal procedure manuals. The sea urchin fertilisation and larval development tests, Doughboy scallop larval development test and the macroalgal germination test are NATA accredited. The aforementioned organisms were selected for testing because they were:

- representative of marine species of southern Australian waters;
- standardised toxicity protocols available; and
- available at the time of testing.

The selected species meet the minimum data requirements of the Australian and New Zealand Water Quality Guidelines (2000) necessary to conduct a DTA and to derive safe dilution factors. The safe dilution factors were calculated using the ANZECC/ARMCANZ (2000) methods.

Both acute (short) and chronic (long) toxicity tests conducted. The standard method used to derive safe dilution factors for discharges entails the use of chronic toxicity data. Therefore, acute to chronic ratios (ACR) are needed to convert acute toxicity data to estimates of chronic toxicity.

The relative toxicity of the desalination plant discharge and the salinity-adjusted intake samples indicated that the primary stressor was salinity. The other potential causative agents being chemicals added during the desalination process. DTA testing for the full suite of test organisms to the three waste discharge scenarios yielded safe dilution factors less than 29:1.

5.5.1.1 DIRECT TOXICITY ASSESSMENT RESULTS

ROUND ONE

In round one samples representing waste disposal Case 2 (concentrate plus pre-treatment supernatant) and intake water that had its salinity adjusted to that of the Case 2 sample were tested. The EC10 results for these samples are presented in Table 5-36.

Table 5-36 Results of the direct toxicity assessment of Perth Seawater Desalination Plant concentrate plus pre-treatment supernatant discharge (Case 2) and salinity adjusted intake water

Direct toxicity assessment test	EC10 values (% sample)	
	Case 2 discharge (concentrate + pre-treatment supernatant)	Salinity Adjusted Intake
	EC_{10}	EC_{10}
Microalgal yield	13 (0-25)	17 (0-17)
Sea urchin fertilisation	12.6 (11.9-13.1)	18.1 (8.4-23.2)
Sea urchin larval development	13.1 (12.5-13.4)	13.3 (12.7-13.5)
Doughboy Scallop larval development	12.6 (12.3-12.6)	12.3 (12-12.6)

Macroalgal germination	51.4 (44.3-57.1)	45.3 (40.7-49.7)
Amphipod survival	>100	>100
Fish imbalance	12.7 (4.7-13.9)	12.8 (4.7-13.9)

The EC10 results of the two samples for each species were not significantly different, indicating that salinity was the sole cause of the toxicity.

ROUND TWO

In round two samples representing waste disposal Cases 1, 2 and 3 and intake water that had its salinity adjusted to that of the Case 2 sample were tested. Results for the DTA testing of the samples are presented in Table 5-37.

Table 5-37 Results of the direct toxicity assessment of Perth Seawater Desalination Plant concentrate plus pre-treatment supernatant discharge and salinity adjusted intake water

Direct toxicity assessment test	EC10 values (% sample)			
	Waste disposal options			Salinity adjusted intake
	3	2	1	
Microalgal yield	15 (0 – 26)	12*	38*	20 (0 – 27)
Sea urchin fertilisation	39.0 (37.6 – 40.4)	47.4 (46.4 – 48.1)	16.6 (10.9 – 20.5)	39.6 (36.3- 42.6)
Sea urchin larval development	13.0 (12.5 – 13.4)	7.3 (6.3 – 8.0)	13.4 (12.9 – 13.6)	13.1 (12.8 – 13.3)
Doughboy Scallop larval development	12.4 (12.0 – 12.6)	12.5 (12.0 – 12.6)	14.3 (12.3 – 15.1)	12.4 (12.0 – 12.6)
Macroalgal germination	40.7 (39.3 – 41.7)	64.6 (57.2 – 73.0)	54.2 (39.8 – 63.3)	41.3 (39.7 – 41.9)
Amphipod survival	> 100	> 100	> 100	> 100
Fish imbalance	17.2 (0.0 – 20.9)	18.2 (0.0 – 20.7)	18.6 (0.0 – 20.1)	19.0 (0.0 – 26.7)

* These values are NOECs rather than EC10 values.

NOEC values and EC10 values that do not have 95% confidence limits or are greater than 100 % cannot be statistically compared. For waste disposal Case 3, there were no significant differences in the EC10 values compared to those for the salinity adjusted intake for six datasets and it could not be determined if there were differences for the amphipod. For waste disposal Case 2, there were no significant differences in the EC10 values compared to those for the salinity adjusted intake for three datasets, and significant increases and decreases in toxicity for two datasets and it could not be determined if there were differences for the microalga and amphipod. For Case 1 there were no significant differences in the EC10 values compared to those for the salinity adjusted intake for four datasets, one dataset where the toxicity changed significantly and it could not be determined if there were differences for the microalga and amphipod.

While there are significant differences in the toxicity of samples for the various options to individual species there was no clear evidence that Case 2 and 1 have different toxicity to Case 3.

Direct toxicity assessment tests were also conducted on the ferric-dosed and polymer-dosed samples. As these results were not central to the aims of the project the data are not presented. Overall, both of these samples were considerably less toxic than all three of the waste discharge cases (i.e. 1, 2 and 3).

5.5.1.2 PROTECTIVE CONCENTRATIONS

ROUND ONE

The EC10 values for the salinity adjusted intake water from the PSDP that were used to derive the PC99 and safe dilution factors are presented in Table 5-38.

Table 5-38 Concentrations of the salinity adjusted intake water from the Perth Seawater Desalination Plant that cause a 10% effect (EC10) that were used in BurrliOZ to derive protective concentrations for 99% of species and corresponding safe dilution factors. The acute to chronic ratios were only applied to the acute toxicity values (i.e. for the amphipod and fish).

DTA Test	EC10 values (% sample) for salinity adjusted intake water			
	ACR 1	ACR 2.5	ACR 5	ACR 10
Microalgal yield	17	17	17	17
Sea urchin fertilisation	13.3	13.3	13.3	13.3
Sea urchin larval development [1]	-	-	-	-
Doughboy Scallop development	12.3	12.3	12.3	12.3
Macroalgal germination	45.3	45.3	45.3	45.3
Amphipod survival	100	40	20	10
Fish imbalance	12.7	5.1	2.5	1.3

Figure 5-22 to 2-23 display the SSDs derived from the EC10 data showing the fit of the data by the BurrliOZ software.

1 Sea urchin larval development data was not used as BurrliOZ only uses one toxicity value per species and the sea urchin fertilisation is the more conservative.

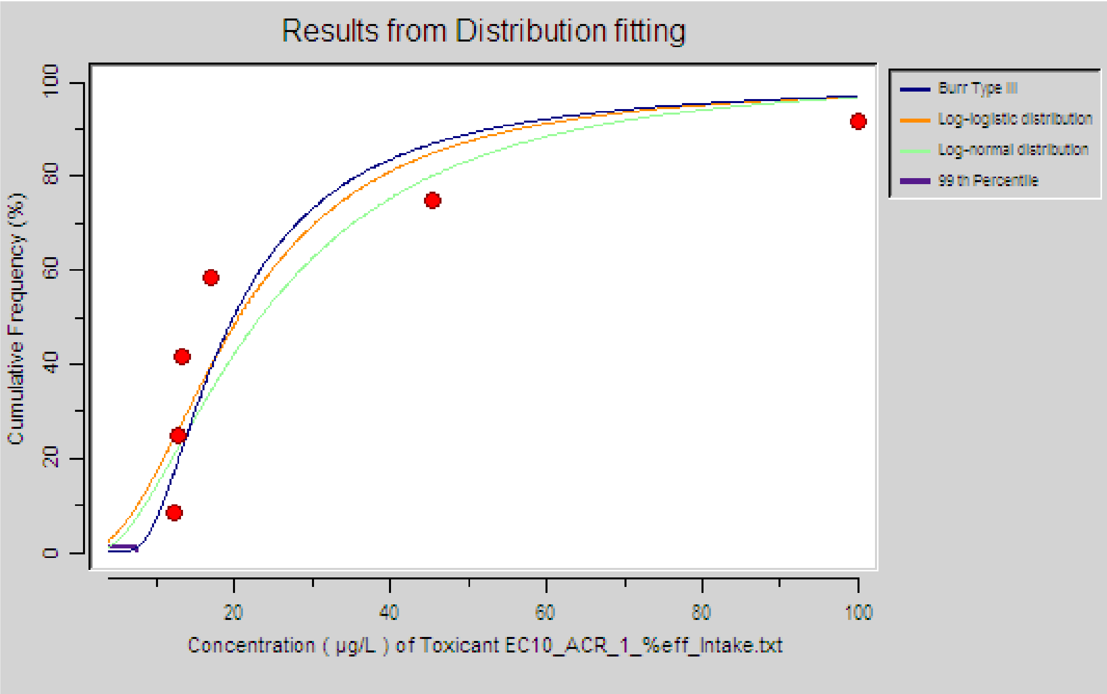

Figure 5-22 Species sensitivity distributions of EC10 values using an ACR of 1 for salinity adjusted intake water from the Perth Seawater Desalination Plant.

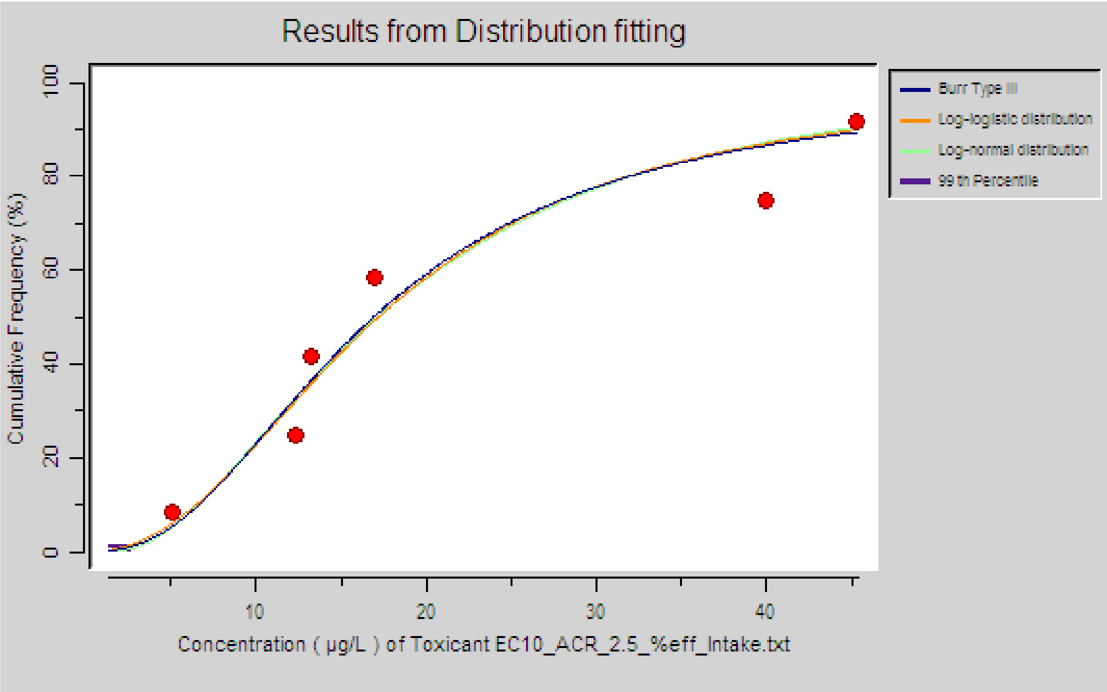

Figure 5-23 Species sensitivity distributions of EC10 values using an ACR of 2.5 for salinity adjusted intake water from the Perth Seawater Desalination Plant.

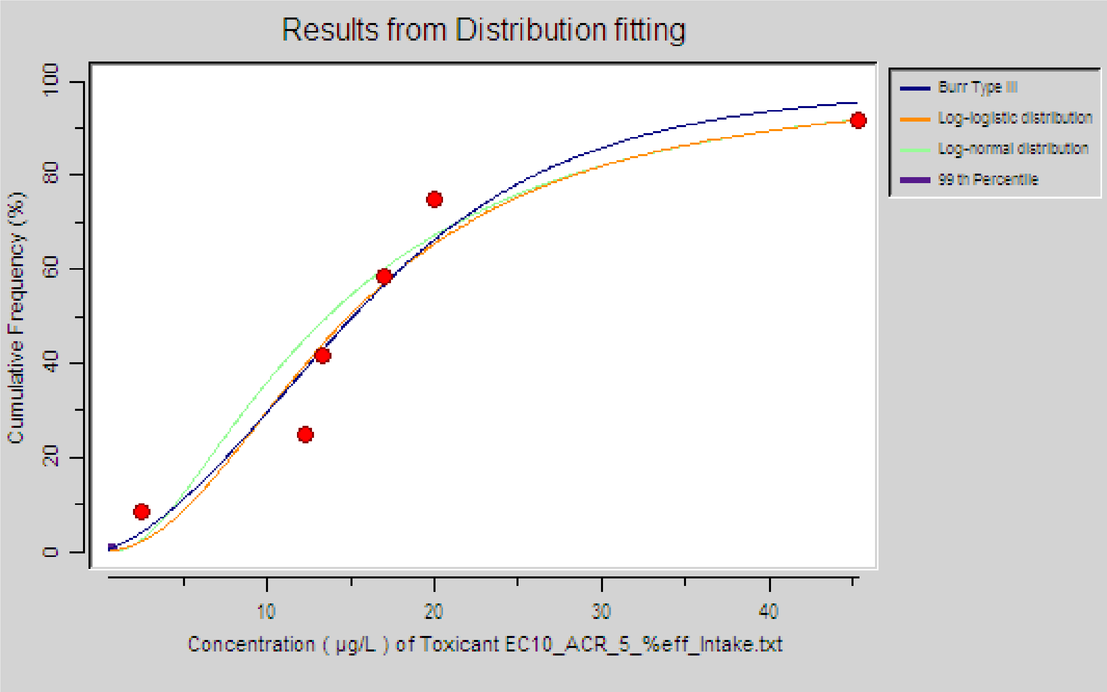

Figure 5-24 Species sensitivity distributions of EC10 values using an ACR of 5 for salinity adjusted intake water from the Perth Seawater Desalination Plant.

