Appendix K – Marine Assessment

Hunter Water Corporation

Belmont Drought Response Desalination Plant
Marine Environment Assessment Report

November 2019

Executive summary

Overview

The Marine Environment Assessment Report was developed to assess the likely impacts of the future construction and operation of the Belmont Drought Response Desalination Plant (the Project), which is also referred to as the temporary desalination plant, on the marine environment, including threatened species and communities listed under the *Biodiversity Conservation Act 2016* (BC Act 2016), *Fisheries Management Act 1994* (FM Act 1994) and relevant Matters of National Environmental Significance (MNES) listed under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act 1999).

This Marine Assessment Report has been prepared to support the Environmental Impact Statement for the Project. Assessment of the existing marine ecology and potential impacts from the construction and operation of the Project has been completed using a combination of methods, including review of relevant legislation, database searches and review of existing studies and data.

Existing environment

Ambient water quality

Seawater temperature measurements collected from the vicinity of the Belmont WWTW outfall between February and June 2018 showed that water temperatures ranged from 15°C to 23°C; salinity ranged from 32.7 to 36.4 practical salinity units (PSU) for the 20th to 80th percentiles, respectively; and approximately half of the turbidity values exceeded the recommended water quality guideline of 0.5 NTU.

Ammonia (NH_X) generally remained within the recommended guideline value. The average concentrations of nitrogen oxides (NO_X) and total nitrogen and 80th percentile values were both above their respective recommended water quality guidelines. Total phosphorus concentrations on the other hand were within guideline water quality values.

Generally the medians of faecal coliforms and enterococci were lower than respective limits of reporting with average values for both above the 80th percentile due to isolated occurrences of spikes in concentrations.

Groundwater

Water quality sampling of the saline aquifer supply completed late 2018-2019 across a number of events identified that salinity was consistent with ambient seawater quality conditions. Further, levels of potential contaminants within the intake groundwater (e.g. nutrients, metals, faecal coliforms, suspended solids, etc.) were well below those entrained within the effluent stream being discharged from the WWTW outlet.

Substrate and sediment quality

The existing ocean outfall, which has been in place since 1982, provides a hard substrate within an otherwise open area of soft sandy substrate. The soft sediment habitat around the Belmont WWTW outfall is predominantly comprised of sand fractions, rather than larger gravel/cobbles or smaller silt and clay fractions.

Historical sediment quality testing determined that there is no evidence to suggest that the Belmont outfall is a point source for contaminants. Differences in total organic carbon and metals observed between sampling sites were largely attributable to the difference in particle size distribution and were deemed unrelated to the presence or operation of the outfall.

Epibenthic and benthic ecology

A variety of filter feeding organisms have recruited to the Belmont WWTW outfall pipe, such that there is now a locally dense and diverse community established forming a sponge garden. This sponge garden and associated sessile organisms form a diverse biogenic habitat that supports an array of invertebrate and fish species. The soft sediment adjacent to the pipeline supports occasional seapens.

Annual infauna monitoring at the Belmont WWTW outfall showed that assemblages are typically dominated by marine worms and small crustaceans. A few prevalent taxa (Polygordiidae, Phoronidae and Spionidae) were found to vary with increasing distance from the outfall, indicating that effluent discharge has a localised effect on infaunal assemblages in proximity to the point of discharge.

Fish assemblages

Fish assemblages associated with the pipeline include those that are using the structure of sponge gardens as refugia, those that are actively feeding on the sessile organisms, and higher order predators which are attracted to this prey. Species observed include the highly abundant Mado which were ubiquitous across the pipe. The next most commonly observed fish was the Australian Salmon, which were schooling in the water column above the pipe. Less commonly observed fish include the stripey, striped catfish, eastern fortescue, wrasse, gobies, leatherjackets, moray eel, sergeant baker, and Port Jackson shark.

Conservation values

Marine biologically important areas for some of the region's protected species (DoEE, 2015) cover the Project locality, comprising humpback whale migration, shearwater bird foraging, Indo-Pacific/Spotted Bottlenose dolphin breeding and calving and grey nurse shark breeding. Further, the Project is located within a broad area that is designated by the Department of Primary Industries as key fish habitat.