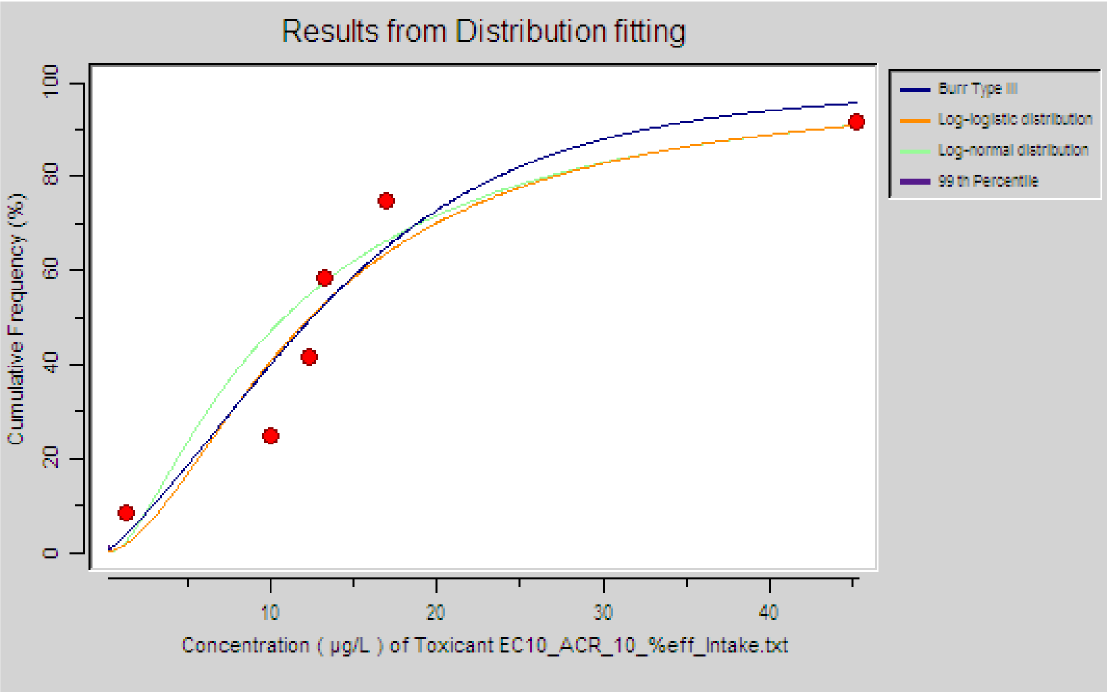

Figure 5-25 Species sensitivity distributions of EC10 values using an ACR of 10 for salinity adjusted intake water from the Perth Seawater Desalination Plant.

The fit of the Burr Type III distribution to each of the above sets of data was acceptable with the goodness of fit values ranging from 25 for the data with an ACR of 1 to 22.6 for the ACR of 10. The higher the goodness of fit values the better the fit. The values obtained for the above SSDs are similar to those obtained for trigger values in the Australian and New Zealand water quality guidelines (ANZECC and ARMCANZ, 2000) that are based on the same number of data.

The concentrations of the PSDP salinity adjusted intake water that must be achieved in order to protect 99% of species and corresponding safe dilution factors are presented in Table 5-39.

Table 5-39 Concentrations of the salinity adjusted intake water from the Perth Seawater Desalination Plant that should be met in order to protect 99% of species (PC99) and the corresponding safe dilution factors calculated from EC10 based species sensitivity distributions.

PC values and corresponding safety factors	PC99 (% sample) and safe dilution factors for salinity adjusted intake water			
	EC10 (ACR 1)	EC10 (ACR 2.5)	EC10 (ACR 5)	EC10 (ACR 10)
PC 99	7.44	2.62	0.95	0.40
Safe dilution factor	14:1	39:1	106:1	250:1

The safe dilution factors that must be achieved in order to protect 99% of endemic marine species ranged from 14:1 for an ACR of 1 to 220:1 for an ACR of 10 using EC10 data. By using the recommended ACR of 2.5, a safe dilution factor of 39:1 would be required to protect 99% of endemic marine species.

The EC10 values for the waste discharge Case 2 sample (concentrate plus pre-treatment supernatant) used to derive the PC99 and safe dilution factors are presented in Table 5-40.

Table 5-40 Concentrations of the Case 2 sample from the Perth Seawater Desalination Plant that cause a 10% effect (EC10) that were used in BurrliOZ to derive protective concentrations for 99% of species and corresponding safe dilution factors when acute to chronic ratios of 1, 2.5, 5 and 10 were used. 2

DTA Test	EC10 values (% sample) for Case 2 waste discharge			
	ACR 1	ACR 2.5	ACR 5	ACR 10
Microalgal yield	13	13	13	13
Sea urchin fertilisation	12.6	12.6	12.6	12.6
Sea urchin larval development 3	-	-	-	-
Scallop larval development	12.6	12.6	12.6	12.6
Macroalgal germination	51.4	51.4	51.4	51.4
Amphipod survival	100	40	20	10
Fish imbalance	12.8	5.1	2.5	1.3

Figures 2-24 to 2-27 display the SSDs derived from the EC10 data showing the fit of the data by the BurrliOZ software.

2 ACR was only applied to acute toxicity data i.e. the fish and amphipod.
3 Sea urchin larval development data was not used as BurrliOZ only uses one toxicity value per species and the sea urchin fertilisation is the more conservative.

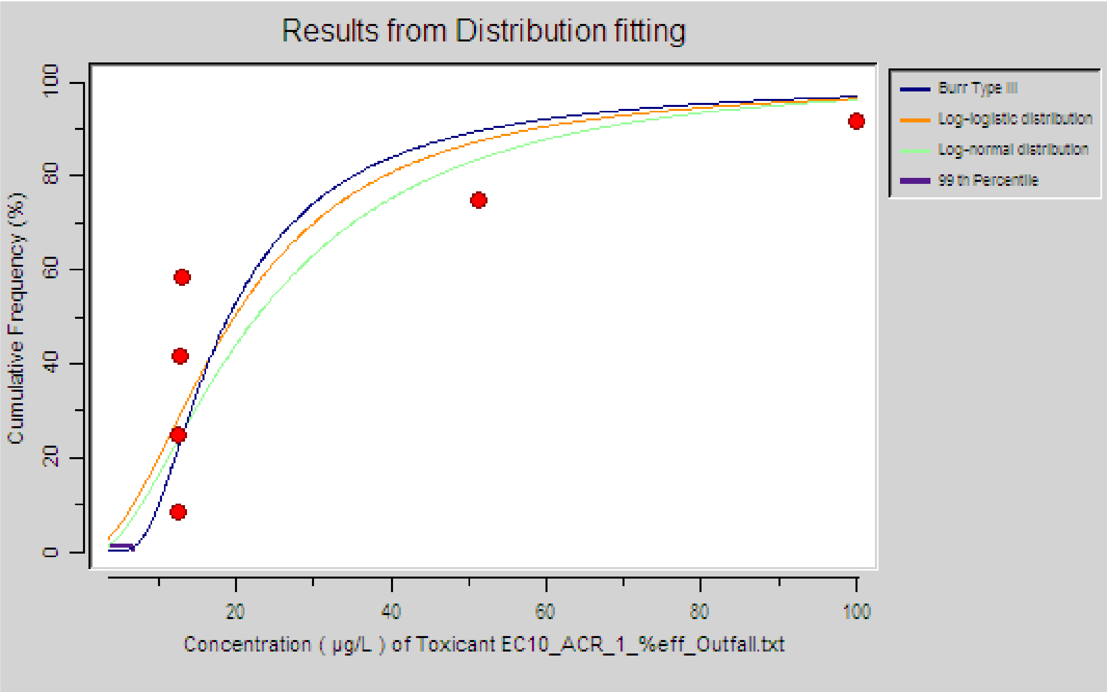

Figure 5-26 Species sensitivity distributions of EC10 values using an ACR of 1 for the Case 2 sample from the Perth Seawater Desalination Plant.

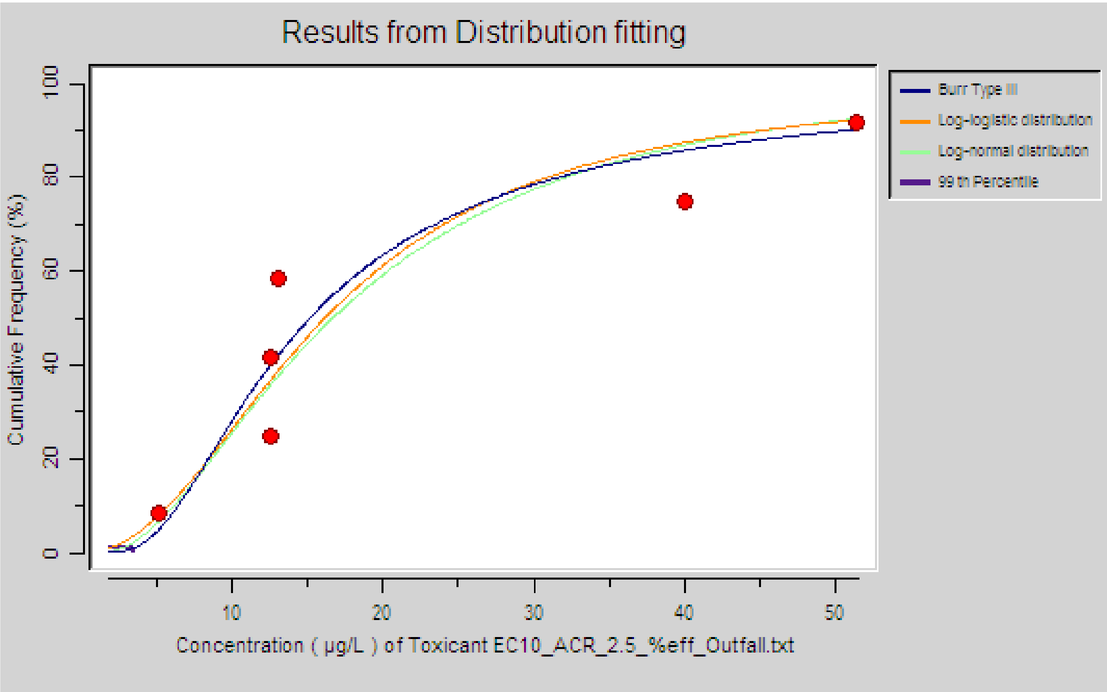

Figure 5-27 Species sensitivity distributions of EC10 values using an ACR of 2.5 for the Case 2 sample from the Perth Seawater Desalination Plant.

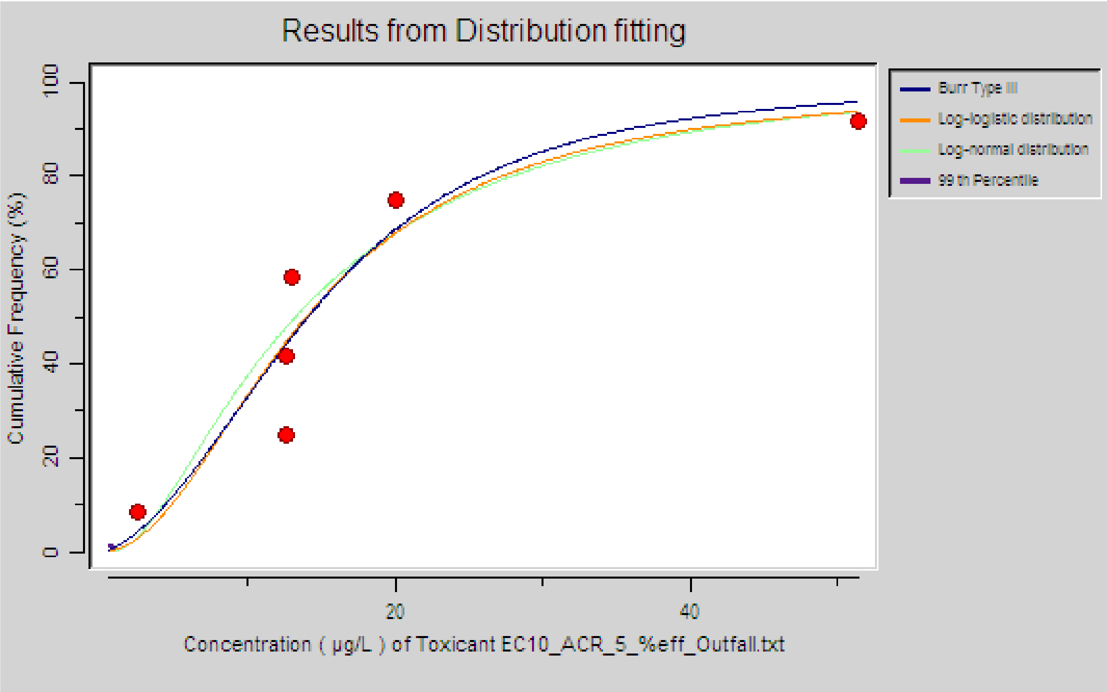

Figure 5-28 Species sensitivity distributions of EC10 values using an ACR of 5 for the Case 2 sample from the Perth Seawater Desalination Plant.

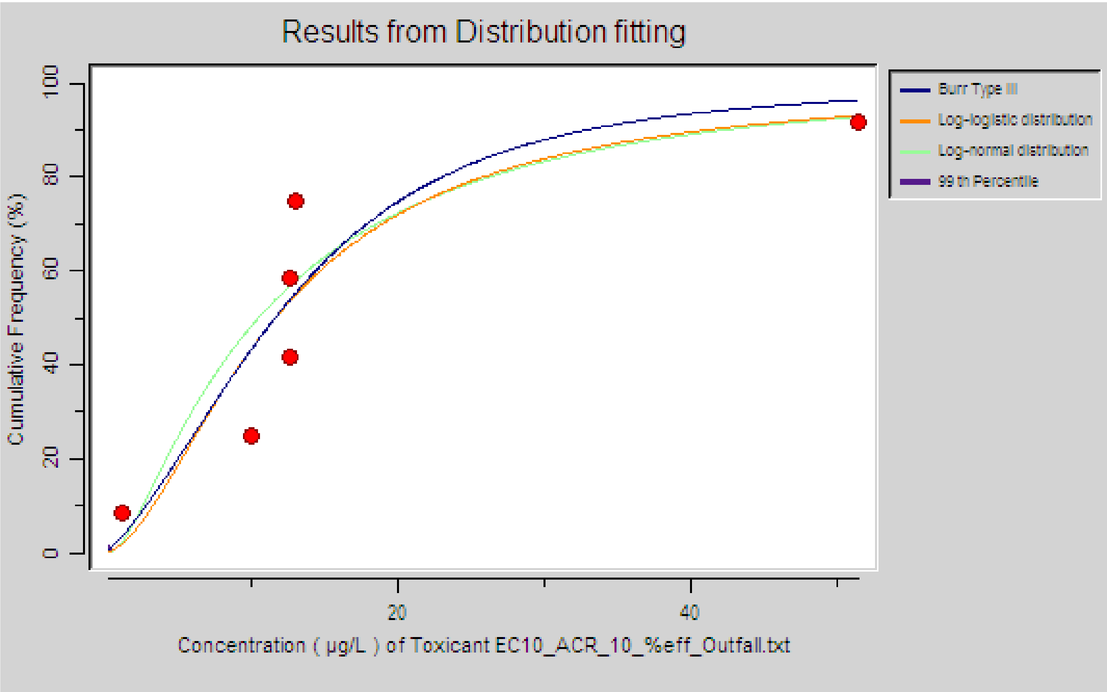

Figure 5-29 Species sensitivity distributions of EC10 values using an ACR of 10 for the Case 2 sample from the Perth Seawater Desalination Plant.

The fit of the Burr Type III distribution to each set of data was acceptable with the goodness of fit values ranging from 25.1 for the data with an ACR of 1 to 22.7 for the ACR of 10. The higher the goodness of fit values the better the fit. The values obtained for the above SSDs are similar to those obtained for trigger values in the Australian and New Zealand water quality guidelines (ANZECC and ARMCANZ, 2000) that are based on the same number of data.

The concentrations of the Case 2 sample that must be achieved in order to protect 99% of endemic marine species and the corresponding safe dilution factors, derived from the Burr type III distribution, are presented in Table 5-41.

Table 5-41 Concentrations of the Case 2 discharge from the Perth Seawater Desalination Plant that should be met in order to protect 99% of species (PC99) and the corresponding safe dilution factors calculated from EC10 based species sensitivity distributions.

Type of value generated	PC99 (% sample) and safe dilution factors for waste discharge Case 2			
	EC10 (ACR 1)	EC10 (ACR 2.5)	EC10 (ACR 5)	EC10 (ACR 10)
PC 99	6.85	3.49	1.01	0.44
Safe dilution factor	15:1	29:1	100:1	228:1

Safe dilution factors calculated to protect 99% of species ranged from 15:1 for an ACR of 1 to 228:1 for an ACR of 10 using EC10 data. By using the ACR of 2.5, a safe dilution factor of 29:1 would be required to protect 99% of species.

ROUND TWO

The data used to calculate the PC99 and safe dilution factors for each of the three waste disposal options and the salinity adjusted intake sampled in round two are provided in

Table 5-42 to Table 5-45.

Table 5-42 Concentrations of the Case 1 discharge sample that cause a 10% effect (EC10) and were used in BurrliOZ to derive protective concentrations for 99% of species and safe dilution factors when acute to chronic ratio values of 1, 2.5, 5 and 10 were used to convert acute toxicity data to estimates of chronic toxicity. 4

DTA Test	EC10 values (% sample) for Case 1 waste discharge			
	EC_{10} (ACR 1)	EC_{10} (ACR 2.5)	EC_{10} (ACR 5)	EC_{10} (ACR 10)
Microalgal yield	38*	38	38	38
Sea urchin fertilisation	13.4	13.4	13.4	13.4
Sea urchin larval developments	-	-	-	-
Scallop larval development	14.3	14.3	14.3	14.3
Macroalgal germination	54.2	54.2	54.2	54.2

4 ACR was only applied to acute toxicity data i.e. the fish and amphipod.
5 Sea urchin larval development data was not used as BurrliOZ only uses one toxicity value per species and the sea urchin fertilisation is the more conservative.

Amphipod survival	100	40	20	10
Fish imbalance	18.6	7.4	3.7	1.9

Table 5-43 Concentrations of the Case 2 discharge sample that cause a 10% effect (EC10) and were used in BurrliOZ to derive protective concentrations for 99% of species and safe dilution factors when acute to chronic ratio values of 1, 2.5, 5 and 10 were used to convert acute toxicity data to estimates of chronic toxicity.6

DTA Test	**EC10 values (% sample) for Case 2 waste discharge**			
	EC_{10} (ACR 1)	EC_{10} (ACR 2.5)	EC_{10} (ACR 5)	EC_{10} (ACR 10)
Microalgal yield	12*	12	12	12
Sea urchin fertilisation	7.3	7.3	7.3	7.3
Sea urchin larval development7	-	-	-	-
Scallop larval development	12.5	12.5	12.5	12.5
Macroalgal germination	64.6	64.6	64.6	64.6
Amphipod survival	100	40	20	10
Fish imbalance	18.2	7.3	3.6	1.8

Table 5-44 Concentrations of the Case 3 discharge sample that cause a 10% effect (EC10) and were used in BurrliOZ to derive protective concentrations for 99% of species and safe dilution factors when acute to chronic ratio values of 1, 2.5, 5 and 10 were used to convert acute toxicity data to estimates of chronic toxicity.

DTA Test	**EC10 values (% sample) for Case 3 waste discharge**			
	EC_{10} (ACR 1)	EC_{10} (ACR 2.5)	EC_{10} (ACR 5)	EC_{10} (ACR 10)
Microalgal yield	15	15	15	15
Sea urchin fertilisation	13	13	13	13
Sea urchin larval development	-	-	-	-
Scallop larval development	12.4	12.4	12.4	12.4
Macroalgal germination	40.7	40.7	40.7	40.7

6 ACR was only applied to acute toxicity data i.e. the fish and amphipod.
7 Sea urchin larval development data was not used as BurrliOZ only uses one toxicity value per species and the sea urchin fertilisation is the more conservative.

Amphipod survival	100	40	20	10
Fish imbalance	17.2	6.9	3.4	1.7

Table 5-45 Concentrations of the salinity adjusted intake water sample that cause a 10% effect (EC10) and were used in BurrliOZ to derive protective concentrations for 99% of species and safe dilution factors when acu te to chronic ratio values of 1, 2.5, 5 and 10 were used to convert acute toxicity data to estimates of chronic toxicity 8.

DTA Test	**EC10 values (% sample) for salinity adjusted intake**			
	EC_{10} (ACR 1)	EC_{10} (ACR 2.5)	EC_{10} (ACR 5)	EC_{10} (ACR 10)
	% eff	% eff	% eff	% eff
Microalgal yield	20	20	20	20
Sea urchin fertilisation	13.1	13.1	13.1	13.1
Sea urchin larval development9	-	-	-	-
Scallop larval development	12.4	12.4	12.4	12.4
Macroalgal germination	41.3	41.3	41.3	41.3
Amphipod survival	100	40	20	10
Fish imbalance	19	7.6	3.8	1.9

Figure 5-30 to Figure 5-45 display the SSDs derived from the EC10 data showing the fit of the data by the BurrliOZ software.

8 ACR was only applied to acute toxicity data i.e. the fish and amphipod.
9 Sea urchin larval development data was not used as BurrliOZ only uses one toxicity value per species and the sea urchin fertilisation is the more conservative.

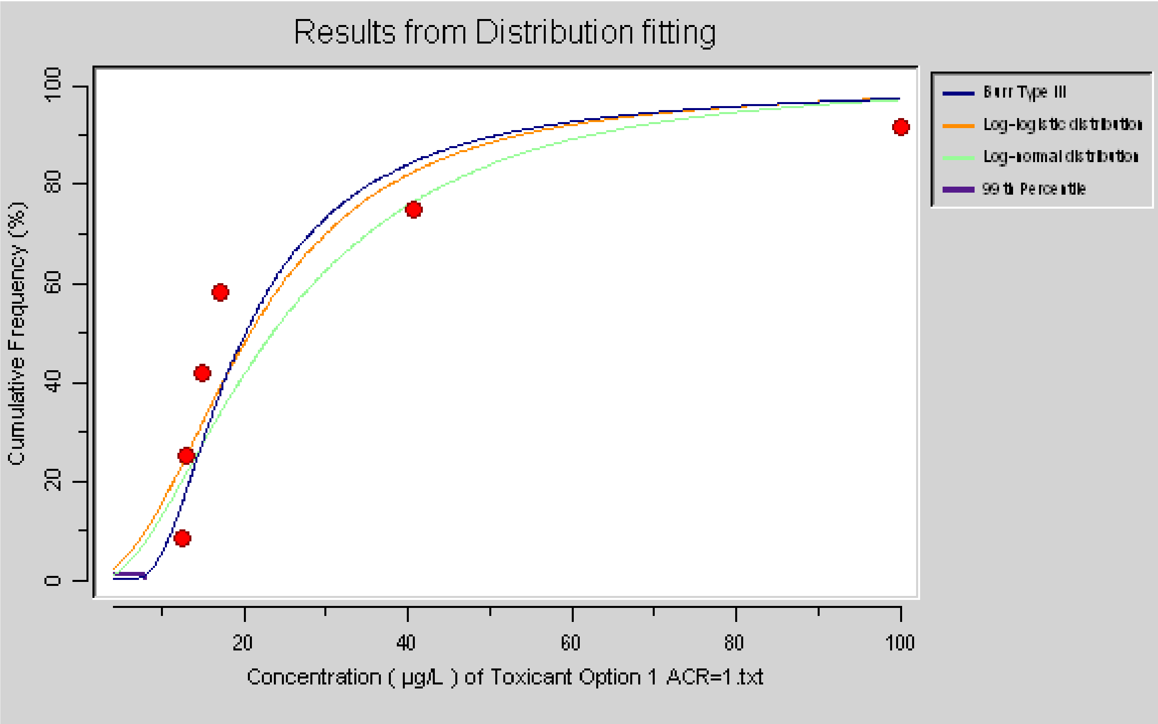

Figure 5-30 Species sensitivity distributions of EC10 values using an ACR of 1 for the round two Case 3 sample from the Perth Seawater Desalination Plant.

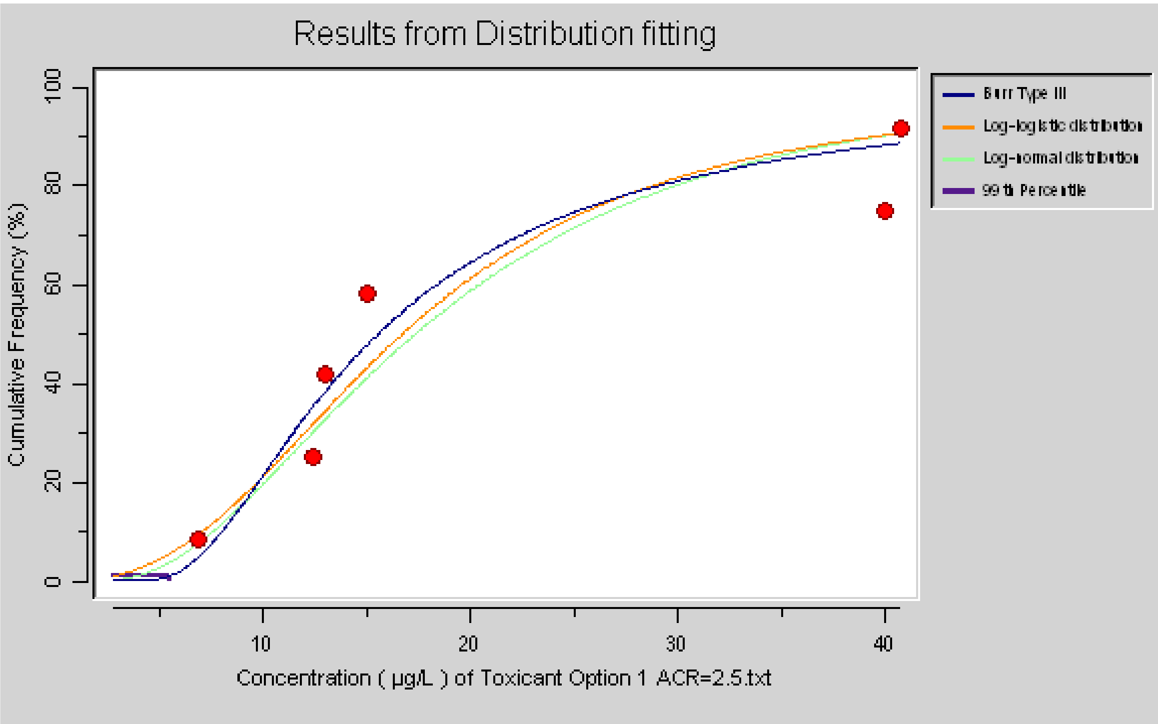

Figure 5-31 Species sensitivity distributions of EC10 values using an ACR of 2.5 for the round two Case 3 sample from the Perth Seawater Desalination Plant.

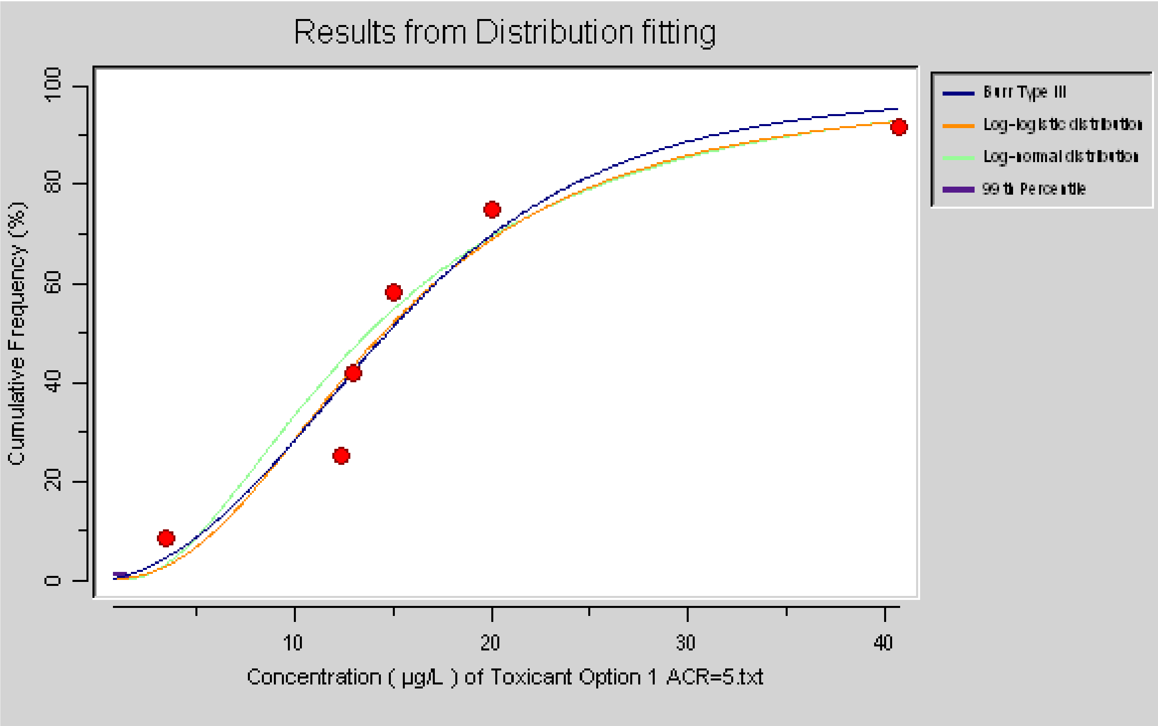

Figure 5-32 Species sensitivity distributions of EC10 values using an ACR of 5 for the round two Case 3 sample from the Perth Seawater Desalination Plant.

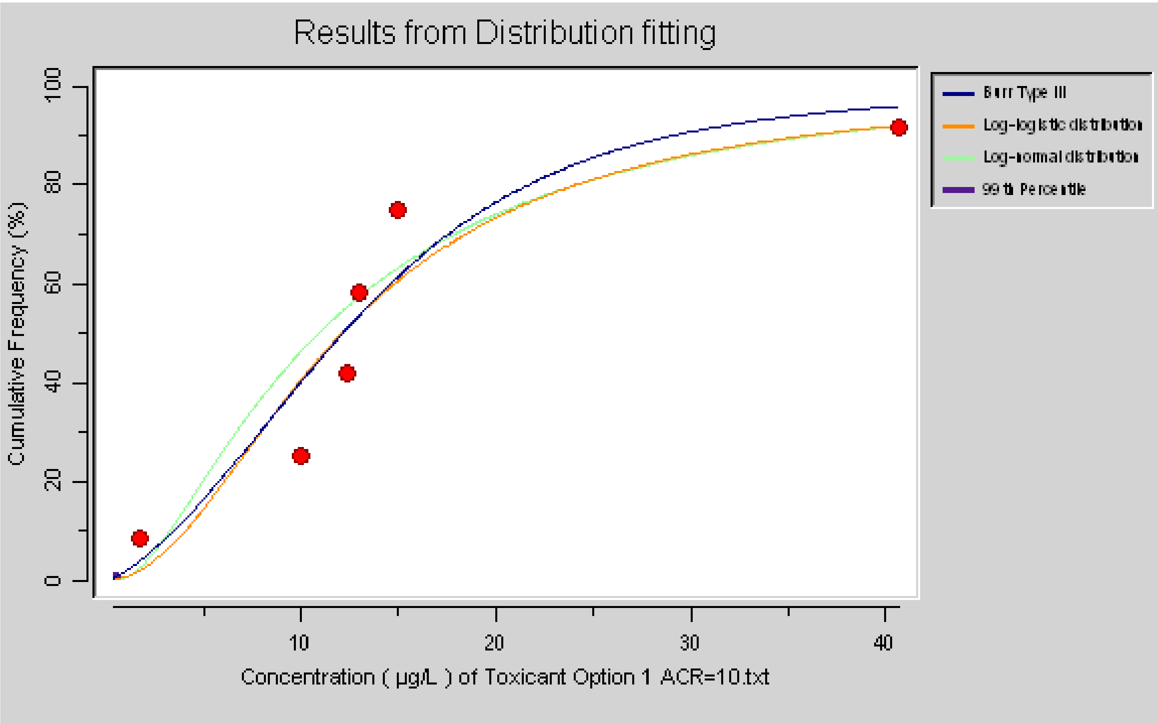

Figure 5-33 Species sensitivity distributions of EC10 values using an ACR of 10 for the round two Case 3 sample from the Perth Seawater Desalination Plant.