One hundred and forty-two (142) listed threatened species were identified by the BC and FM BioNet as species having the potential to occur within the project area. Of these species the following were identified as potentially occurring in the project area and assessed under the BC Act 2016 assessment criteria: New Zealand fur seal (*Arctocephalus forsteri)* (vulnerable), Southern right whale (*Eubalaena australis*) (endangered 1), dugong (*Dugong Dugon*) (endangered 1), humpback whale (*Megaptera novaeangliae*) (vulnerable), and loggerhead *(Caretta caretta)* (endangered 1) and green turtles (*Chelonia mydas*) (vulnerable).

Schedule 4, 4A and 5 of the FM Act 1994 provides lists of critically endangered, endangered and vulnerable species, populations and ecological communities occurring in NSW. The great white shark (*Carcharodon carcharias*) was identified as potentially occurring in the project area and was thus assessed under the FM Act 1994 assessment criteria as Hawks Nest and Stockton Beach are a known primary residency region for juveniles of the species.

The EPBC Act 1999 Protected Matters Search Tool was used to identify MNES and other matters protected under the EPBC Act 1999 that are predicted to occur in, or relate to the project area. This search identified a number of MNES of relevance to the project and likely to occur within the project area; these have been assessed in accordance with the related Significant Impact Guidelines 1.1 (Commonwealth of Australia, 2013): great white shark, loggerhead, green and hawksbill turtles, southern right whale and humpback whale, dugong and syngnathids.

Impact assessment and management measures

Construction

Given the avoidance of impacting upon dune systems and coastal vegetation combined with the application of standard industry controls for management of release of hazardous and waste materials during construction would be applied, the risk of indirectly impacting the marine environment as a result of the proposed construction work is considered to be as low as reasonably practical.

Commissioning

Commissioning of the facility would occur over an estimated two month period during which raw water and a small percentage of sludge by-product would go to the existing Belmont WWTW inlet works. Transference of this raw water from the intake to the outfall would increase discharge to between 45-50 ML/day compared to an average of 30 ML/day during normal outfall operations. Change in volume of water released at the outfall is not expected to have any influence on the marine environment as long as quality of the raw water released is equivalent to existing conditions at the outfall. The added volume should integrate into surrounding waters with rate of mixing driven by current conditions.

Data indicates that the quality of intake groundwater is within the ranges currently delivered to the receiving environment by the WWTW outlet. Accordingly, as long as raw water conditions are not significantly different during commissioning, the release of additional flow of intake groundwater during the two month testing phase should not have detectable impact upon the marine environment. However, groundwater testing indicates that there are nutrients present in the intake water. Therefore, if nutrient concentrations in raw water are elevated at time of release consideration may need to be given to risk of triggering algal bloom risk at the outfall; depending on extant conditions of the environment and quality of effluent with which raw water would be mixed.

Further to the above, commissioning of the RO plant would require release of pre-treated permeate (desalinated water output from the RO) into the WWTW outfall over a period of two weeks. This activity is likened to release of freshwater into the marine environment similar to that of a stormwater event. As such the release of permeate during this period is not expected to impact on the surrounding waters with a rate of mixing driven by current conditions and reflective of natural variance of ambient conditions.

Operation

Estimates of the discharge, salinity and temperature for the WWTW treated wastewater discharge and the normal full operation capacity of the temporary desalination plant were modelled to understand how operation of the plant may influence the environment from current operations. The assessment gave consideration to potential changes in water quality conditions that would impact upon human health, marine toxicity, ecosystem productivity and salinity. Overall, the key finding from the modelling assessment is that the proposed brine-effluent discharge through the existing diffuser is predicted to have the same or smaller areas of impact (or effect) in terms of human health, ambient salinity and marine ecosystem WQOs. Therefore significant impacts to WQOs are not likely from the proposed brine-effluent discharge.

The current outlet discharge velocity of the WWTW is very low at 0.61 m/s (90th percentile). The corresponding discharge velocity under Normal Full Operation is also predicted to be very low at 0.78 m/s. Further, the current sediment composition of the outfall region is dominated by coarse sands. Therefore, overall changes to sediment composition as a result of operation of the temporary desalination plant are not expected to occur.

Review of the groundwater quality which is planned for extraction/desalination and discharged as brine indicates that levels of metals, nutrients, suspended solids, and faecal coliforms are well below those currently discharged by the WWTW. Therefore, concentrations of potential contaminants in groundwater are not expected to impact on sediment quality by the addition of brine discharge to the effluent.