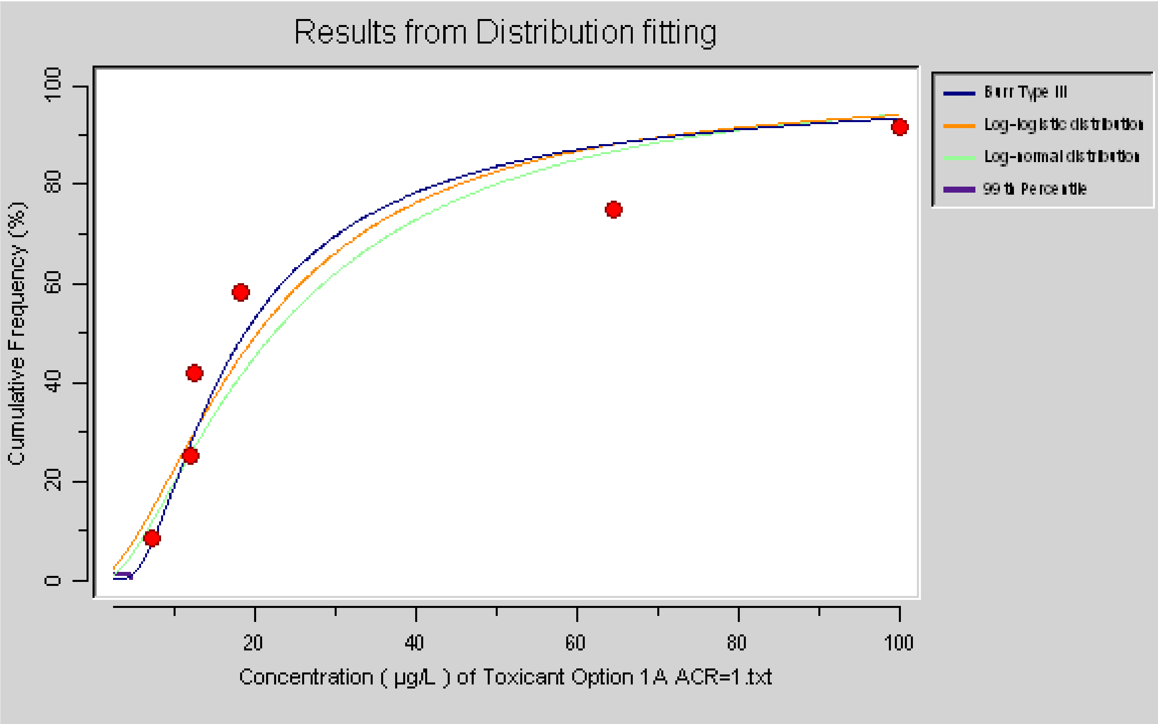

Figure 5-34 Species sensitivity distributions of EC10 values using an ACR of 1 for the round two Case 2 sample from the Perth Seawater Desalination Plant.

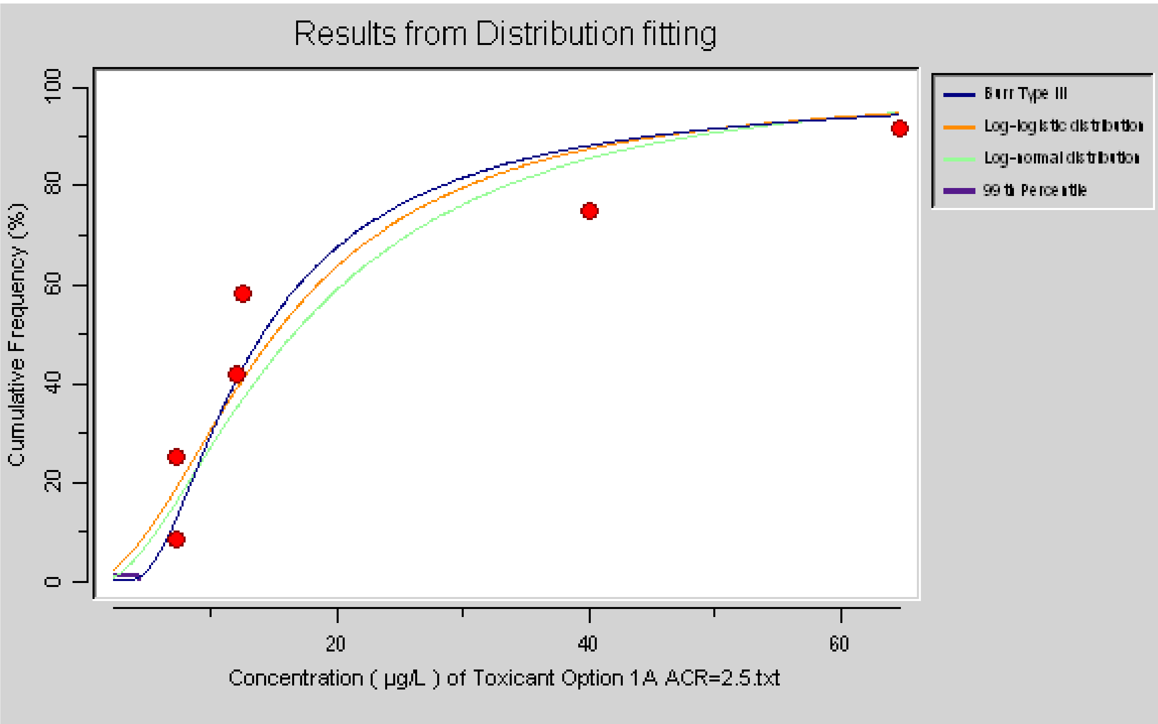

Figure 5-35 Species sensitivity distributions of EC10 values using an ACR of 2.5 for the round two Case 2 sample from the Perth Seawater Desalination Plant.

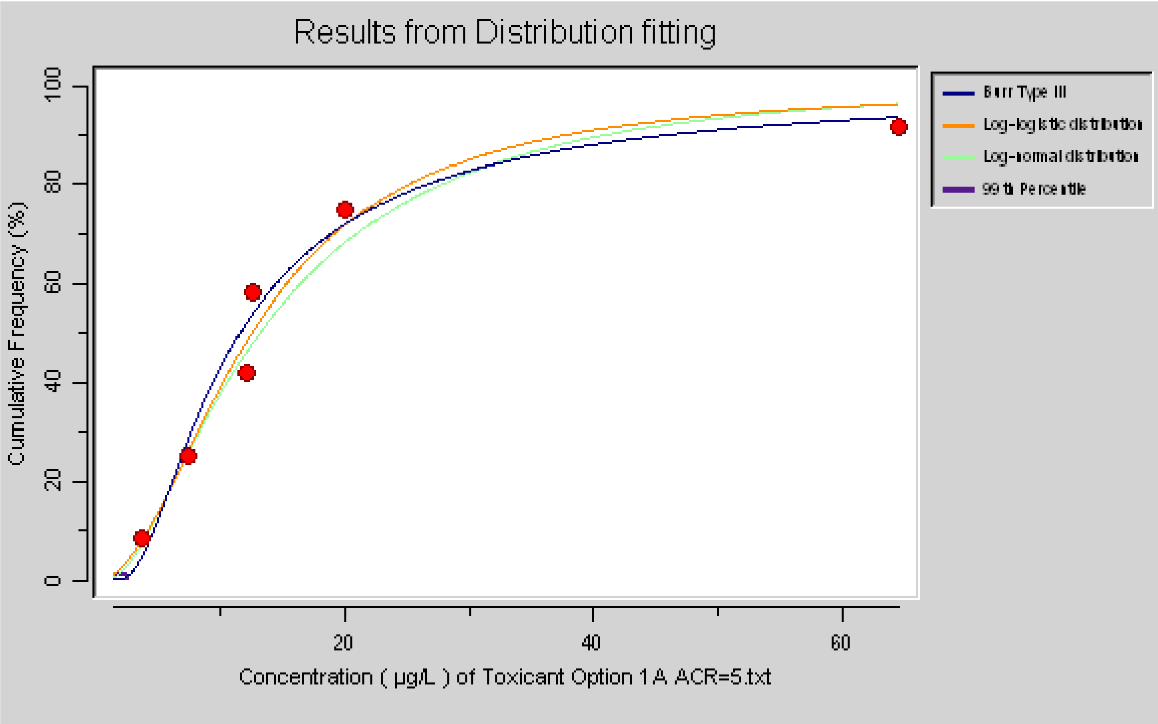

Figure 5-36 Species sensitivity distributions of EC10 values using an ACR of 5 for the round two Case 2 sample from the Perth Seawater Desalination Plant.

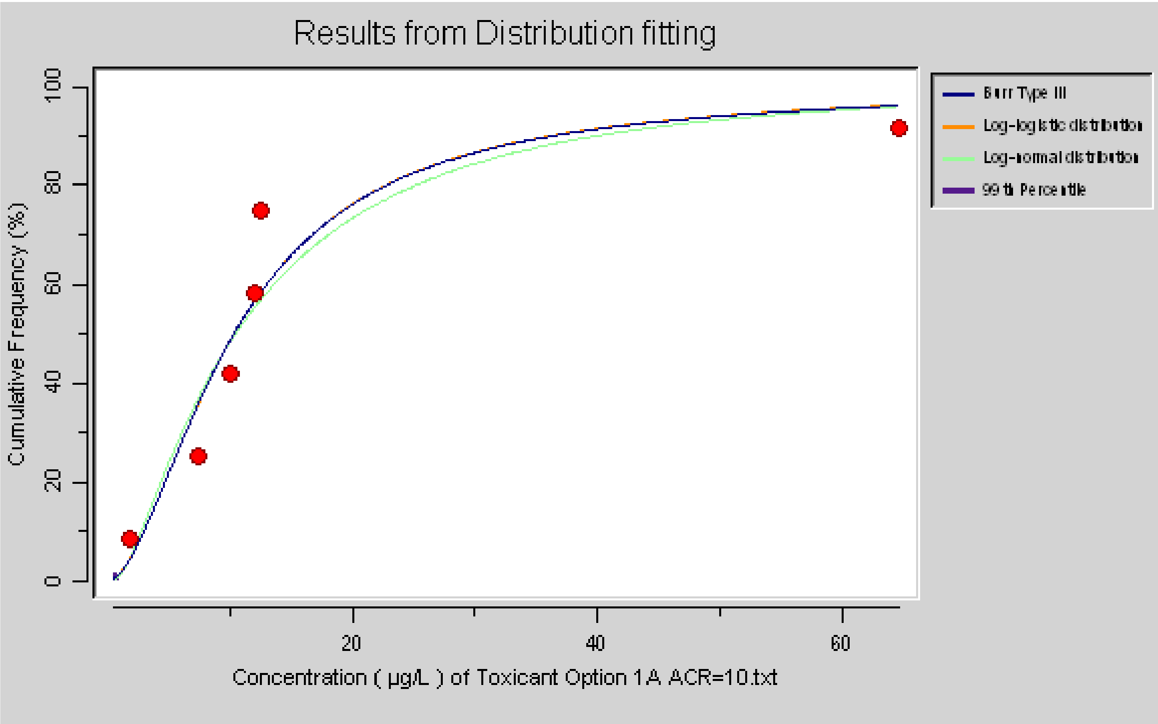

Figure 5-37 Species sensitivity distributions of EC10 values using an ACR of 10 for the round two Case 2 sample from the Perth Seawater Desalination Plant.

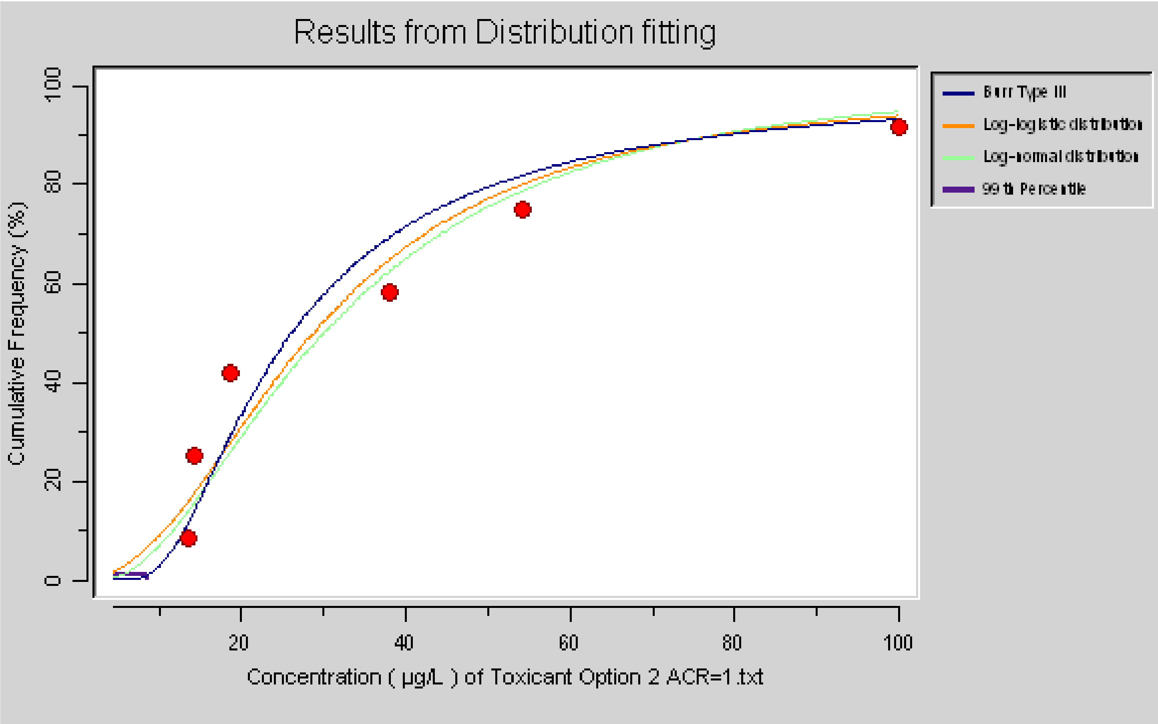

Figure 5-38 Species sensitivity distributions of EC10 values using an ACR of 1 for the round two Case 1 sample from the Perth Seawater Desalination Plant.