The local ecology of the region has been influenced by the ongoing presence of the Belmont WWTW outfall and its operation since 1994. As noted above the outfall provides support for a diverse assemblage of biota that is not representative of surrounding biota which is more depauperate. Benthic infauna communities, and epi-benthic pipeline communities are not expected to be impacted by operation of the temporary desalination plant. Flow on effects to higher order taxa such as fish associated with/attracted to the pipeline community are therefore also expected to be negligible.

Decommissioning

Decommissioning of the temporary desalination plant would reinstate flow levels and water quality at the Belmont WWTW outfall location to pre-desalination conditions. Established marine communities in the vicinity and on the outfall are not expected to be impacted by these changes in conditions.

Onshore decommissioning activities of the plant and any associated infrastructure are not expected to impact on the nearby marine environment as long as appropriate buffer distances and waste management practices are implemented.

Significant impact assessment of threatened species

State assessment

The potential to significantly impact on species identified within the Project area has been assessed on the basis that the identified management and mitigation controls. The assessment was conducted against the BC Act 2016 and FM Act 1994 and considered Threatened Species Assessment Guidelines (Department of Environment and Climate Change (DECC), 2013).

The great white shark listed under the FM Act 1994 and EPBC Act 1999 as threatened, was categorised as being likely to occur within the project outfall area. The Project has been assessed as unlikely to have significant impact on this species under the FM Act 1994 through all phases of work. The proposed works are considered to have a low impact risk on the marine environment.

The six marine species listed under the BC Act 2016 and EPBC Act 1999 as threatened were categorised as being likely to occur within the project outfall area. On the basis of the assessment in operational activities of the plant have been assessed as unlikely to have significant impact on any threatened species under the BC Act 2016 through all phases of work.

Commonwealth assessment

The potential to significantly impact on MNES identified within the project area has been assessed on the basis that the proposed works are considered to be of low impact to the marine environment. The assessment was conducted against the EPBC Act Significant Impact Assessment Guidelines 1.1 (DoEE, 2013).

One Commonwealth protected species Hawksbill turtle (*Eretmochelys imbricata*) that is not protected by State legislation was identified as likely to occur from the assessment. This species was fully assessed following the EPBC Significant Impact Guidelines The results of this assessment indicate that this Project is unlikely to have significant impact on MNES across all phases of the Project.

Summary of management and mitigation measures

The following measures are proposed as management and mitigation measures of relevance to the marine ecology:

- Standard industry obligations such as spill prevention and management measures and the implementation of standard guidelines for the onshore storage and management of waste and hazardous materials during construction, operation and decommissioning.
- Continuation of the Ocean Outfall Monitoring Program (EPL 1771) throughout operation of the project including benthic infauna and sediment quality testing.
- Mitigation measures as outlined in the Construction Environmental Management Plan (CEMP) (refer to Section 8 of the EIS).

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1. Introduction

1.1 Overview

The Lower Hunter has sufficient water to meet its needs in average climate conditions in the medium term. However, the region's reliance on rain-fed dams and groundwater supplies makes it vulnerable to severe drought.

The Lower Hunter Water Plan (LHWP) was developed in 2014 with the aim to ensure that the Lower Hunter is able to withstand a severe drought as well as meeting community needs in the medium term. Within the plan, desalination is proposed in conjunction with other staged drought response measures in the event of an extreme drought. A drought response desalination plant would help make the water supply system more resilient to climate variability, with the primary benefit being that it would provide a drought contingency measure that is not dependant on rainfall.

Following a number of options assessments, a drought response desalination plant (also referred to as the temporary desalination plant) to be located within the existing wastewater treatment works site at Belmont was selected as the preferred option. Hunter Water submitted a State Significant Infrastructure (SSI) application for the Project to the Department of Planning and Environment in November 2017 and received the Secretary's Environmental Assessment Requirements (SEARs) in December 2017 (SSI 8896). These SEARs outline the requirements for the preparation of an Environmental Impact Statement (EIS) to assess the future construction and operation of the Project, with particular requirements for the assessment of the marine environment.

1.2 Purpose and scope of this report

This Marine Assessment Report has been prepared as a supporting document to the EIS. The purpose of this report is to assess the likely impacts of the future construction and operation of the proposal on the marine environment, including threatened species and communities listed under the *Biodiversity Conservation Act 2016* (BC Act), *Fisheries Management Act 1994* (FM Act) and relevant Matters of National Environmental Significance (MNES) listed under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The scope of this report is limited to assessment of the marine environment; terrestrial and other aquatic/estuarine biodiversity values are covered within the Biodiversity Development Assessment Report (BDAR) for the Project (GHD, 2019a).