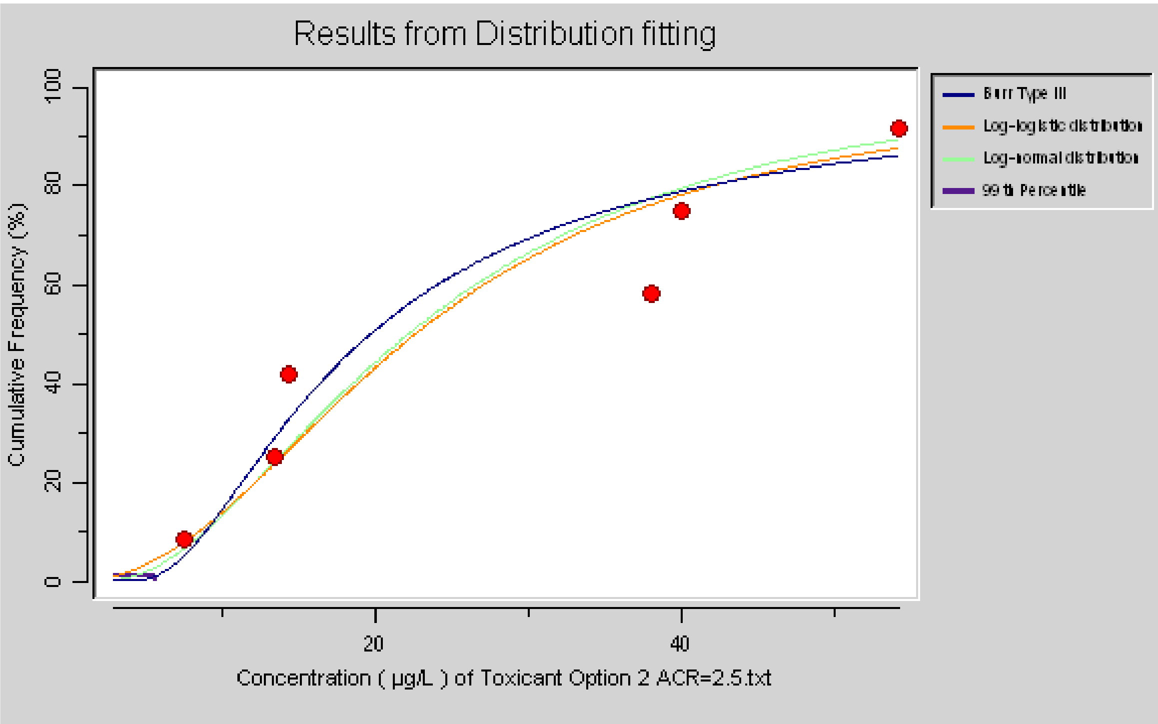

Figure 5-39 Species sensitivity distributions of EC10 values using an ACR of 2.5 for the round two Case 1 sample from the Perth Seawater Desalination Plant.

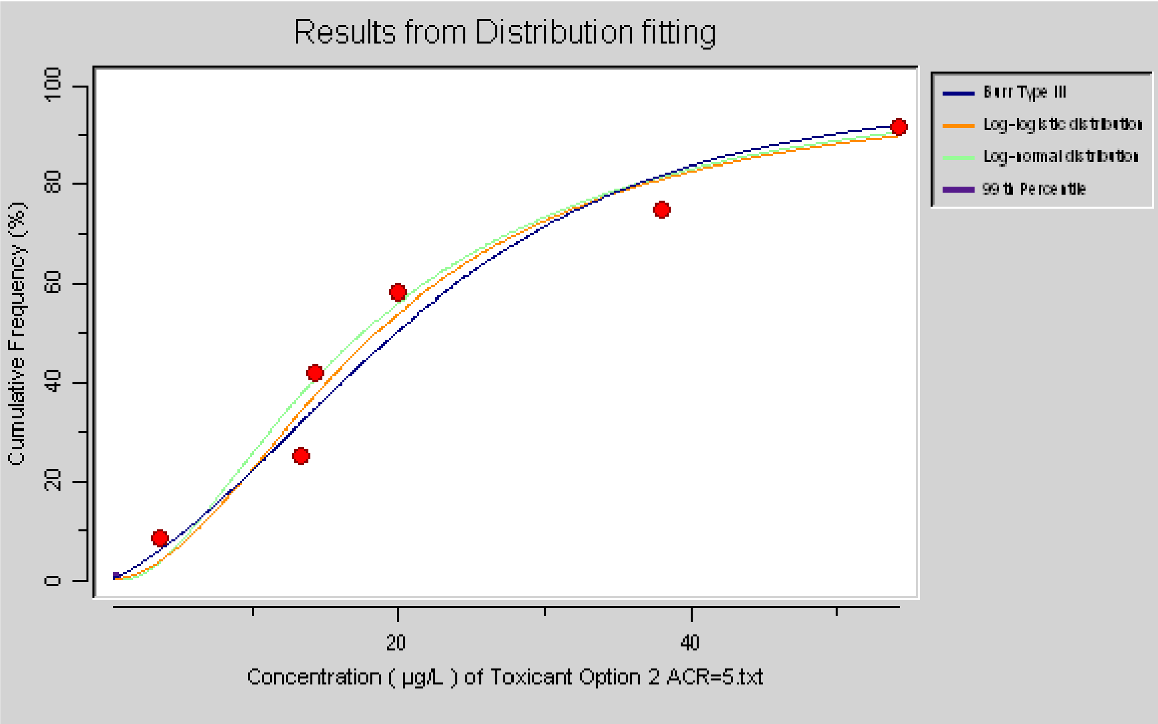

Figure 5-40 Species sensitivity distributions of EC10 values using an ACR of 5 for the round two Case 1 sample from the Perth Seawater Desalination Plant.

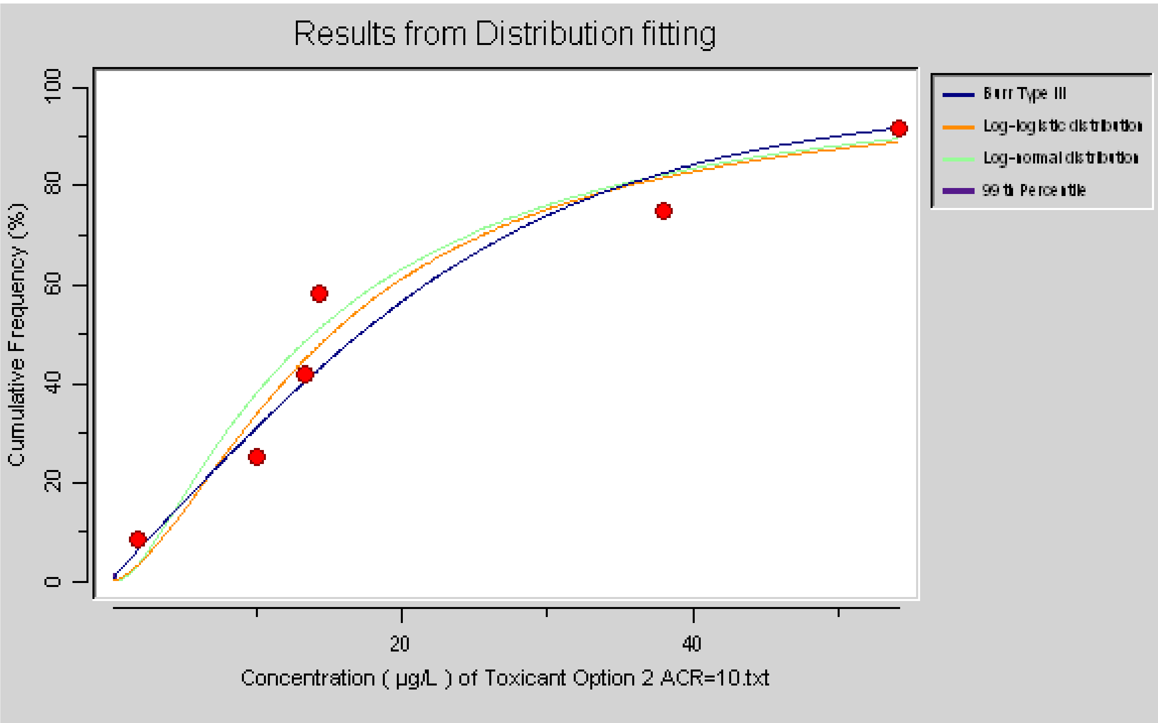

Figure 5-41 Species sensitivity distributions of EC10 values using an ACR of 10 for the round two Case 1 sample from the Perth Seawater Desalination Plant.

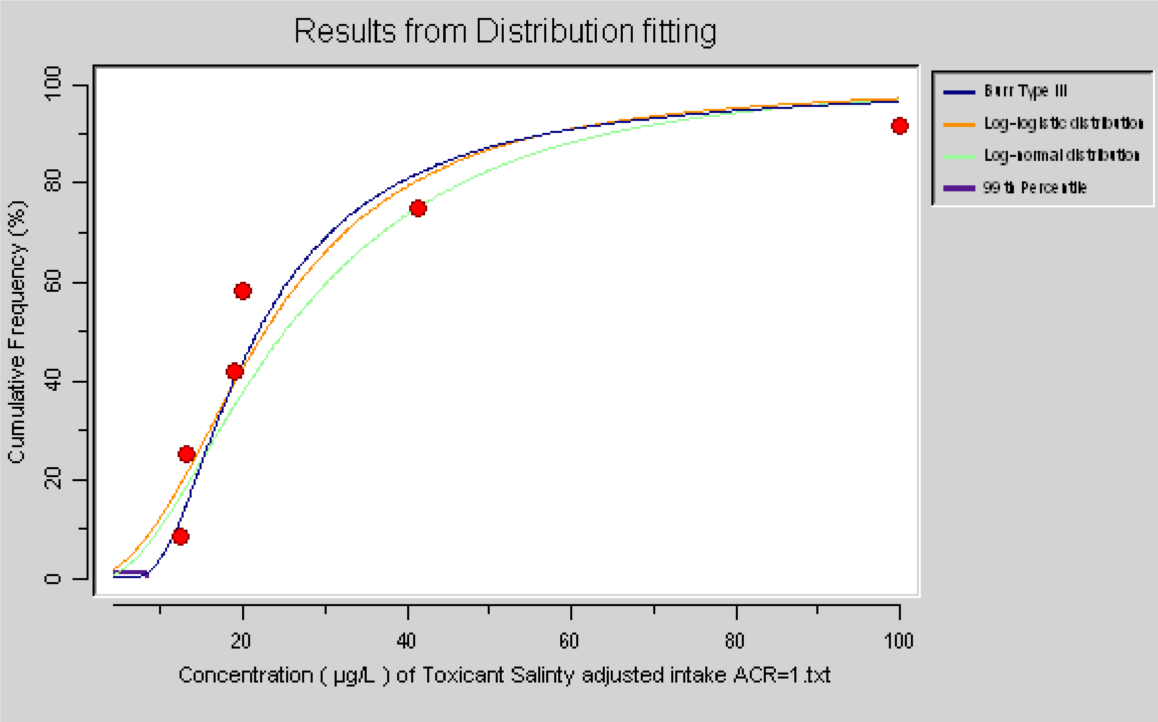

Figure 5-42 Species sensitivity distributions of EC10 values using an ACR of 1 for the round two salinity adjusted intake sample from the Perth Seawater Desalination Plant.

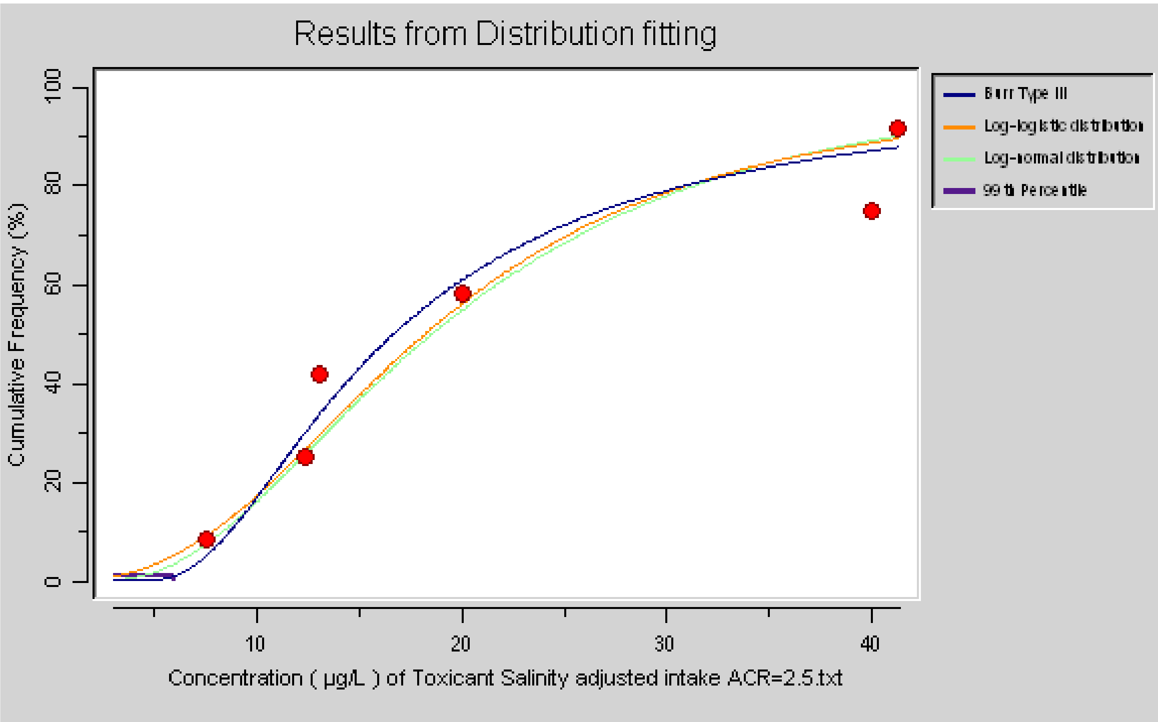

Figure 5-43 Species sensitivity distributions of EC10 values using an ACR of 2.5 for the round two salinity adjusted intake sample from the Perth Seawater Desalination Plant.

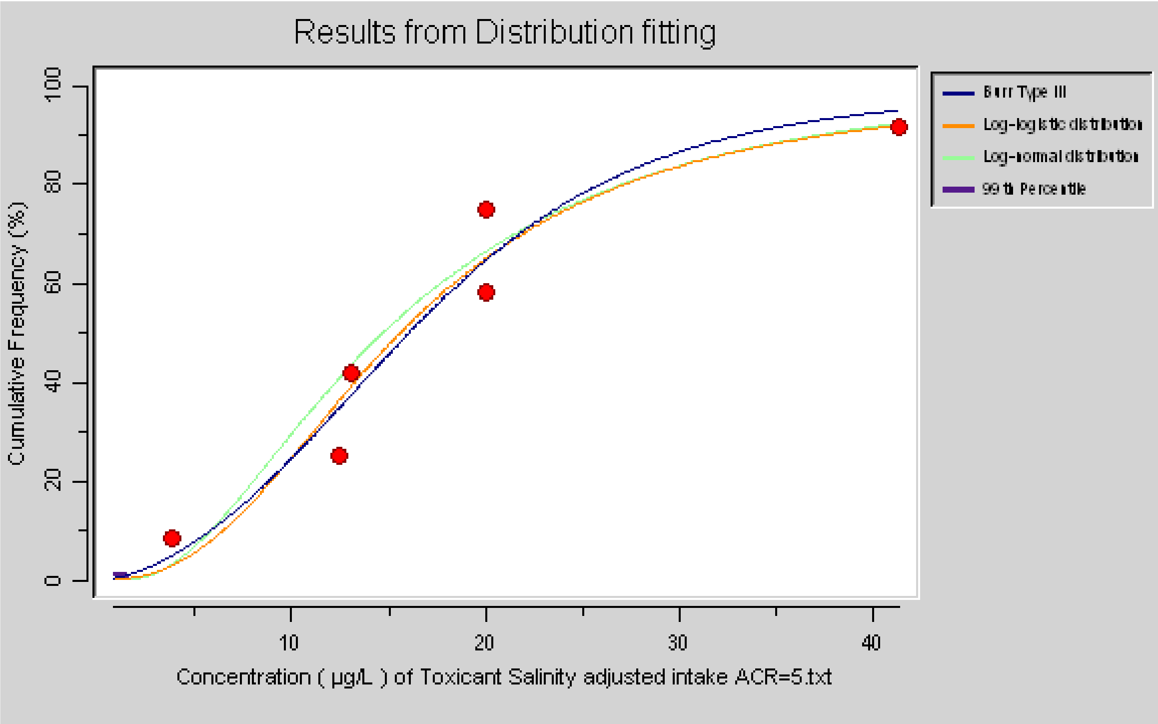

Figure 5-44 Species sensitivity distributions of EC10 values using an ACR of 5 for the round two salinity adjusted intake sample from the Perth Seawater Desalination Plant.