1.3 Secretary's Environmental Assessment Requirements

Hunter Water submitted an SSI application for the proposal with the Department of Planning and Environment (DPE) in November 2017 and received SEARs in December 2017. A revised SEARs was issued following comment and discussed between Hunter Water and DPE on 24 January, 2018. The SEARs relevant to the marine environment issues are reproduced in Table 1-1.

Table 1-1 SEARs (SSI 8896) – Marine environment

Key issues	Requirements	Relevant section
Water Quality	An assessment of the proposed development on the water quality at the outfall, including detail of dispersion in various flow scenarios and during varied tides	Section 5.2.1 of this report and Section 4 in the Brine Discharge Modelling report.
Aquatic ecology (only marine)	A description of the aquatic and riparian habitats adjacent to the development site	Section 5 of this report and Section 6 of the BTDP BDAR report.
	An analysis of any interactions of the proposed development with aquatic and riparian environments and predictions of any impacts upon these environments	Section 6 of this report and Section 8 of the BTDP BDAR report.
	Details of proposed buffer distances between the development and adjacent aquatic and riparian habitats	Section 1.3 of the BTDP BDAR report
	Details of the mitigation measures for potential impacts to marine vegetation and key fish habitats, including water quality impacts, to be implemented during the construction and operation of the proposed development.	Section 6 of this report and Section 8 of the BTDP BDAR report.

1.4 Disclaimer

This report has been prepared by GHD for Hunter Water Corporation and may only be used and relied on by Hunter Water Corporation for the purpose agreed between GHD and the Hunter Water Corporation as set out in Section 1.2 of this report.

GHD otherwise disclaims responsibility to any person other than Hunter Water Corporation arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report. GHD disclaims liability arising from any of the assumptions being incorrect.

The opinions, conclusions and any recommendations in this report are based on information obtained from, and testing undertaken at or in connection with, specific sample points. Site conditions at other parts of the site may be different from the site conditions found at the specific sample points.

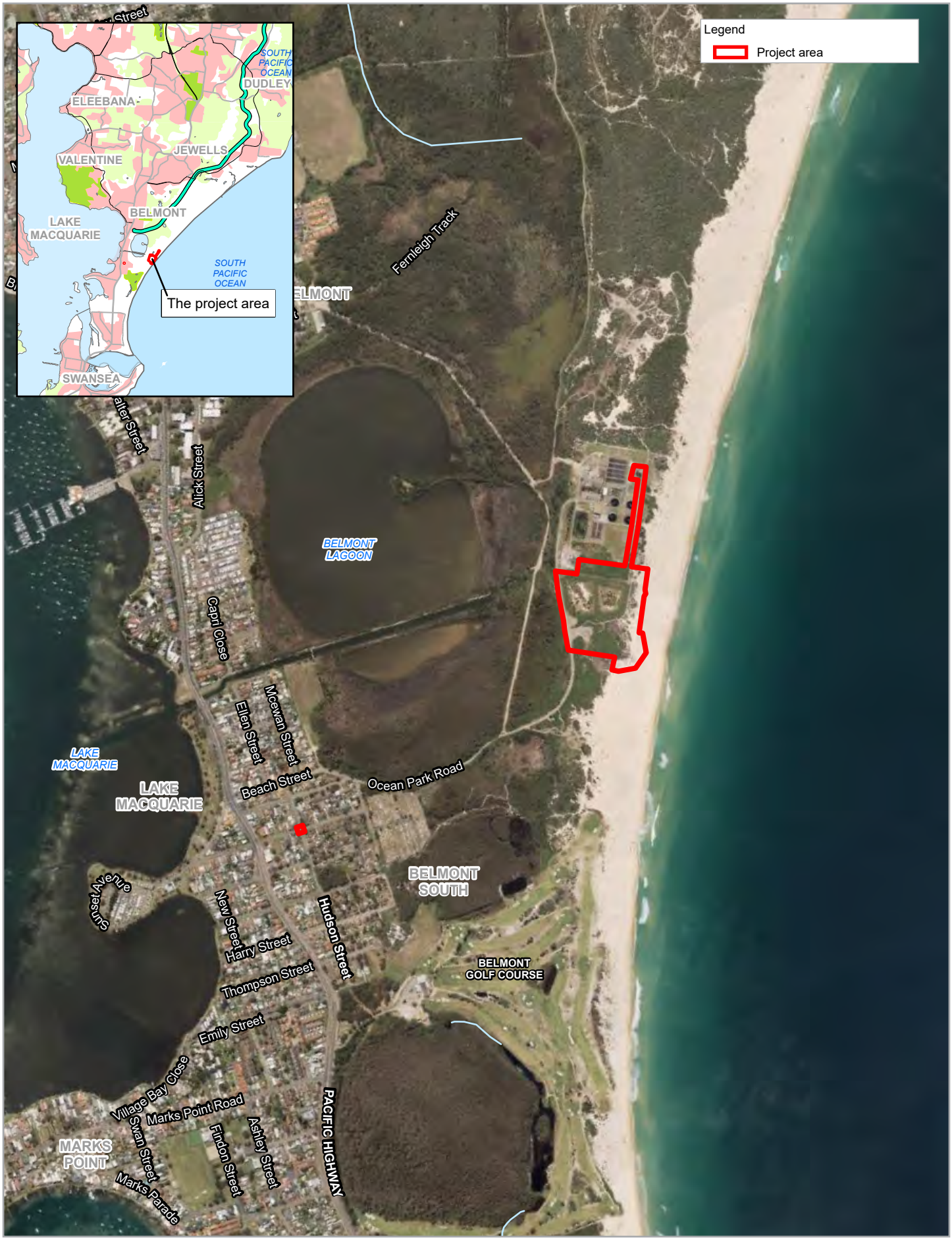
Investigations undertaken in respect of this report are constrained by the particular site conditions, such as the location of buildings, services and vegetation. As a result, not all relevant site features and conditions may have been identified in this report.