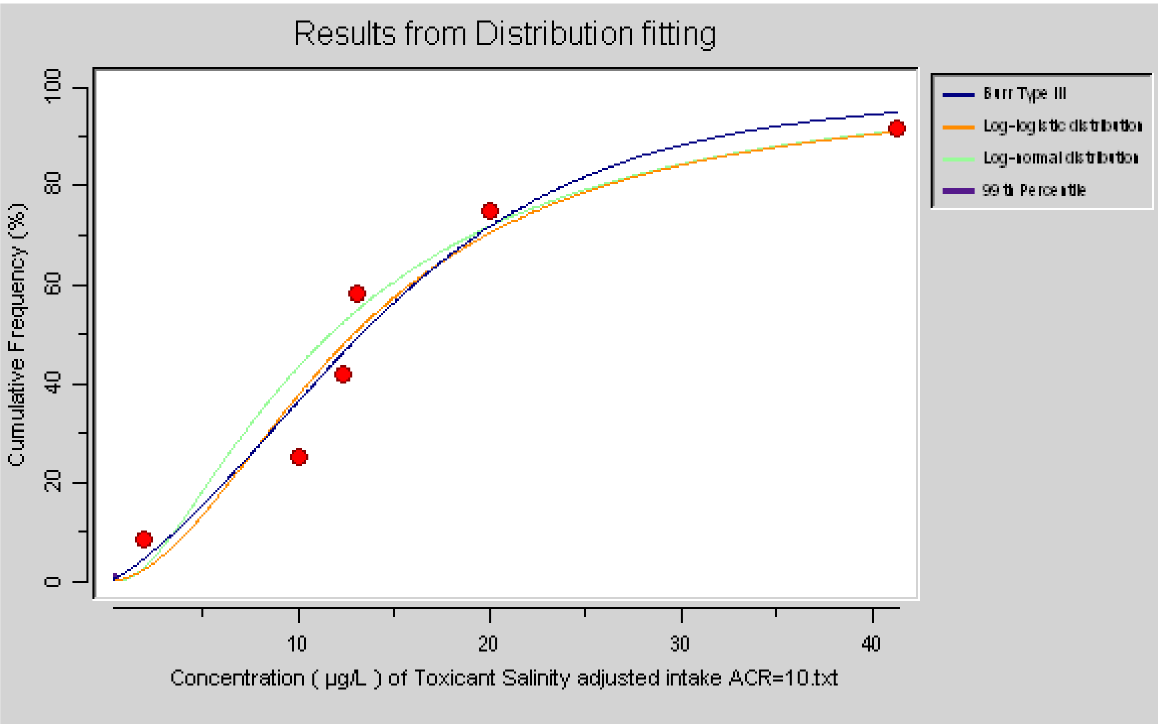

Figure 5-45 Species sensitivity distributions of EC10 values using an ACR of 10 for the round two salinity adjusted intake sample from the Perth Seawater Desalination Plant.

The fit of the Burr Type III distribution to each set of round two toxicity data was acceptable with the goodness of fit values ranging from 22.01 to 26.81. The higher the goodness of fit values the better the fit. The values obtained for the above SSDs are similar to those obtained for trigger values in the Australian and New Zealand water quality guidelines (ANZECC and ARMCANZ, 2000) that are based on the same number of data.

The PC99 and corresponding safe dilution factors derived for the waste discharge option samples are presented in Table 5-46. As would be expected the size of the PC99 values decreases while the size of the safe dilution factors increases for each sample as the ACR values increase in size. The PC99 values for the various samples calculated using one ACR are all similar varying by no more than a factor of 2.7 (e.g. the PC99 values in column three). The safe dilution factors for the various samples calculated using one ACR are also similar, again varying by no more than a factor of 2.7. The safe dilution factors presented in Table 5-46 ranged from 11.6 (Case 1 with an ACR of 1) to 345 (Case 1 with an ACR of 10). The safe dilution factors calculated using the recommended ACR of 2.5 ranged from 16.7 to 22.6.

Table 5-46 The concentrations of the round two samples that should theoretically protect 99% of marine species (PC99) and the corresponding safe dilution factors calculated using EC10 data and a range of acute to chronic ratios.

Sample	Type of data generated	PC99 (% sample) and safe dilution factors			
		EC10 (ACR 1)	EC10 (ACR 2.5)	EC10 (ACR 5)	EC10 (ACR 10)
Case 1	**PC 99**	8.64	5.61	0.99	0.29
	Safe dilution factor	11.6	17.8	101	345
Case 2	**PC 99**	4.79	4.42	2.57	0.76
	Safe dilution factor	20.9	22.6	38.9	131.6
Case 3	**PC 99**	7.97	5.45	1.51	0.65
	Safe dilution factor	12.5	18.3	66.2	153.8
Salinity adjusted intake	**PC 99**	8.36	5.98	1.52	0.61
	Safe dilution factor	12	16.7	65.8	163.9

5.6 DIRECT TOXICITY ASSESSMENT OF LOW FLOW DISCHARGE - GCDP

Veolia commissioned Hydrobiology to investigate the potential for local marine organisms to suffer from acute toxicity after short-term exposure (i.e. less than 4h) to waste brines from the Gold Coast Desalination Plant (GCDP). This investigation was designed to address the potential risk associated with occasional short exposures to waste brines that may occur as a result of, for example, an emergency plant shut down during which low flow desalination effluent would be released through the diffuser.

Hydrobiology developed in an adapted ecotoxicological testing method in conjunction with Ecotox Services Australasia for a direct toxicity assessment of short-duration pulse exposures of desalination brine to discharge area organisms. This was in response to unplanned shut downs of the desalination plant (power outages etc.) which caused a decrease in pressure at the outfall diffuser, resulting in short pulses of increased salinity brines reaching the receiving environment. The study identified the potential impact in terms of acute toxicity to the resident organisms in the outfall area.

The following three tests were selected for the pulse exposure testing as they were the most sensitive tests of the DTA suite previously tested for the GCDP:

- 72h marine algal growth test using *Nitzschia closterium* (based on Stauber et al. 1994)
- 48h bivalve larval development using the Sydney rock oyster *Saccostrea glomerata* (based on Krassoi et al. 1995, 1996 and APHA, 1998)
- 96h larval fish imbalance toxicity test using barramundi *Lates calcarifer* (based on USEPA 2002)

Test organisms were exposed to a 1h and 4-hour pulse concentrated effluent treatment after which the water was replaced with background seawater (i.e. reflecting typical conditions outside of the mixing zone when standard operation of the desalination plant occurs) and were maintained for the remainder of the test.

This new pulse-exposure DTA indicated that marine organisms tended to be less sensitive when exposed to elevated salinity for a few hours (up to 4 hours) compared with longer exposures. The following TVs were derived for pulse exposures such as those observed in low flow incidents:

- salinity concentration up to 42.0 ppt for an incident lasting less than one hour; and
- salinity concentration up to 41.9 ppt for an incident up to 4h.

5.7 SEAWATER DESALINATION ECOTOXICITY ASSESSMENT SUMMARY

The size and scale of each of the operational large seawater desalination plants in Australia and the dilution required to protect the receiving environment and the stated dilution achieved by each plants diffusers can be seen in Table 6-1. As can be seen, the required dilution ratio for all of these plants under normal operation is less than the proposed EDPD discharge dilution of 40:1, which can be considered very conservative in the context of the other operating plants. As discussed in Section 3, the toxicity associated with process and cleaning chemicals can be managed using standard procedures for their disposal into the waste stream at appropriate concentrations to ensure they have no effect on the receiving environment upon discharge.

6.RECOMMENDATIONS

Given the results from the ecotoxicity assessments of the ADP and ODDP where regionally relevant species were used for pre and post operational assessments, the EPDP will be considerably smaller (24 ML/day) than that of the ADP (250ML/day) and the discharge brine will be less saline due to a lower recovery rate, and that only ADP approved process chemicals and requirements for cleaning chemical disposal will be enforced for the EPDP, a full ecotoxicological assessment of the EPDP discharge is not deemed necessary. Where the disposal of CIP chemicals is considered in the waste stream, the required dilution will need to be achieved as per the ADP assessment. For alternative CIP chemicals, a full ecotoxicity assessment similar to that carried out as part of the ADP ecotoxicity assessment to derive a safe dilution will need to be completed.

It is recommended that a subset of regionally relevant organisms be used to do chronic pre-operational ecotoxicity testing of a pilot plant saline concentrate. The suggested species and tests should include:

- *N. closterium* 72h growth inhibition test.
- *M. gallaprovincialis* 14-day larval development test.
- *H. tuberculata* 72h larval development test.

The results of these tests can then be directly compared with the ADP results, but also supported by the results from the numerous tests undertaken on large seawater desalination plants around Australia for more toxicity context. The inclusion of the microalga is important to understand the potential additional toxicity of added anti-scalant above that seen for salinity alone. The pilot plant concentrate must be produced using water collected from the proposed feed water point and the proposed anti-scalant. Feed water should also be used as the ecotoxicity test diluent. These results should be within the bounds of that seen for the ADP assessment results considering the differences in the salinity of the discharge brine. This should indicate if the proposed 40:1 dilution to be achieved by the EPDP will be adequate to protect the receiving environment from any adverse effects from the brine discharge.

We also recommend that a post operational ecotoxicity assessment of the brine discharge be undertaken using the same subset of ecotoxicity tests as the plant is commissioned and brought up to capacity, in a similar requirement to that placed upon the ADP (for example testing to be carried out at 50% of total production then 3 months and 6 months after full production has commenced).

Given the results of the ecotoxicological assessments for other large seawater desalination plants in Australia and the resultant discharge dilution ratios (Table 6-1), and the size and output volume of the proposed EPDP, the proposed 40:1 dilution rate that is to be achieved by the edge of the mixing zone should be adequate to protect the receiving environment. The recommended pre and post commissioning testing regime will ensure that this is achievable. The treatment of cleaning chemicals should be handled so that concentrations that enter the discharge stream are very low and present no risk to the receiving environment.

Table 6-1 Stated achievable dilution ratios and calculated dilutions ratios for selected large seawater desalination plants.

Plant	Max operation capacity (ML/day)	Stated achievable dilution ratio	Calculated required dilution ratio
Adelaide Desalination Plant	275	50:1	11:1 – 21:1 for 95% protection
Victoria Desalination Plant	410	30:1	29:1 for 99% protection
Sydney Desalination Plant	250	30:1	40:1 for 95% (Stream 2 as the most toxic)
Perth Desalination Plant	144	45:1	13:1 for 95% protection
Eyre Peninsula Desalination Plant	24	40:1	TBD

7.REFERENCES

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Appendix T Toxicity Assessment Extension

Hazel Vandeleur
SA Water
250 Victoria Square
Adelaide, SA 5000

25/01/2024

TOXICITY ASSESSMENT OF ADELAIDE DESALINATION PLANT BRINE

Dear Hazel,

Background

This brief letter report details the findings of the Toxicity Assessment of Adelaide Desalination Plant Brine to the Larvae of the Mediterranean Mussel (*Mytilus galloprovincialis*). Testing was conducted in response to concerns raised by the aquaculture industry regarding the effects of brine discharge into the receiving environment and consequent impacts to the nearby industry. *Mytilus galloprovincialis* was selected due to its relevance to the local aquaculture industry.

Test protocol

Testing was conducted in December 2023 by a NATA accredited laboratory. The intended test was the standard 48-hr larval development test, using the Ecological Society of America Standard Operating procedure 106 (ESA, 2016), which is based on American Public Health Association (1998) and United States Environmental Protection Agency (1996) guidelines. In this instance, the test was extended to 72-hrs in order to achieve a statistically robust result. Extension of the test to 72 h following a progression check at 48 h is standard practice and is done in order to achieve a statistically robust result. The results are considered valid despite the deviation from protocol, as evidenced by the accompanying satisfactory QAQC results.

The brine sample provided to the laboratory was serially diluted with salinity adjusted filtered seawater (FSW) to 36.2 ppt with GP2 salt to achieve the test concentrations. A FSW control, a diluent Control (Salinity adjusted FSW) and four salinity controls were tested concurrently with the sample.

Test results

The toxicity test report (TR2194/1_R01) provides a 72-hr IC10 dilution of 6.4% (6.33-6.44). The salinity control results indicated that salinity was the driver of toxicity and that no other compounds were present in the brine that caused toxicity effects. The results indicated that the salinity threshold for larval development was 38-39 ppt, as expected for the species.

The observed results align with previous testing of the Adelaide Desalination Plant Brine using *M. galloprovincialis* from 2011-2013. The previous tests reported an IC10 of 6.4 and 6.3, three and six months after fully operational, respectively. The corresponding Safe Dilutions were 31.3 and 31.8, calculated based on the chronic IC10 value.

Conclusions

There were no notable differences between the recent test results for the Adelaide Desalination Plant Brine and those conducted in 2011-2013 using the same species. The results indicate that salinity is the sole driver of toxicity and the previous Safe Dilutions (31.3-31.8) are expected to be applicable, provided that there are no changes to current operating procedures or substances used. Consequently, the target discharge dilution of 40:1 is regarded as sufficient to protect the receiving environment, including the interests of the nearby aquaculture industry.

I trust this letter meets your requirements. Please do not hesitate to contact me for further information or clarification.

Dustin Hobbs
Principal Ecotoxicologist

Toxicity Assessment of Adelaide Desalination Plant Brine to the Larvae of the Blue Mussel

SA Water

Test Report

December 2023

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Unit 27, 2 Chaplin Drive
Lane Cove NSW 2066 Australia
www.ecotox.com.au
ECOTOX SERVICES AUSTRALIA PTY LIMITED
ABN 95 619 426 201

Toxicity Test Report: TR2194/1_R01

Accredited for compliance with ISO/IEC 17025 - Testing

Client:	SA Water 250 Victoria Square Adelaide SA 5000	**ESA Job #:** **Date Sampled:** **Date Received:**	PR2194 04 December 2023 08 December 2023
Attention:	Tiani Zollo Semmler	**Sampled By:**	Client
Client Ref:	PO A59286	**ESA Quote #:**	PL2194_q01

Lab ID No.:	**Sample Name:**	**Sample Description:**
11357	Adelaide Desalination Plant Brine (ADPB)	Aqueous sample, pH 7.9*, salinity 64.9‰*, total ammonia 2.3mg/L*. Sample received at 13ºC* in apparent good condition.

*NATA accreditation does not cover the performance of this service

Test Performed:	48-hr larval development test using the mussel *Mytilus galloprovincialis*
Test Protocol:	ESA SOP 106 (ESA 2016), based on APHA (1998) and USEPA (1996)
Test Temperature:	The test was performed at 20±1°C.
Deviations from Protocol:	The test duration was extended to 72hr
Comments on Solution Preparation:	The sample was serially diluted with salinity adjusted filtered seawater (FSW) to 36.2‰ with GP2 salt to achieve the test concentrations. A FSW control, a diluent Control (Salinity adjusted FSW) and four salinity controls were tested concurrently with the sample.
Source of Test Organisms:	Farm-reared, Spencer Gulf, SA
Test Initiated:	11 December 2023 at 1900h

Salinity controls	**% Normal larvae (Mean ± SD)**	Sample 11357: *ADPB* **Concentration (%)**	**% Normal larvae (Mean ± SD)**	*Vacant*
FSW Control	72.3 ± 3.0	Diluent Control	73.8 ± 2.6	
Diluent Control	73.8 ± 2.6	1.6	74.5 ± 3.1	
1.6% (36.7‰)	73.8 ± 1.7	3.1	76.3 ± 1.7	
3.1% (37.2‰)	73.0 ± 2.9	6.3	71.5 ± 1.9	
6.3% (38.0‰)	73.5 ± 2.7	12.5	0.0 ± 0.0	
12.5% (40.0‰)	0.0 ± 0.0	25	0.0 ± 0.0	
		50	0.0 ± 0.0	
		100	0.0 ± 0.0	

72-hr EC10 = 6.4 (6.33-6.44)%
72-hr EC50 = 8.6 (8.48-8.73)%
NOEC = 6.3%
LOEC = 12.5%

QA/QC Parameter	**Criterion**	**This Test**	**Criterion met?**
FSW Control mean % normal	≥70%	73.8%	Yes
Reference Toxicant within cusum chart limits	8.8-12.3µg Cu/L	10.4µg Cu/L	Yes

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ECOTOX SERVICES AUSTRALIA PTY LIMITED
ABN 95 619 426 201

Toxicity Test Report: TR2194/1_R01

Test Report Authorised by: Dr Rick Krassoi, Director on 24 January 2024

Results are based on the samples in the condition as received by ESA.

NATA Accredited Laboratory Number: 14709

Document Change Control:

Test Report TR2194/1 replaced with TR2194/1_R01 to correct the EC test duration to 72-hr to reflect actual test duration.

Citations:

APHA (1998) *Standard Methods for the Examination of Water and Wastewater*. 20th Ed. American Public Health Association, American Water Works Association and the Water Environment Federation, Washington, DC, USA.

ESA (2016) *Bivalve Larval Development Test*. Issue No. 15. Ecotox Services Australasia, Sydney, NSW

USEPA (1996) *Bivalve acute toxicity test (embryo larval) OPPTS 850.1055. Ecological Effects Test Guidelines.* United States Environmental Protection Agency. Prevention, Pesticides and Toxic Substances. EPA/712/C-96/137.

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Chain-of-Custody Documentation

Sample Receipt Notification

Attention : Tiani Zollo Semmler

Client : SA Water
250 Victoria Square
Adelaide SA 5000

Email : tiani.zollosemmler@sawater.com.au
Telephone : 08 7424 3020
Facsimile :

Date : 9/12/2023

Re : Receipt of Samples **Pages :** **2**

ESA Project : PR2194 ☑ For Review ☐ Additional Documentation Required - Please Respond

Sample Delivery Details

Completed Chain of Custody accompanied samples: **YES**
Samples received in apparent good condition and correctly bottled: **YES**
Security seals on sample bottles and esky intact: **YES**

Date samples received : 8/12/2023
Time samples received : 10:30
No. of samples received : 1
Sample matrix : Aqueous
Sample temperature : 11-15°C

Comments : 4 x 1.25L sample received at 13 degrees C in apparent good condition

Contact Details

Projects Manager : Dr Rick Krassoi
Telephone : 61 2 9420 9481
Facsimile : 61 2 9420 9484
Email : rkrassoi@ecotox.com.au

Please contact customer services officer for all queries or issues regarding samples

Note that the chain-of-custody provides definitive information on the tests to be performed

Chain-of-Custody / Service Request Form

Datasheet ID: 601.1
Last Revised: 14 December 2022

Customer: SA Water - Adelaide Desalination Plant
Contact Name: Hazel Vandeleur
Phone: 0407106531 Email: hazel.vandeleur@sawater.com.au
Purchase Order: A59286

Ship To: Ecotox Services - Unit 27, 2 Chaplin Drive, Lane Cove NSW 2066
Attention: Rick Krassoi
(please provide an email address for sample receipt notification)

13°C

	Sample Date (day/month /year)	Sample Time	Sample Name (exactly as written on the sample vessel)	Sample Method (eg. Grab, composite etc.)	Number and Volume of Containers (eg 2 x 1L)	Tests Requested (See reverse for guidance)	Comments / Instructions
11357	04/12/23	0830hrs	Adelaide Desalination Plant brine	Grab	4 x 1.25L	72-hr Larval development test using Mussel Mytilus galloprovincialis (based on APHA Method 8610C, 1998 and USEPA 1996)*	

Comments / Instructions:

Note that testing will be delayed if an incomplete chain of custody is received

- Additional treatment of samples (i.e. spiking)
- Sub-contracted services (i.e. chemical analyses)
- Dilutions required (if different than 100% down to 6.25%)
- Sample holding time restriction (if applicable)
- Sample used for litigation (if applicable)

Note: An MSDS must be attached if Available

ESA Project Number: PR 2194

1) Released By: Dylan Yong	Date: 07/12/23	2) Received By: [signature]	Date: 8/12/23	3) Released By:	Date:	4) Received By:	Date:
Of: AAPL	Time: 0800 hrs	Of: ESA	Time: 1030	Of:	Time:	Of:	Time:

Note that the chain-of-custody documentation will provide definitive information on the tests to be performed.

Ecotox Services Australia . Unit 27, 2 Chaplin Drive, Lane Cove NSW 2066 AUSTRALIA
Phone: 61 2 9420-9481 Email: info@ecotox.com.au

ecotox SERVICES AUSTRALIA

Statistical Printouts for the Mussel Toxicity Tests

Bivalve Larval Development Test-Proportion Normal

Start Date:	11/12/2023 19:00	Test ID:	PR2194/03	Sample ID:	Adelaide Brine
End Date:	14/12/2023 19:00	Lab ID:	11357	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 106	Test Species:	MG-Mytilus galloprovincialis
Comments:					

Conc-%	1	2	3	4
FSW Control	0.7600	0.7100	0.6900	0.7300
Diluent Control	0.7600	0.7400	0.7000	0.7500
1.6	0.7300	0.7800	0.7600	0.7100
3.1	0.7400	0.7700	0.7600	0.7800
6.3	0.7300	0.6900	0.7300	0.7100
12.5	0.0000	0.0000	0.0000	0.0000
25	0.0000	0.0000	0.0000	0.0000
50	0.0000	0.0000	0.0000	0.0000
100	0.0000	0.0000	0.0000	0.0000

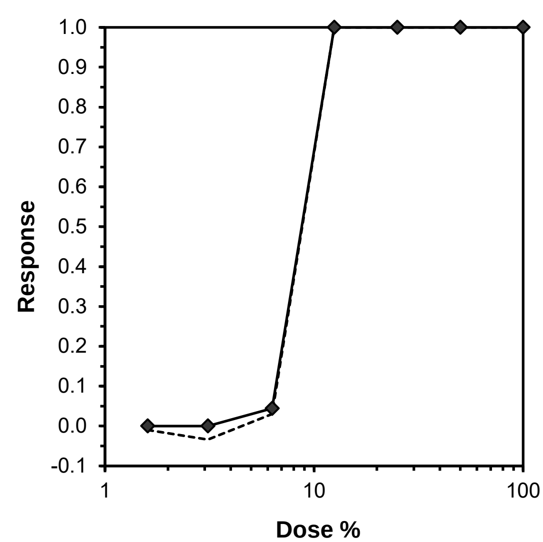
			Transform: Arcsin Square Root						1-Tailed		Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD	Mean	N-Mean
FSW Control	0.7225	0.9797	1.0164	0.9803	1.0588	3.298	4					
Diluent Control	0.7375	1.0000	1.0332	0.9912	1.0588	2.864	4	*			0.7483	1.0000
1.6	0.7450	1.0102	1.0420	1.0021	1.0826	3.429	4	-0.452	2.290	0.0443	0.7483	1.0000
3.1	0.7625	1.0339	1.0619	1.0357	1.0826	1.882	4	-1.483	2.290	0.0443	0.7483	1.0000
6.3	0.7150	0.9695	1.0078	0.9803	1.0244	2.097	4	1.313	2.290	0.0443	0.7150	0.9555
12.5	0.0000	0.0000	0.0500	0.0500	0.0500	0.000	4				0.0000	0.0000
25	0.0000	0.0000	0.0500	0.0500	0.0500	0.000	4				0.0000	0.0000
50	0.0000	0.0000	0.0500	0.0500	0.0500	0.000	4				0.0000	0.0000
100	0.0000	0.0000	0.0500	0.0500	0.0500	0.000	4				0.0000	0.0000

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.05)	0.94388	0.887	-0.37568	-0.82634
Bartlett's Test indicates equal variances (p = 0.75)	1.21035	11.3449		
The control means are not significantly different (p = 0.48)	0.75222	2.44691		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU	MSDu	MSDp	MSB	MSE	F-Prob	df
Dunnett's Test	6.3	12.5	8.87412	15.873	0.03988	0.05406	0.00201	0.00075	0.09346	3, 12
Treatments vs Diluent Control										

Log-Logit Interpolation (200 Resamples)

Point	%	SD	95% CL(Exp)		Skew
IC05	6.3088	0.3135	4.6897	6.3645	-1.8047
IC10	6.3872	0.0186	6.3283	6.4422	-0.0062
IC15	6.4619	0.0180	6.4055	6.5163	-0.0335
IC20	6.5340	0.0176	6.4798	6.5878	-0.0552
IC25	6.6046	0.0172	6.5522	6.6579	-0.0726
IC40	6.8156	0.0164	6.7673	6.8674	-0.1074
IC50	6.9639	0.0160	6.9169	7.0147	-0.1215

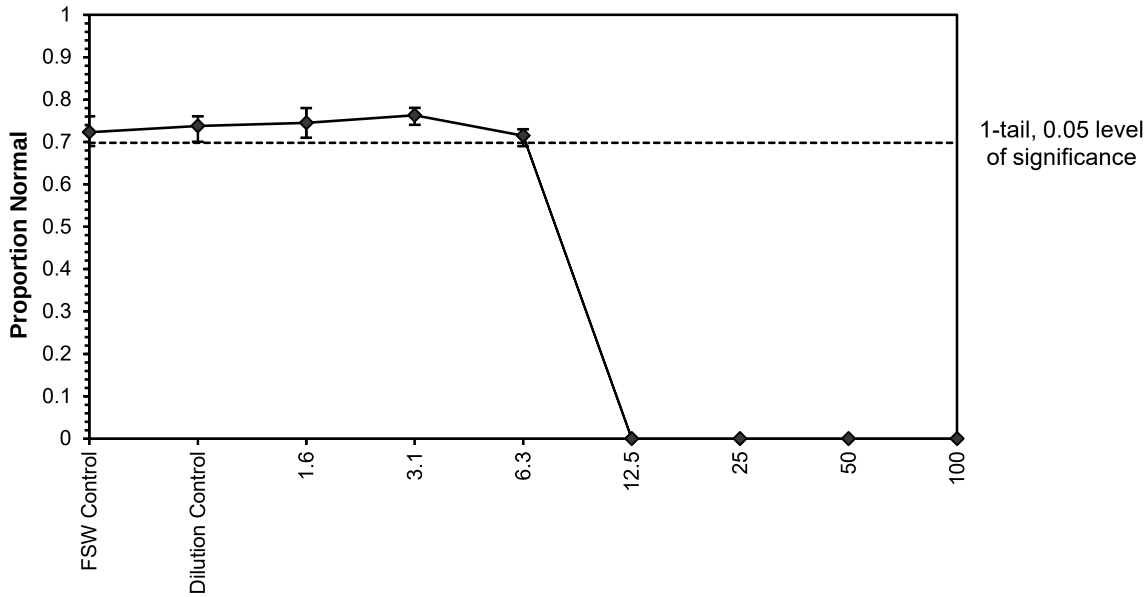


 ToxCalc v5.0.23 Reviewed by:_____

Bivalve Larval Development Test-Proportion Normal

Start Date:	11/12/2023 19:00	Test ID:	PR2194/03	Sample ID:	Adelaide Brine
End Date:	14/12/2023 19:00	Lab ID:	11357	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 106	Test Species:	MG-Mytilus galloprovincialis
Comments:					

Dose-Response Plot



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Sample Date:		Protocol:	ESA 106	Test Species:	MG-Mytilus galloprovincialis
Comments:					

		Auxiliary Data Summary					
Conc-%	**Parameter**	**Mean**	**Min**	**Max**	**SD**	**CV%**	**N**
FSW Control	% Normal	72.25	69.00	76.00	2.99	2.39	4
Diluent Control		73.75	70.00	76.00	2.63	2.20	4
1.6		74.50	71.00	78.00	3.11	2.37	4
3.1		76.25	74.00	78.00	1.71	1.71	4
6.3		71.50	69.00	73.00	1.91	1.94	4
12.5		0.00	0.00	0.00	0.00		4
25		0.00	0.00	0.00	0.00		4
50		0.00	0.00	0.00	0.00		4
100		0.00	0.00	0.00	0.00		4
FSW Control	pH	8.10	8.10	8.10	0.00	0.00	1
Diluent Control		8.10	8.10	8.10	0.00	0.00	1
1.6		8.10	8.10	8.10	0.00	0.00	1
3.1		8.10	8.10	8.10	0.00	0.00	1
6.3		8.10	8.10	8.10	0.00	0.00	1
12.5		8.10	8.10	8.10	0.00	0.00	1
25		8.10	8.10	8.10	0.00	0.00	1
50		8.10	8.10	8.10	0.00	0.00	1
100		8.10	8.10	8.10	0.00	0.00	1
FSW Control	Salinity ppt	35.60	35.60	35.60	0.00	0.00	1
Diluent Control		36.20	36.20	36.20	0.00	0.00	1
1.6		36.30	36.30	36.30	0.00	0.00	1
3.1		37.20	37.20	37.20	0.00	0.00	1
6.3		38.00	38.00	38.00	0.00	0.00	1
12.5		40.00	40.00	40.00	0.00	0.00	1
25		44.00	44.00	44.00	0.00	0.00	1
50		52.30	52.30	52.30	0.00	0.00	1
100		64.90	64.90	64.90	0.00	0.00	1
FSW Control	DO %	99.90	99.90	99.90	0.00	0.00	1
Diluent Control		99.10	99.10	99.10	0.00	0.00	1
1.6		101.50	101.50	101.50	0.00	0.00	1
3.1		100.80	100.80	100.80	0.00	0.00	1
6.3		100.20	100.20	100.20	0.00	0.00	1
12.5		100.20	100.20	100.20	0.00	0.00	1
25		99.50	99.50	99.50	0.00	0.00	1
50		98.60	98.60	98.60	0.00	0.00	1
100		94.80	94.80	94.80	0.00	0.00	1

Bivalve Larval Development Test-Proportion Normal

Start Date:	11/12/2023 19:00	Test ID:	PR2194/03	Sample ID:	Adelaide Brine
End Date:	14/12/2023 19:00	Lab ID:	11357	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 106	Test Species:	MG-Mytilus galloprovincialis
Comments:					

Conc-%	1	2	3	4
FSW Control	0.7600	0.7100	0.6900	0.7300
Diluent Control	0.7600	0.7400	0.7000	0.7500
1.6	0.7300	0.7800	0.7600	0.7100
3.1	0.7400	0.7700	0.7600	0.7800
6.3	0.7300	0.6900	0.7300	0.7100
12.5	0.0000	0.0000	0.0000	0.0000
25	0.0000	0.0000	0.0000	0.0000
50	0.0000	0.0000	0.0000	0.0000
100	0.0000	0.0000	0.0000	0.0000

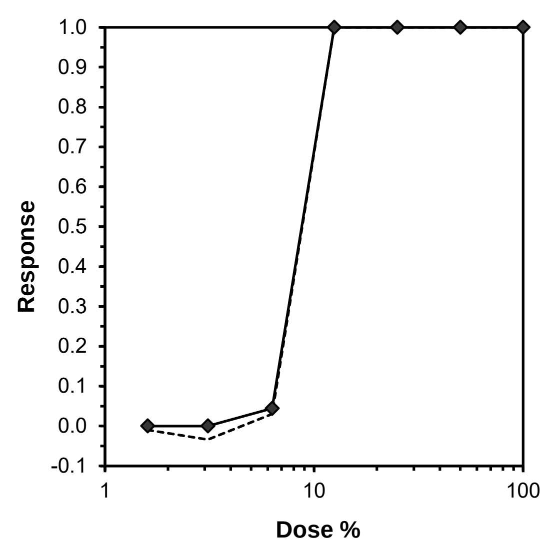
			Transform: Arcsin Square Root						1-Tailed		Number	Total
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD	Resp	Number
FSW Control	0.7225	0.9797	1.0164	0.9803	1.0588	3.298	4					
Diluent Control	0.7375	1.0000	1.0332	0.9912	1.0588	2.864	4	*			105	400
1.6	0.7450	1.0102	1.0420	1.0021	1.0826	3.429	4	-0.452	2.290	0.0443	102	400
3.1	0.7625	1.0339	1.0619	1.0357	1.0826	1.882	4	-1.483	2.290	0.0443	95	400
6.3	0.7150	0.9695	1.0078	0.9803	1.0244	2.097	4	1.313	2.290	0.0443	114	400
12.5	0.0000	0.0000	0.0500	0.0500	0.0500	0.000	4				400	400
25	0.0000	0.0000	0.0500	0.0500	0.0500	0.000	4				400	400
50	0.0000	0.0000	0.0500	0.0500	0.0500	0.000	4				400	400
100	0.0000	0.0000	0.0500	0.0500	0.0500	0.000	4				400	400

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.05)	0.94388	0.887	-0.37568	-0.82634
Bartlett's Test indicates equal variances (p = 0.75)	1.21035	11.3449		
The control means are not significantly different (p = 0.48)	0.75222	2.44691		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU	MSDu	MSDp	MSB	MSE	F-Prob	df
Dunnett's Test	6.3	12.5	8.87412	15.873	0.03988	0.05406	0.00201	0.00075	0.09346	3, 12
Treatments vs D Diluent Control										

Trimmed Spearman-Karber

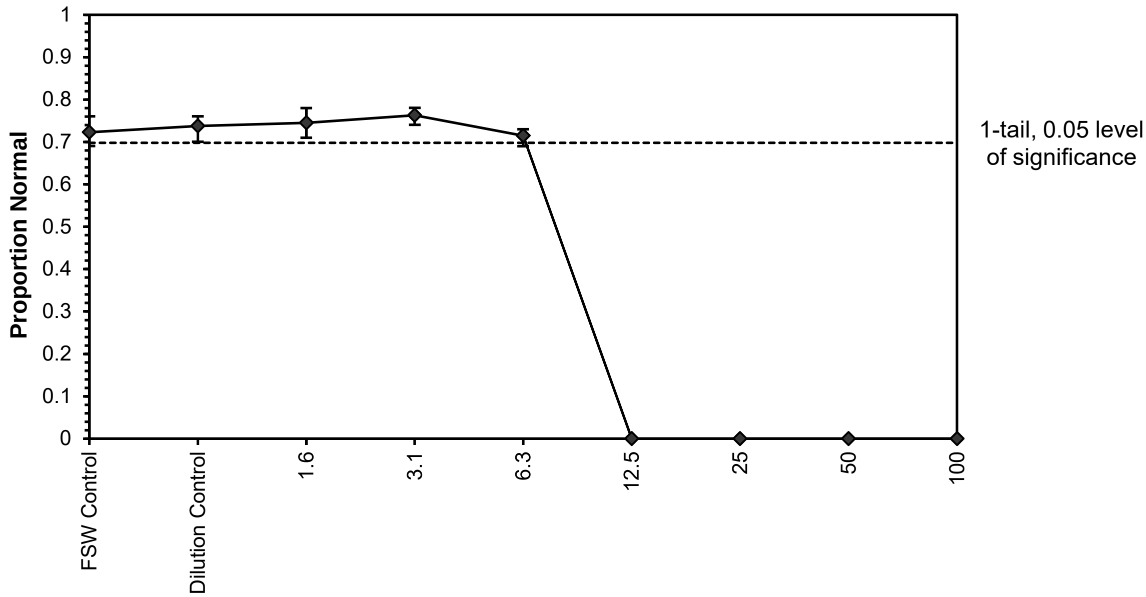
Trim Level	EC50	95% CL	
0.0%	8.6028	8.4799	8.7274
5.0%	8.7335	8.6662	8.8014
10.0%	8.7335	8.6662	8.8014
20.0%	8.7335	8.6662	8.8014
Auto-0.0%	8.6028	8.4799	8.7274



Bivalve Larval Development Test-Proportion Normal

Start Date:	11/12/2023 19:00	Test ID:	PR2194/03	Sample ID:	Adelaide Brine
End Date:	14/12/2023 19:00	Lab ID:	11357	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 106	Test Species:	MG-Mytilus galloprovincialis
Comments:					

Dose-Response Plot



 ToxCalc v5.0.23 Reviewed by:_____

Bivalve Larval Development Test-Proportion Normal

Start Date:	11/12/2023 19:00	Test ID:	PR2194/03	Sample ID:	Adelaide Brine
End Date:	14/12/2023 19:00	Lab ID:	11357	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 106	Test Species:	MG-Mytilus galloprovincialis
Comments:					

Conc-%	Parameter	Auxiliary Data Summary Mean	Min	Max	SD	CV%	N
FSW Control	% Normal	72.25	69.00	76.00	2.99	2.39	4
Diluent Control		73.75	70.00	76.00	2.63	2.20	4
1.6		74.50	71.00	78.00	3.11	2.37	4
3.1		76.25	74.00	78.00	1.71	1.71	4
6.3		71.50	69.00	73.00	1.91	1.94	4
12.5		0.00	0.00	0.00	0.00		4
25		0.00	0.00	0.00	0.00		4
50		0.00	0.00	0.00	0.00		4
100		0.00	0.00	0.00	0.00		4
FSW Control	pH	8.10	8.10	8.10	0.00	0.00	1
Diluent Control		8.10	8.10	8.10	0.00	0.00	1
1.6		8.10	8.10	8.10	0.00	0.00	1
3.1		8.10	8.10	8.10	0.00	0.00	1
6.3		8.10	8.10	8.10	0.00	0.00	1
12.5		8.10	8.10	8.10	0.00	0.00	1
25		8.10	8.10	8.10	0.00	0.00	1
50		8.10	8.10	8.10	0.00	0.00	1
100		8.10	8.10	8.10	0.00	0.00	1
FSW Control	Salinity ppt	35.60	35.60	35.60	0.00	0.00	1
Diluent Control		36.20	36.20	36.20	0.00	0.00	1
1.6		36.30	36.30	36.30	0.00	0.00	1
3.1		37.20	37.20	37.20	0.00	0.00	1
6.3		38.00	38.00	38.00	0.00	0.00	1
12.5		40.00	40.00	40.00	0.00	0.00	1
25		44.00	44.00	44.00	0.00	0.00	1
50		52.30	52.30	52.30	0.00	0.00	1
100		64.90	64.90	64.90	0.00	0.00	1
FSW Control	DO %	99.90	99.90	99.90	0.00	0.00	1
Diluent Control		99.10	99.10	99.10	0.00	0.00	1
1.6		101.50	101.50	101.50	0.00	0.00	1
3.1		100.80	100.80	100.80	0.00	0.00	1
6.3		100.20	100.20	100.20	0.00	0.00	1
12.5		100.20	100.20	100.20	0.00	0.00	1
25		99.50	99.50	99.50	0.00	0.00	1
50		98.60	98.60	98.60	0.00	0.00	1
100		94.80	94.80	94.80	0.00	0.00	1

Bivalve Larval Development Test-Proportion Normal

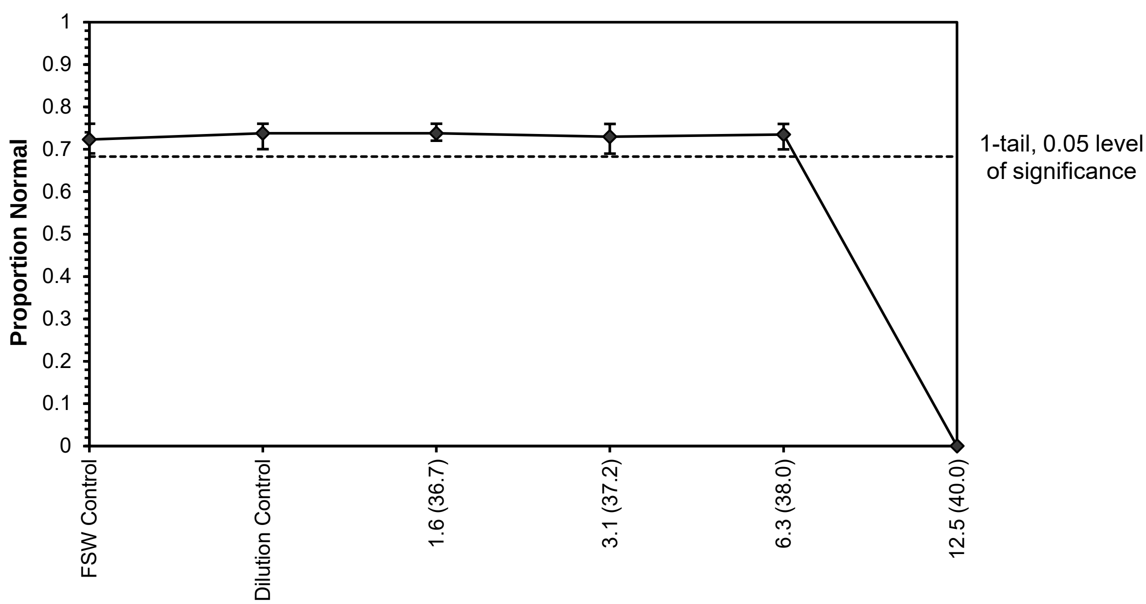
Start Date:	11/12/2023 19:00	Test ID:	PR2194/02	Sample ID:	Controls
End Date:	14/12/2023 19:00	Lab ID:		Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 106	Test Species:	MG-Mytilus galloprovincialis
Comments:					

Conc-	1	2	3	4
FSW Control	0.7600	0.7100	0.6900	0.7300
Diluent Control	0.7600	0.7400	0.7000	0.7500
1.6 (36.7)	0.7300	0.7200	0.7600	0.7400
3.1 (37.2)	0.6900	0.7300	0.7600	0.7400
6.3 (38.0)	0.7300	0.7000	0.7500	0.7600
12.5 (40.0)	0.0000	0.0000	0.0000	0.0000

			Transform: Arcsin Square Root						1-Tailed	
Conc-	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD
FSW Control	0.7225	0.9797	1.0164	0.9803	1.0588	3.298	4	*		
Diluent Control	0.7375	1.0000	1.0332	0.9912	1.0588	2.864	4			
1.6 (36.7)	0.7375	1.0000	1.0330	1.0132	1.0588	1.887	4	-0.857	1.943	0.0377
3.1 (37.2)	0.7300	0.9898	1.0248	0.9803	1.0588	3.216	4	-0.357	1.943	0.0457
6.3 (38.0)	0.7350	0.9966	1.0304	0.9912	1.0588	2.893	4	-0.623	1.943	0.0436
12.5 (40.0)	0.0000	0.0000	0.0500	0.0500	0.0500	0.000	4			

Auxiliary Tests	Statistic		Critical		Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.05)	0.96833		0.887		-0.18657	-0.83312
Bartlett's Test indicates equal variances (p = 0.83)	0.8622		11.3449			
The control means are not significantly different (p = 0.48)	0.75222		2.44691			
Hypothesis Test (1-tail, 0.05)	**MSDu**	**MSDp**	**MSB**	**MSE**	**F-Prob**	**df**
Homoscedastic t Test indicates no significant differences	0.03981	0.05507	0.00022	0.00087	0.86083	3, 12
Treatments vs FSW Control						

Dose-Response Plot



Bivalve Larval Development Test-Proportion Normal

Start Date:	11/12/2023 19:00	Test ID:	PR2194/02	Sample ID:	Controls
End Date:	14/12/2023 19:00	Lab ID:		Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 106	Test Species:	MG-Mytilus galloprovincialis
Comments:					

		Auxiliary Data Summary					
Conc-	**Parameter**	**Mean**	**Min**	**Max**	**SD**	**CV%**	**N**
FSW Control	% Normal	72.25	69.00	76.00	2.99	2.39	4
Diluent Control		73.75	70.00	76.00	2.63	2.20	4
1.6 (36.7)		73.75	72.00	76.00	1.71	1.77	4
3.1 (37.2)		73.00	69.00	76.00	2.94	2.35	4
6.3 (38.0)		73.50	70.00	76.00	2.65	2.21	4
12.5 (40.0)		0.00	0.00	0.00	0.00		4
FSW Control	pH	8.10	8.10	8.10	0.00	0.00	1
Diluent Control		8.10	8.10	8.10	0.00	0.00	1
1.6 (36.7)		8.10	8.10	8.10	0.00	0.00	1
3.1 (37.2)		8.10	8.10	8.10	0.00	0.00	1
6.3 (38.0)		8.10	8.10	8.10	0.00	0.00	1
12.5 (40.0)		8.10	8.10	8.10	0.00	0.00	1
FSW Control	Salinity ppt	35.60	35.60	35.60	0.00	0.00	1
Diluent Control		36.20	36.20	36.20	0.00	0.00	1
1.6 (36.7)		36.60	36.60	36.60	0.00	0.00	1
3.1 (37.2)		37.20	37.20	37.20	0.00	0.00	1
6.3 (38.0)		38.10	38.10	38.10	0.00	0.00	1
12.5 (40.0)		40.10	40.10	40.10	0.00	0.00	1
FSW Control	DO %	99.90	99.90	99.90	0.00	0.00	1
Diluent Control		99.10	99.10	99.10	0.00	0.00	1
1.6 (36.7)		98.90	98.90	98.90	0.00	0.00	1
3.1 (37.2)		99.60	99.60	99.60	0.00	0.00	1
6.3 (38.0)		98.00	98.00	98.00	0.00	0.00	1
12.5 (40.0)		99.60	99.60	99.60	0.00	0.00	1