Site conditions may change after the date of this Report. GHD does not accept responsibility arising from, or in connection with, any change to the site conditions. GHD is also not responsible for updating this report if the site conditions change.

2. The Project

2.1 Project location

The Belmont drought response desalination plant is proposed to be located on the southern portion of the current wastewater treatment works (WWTW) site, on the boundary of Belmont and Belmont South, off Ocean Park Road. The proposed plant is just east of the Belmont Lagoon and west of the coastal dunes along Nine Mile Beach (Figure 2-1).



Paper Size ISO A4

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Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

Hunter Water Corporation
Belmont Temporary Desalination Plant
Marine Environment Assessment Report

Project No. **22-19573**
Revision No. **0**
Date **10/10/2019**

Project location

FIGURE 2-1

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2.2 Project description

2.2.1 Objectives

The key objectives of the Project are to:

- Provide a rainfall independent water source in the event of an extreme drought
- Slow the depletion of existing water storages in the event of an extreme drought

The Project would address these objectives while considering the environmental, social and economic impacts, with the options assessment process considering these factors.

2.2.2 Key features

The Project is for the construction and operation of a drought response desalination plant, designed to produce up to 15 ML/day of potable water, with key components including:

- Seawater intake – The central intake structures would be concrete structures (referred to as a caisson) of approximately nine to 11 m diameter, installed to a depth up to 20 m below existing surface levels. The intake structures will be finished above the existing surface (0.5 m to 1 m) to prevent being covered by dune sands over time. The raw feed water (seawater) input is proposed to be extracted from a sub-surface saline aquifer. This would be extracted by intake pipes located approximately eight to 15 m below ground level radiating out from the central structure. Pipelines and pumps are required to transfer the seawater to the desalination plant.
- Water treatment process plant – The water treatment process plant would comprise a range of equipment potentially in containerised form. Services to and from the process equipment (e.g. power, communications, and raw feed water (seawater)) would comprise a mix of buried and aboveground methods. The general components of the water treatment process would comprise:
  - *Pre-treatment:* a pre-treatment system is required to remove micro-organisms, sediment, and organic material from the seawater.
  - *Desalination:* a reverse osmosis (RO) desalination system made up of pressurising pumps and membranes. These would be comprised of modular components. In addition, a number of tanks and internal pipework would be required.
  - *Post treatment:* desalinated water would be treated to drinking water standards and stored prior to pumping to the potable water supply network.
- Brine disposal system – The desalination process would produce around 28 ML/day of wastewater, comprising predominantly brine, as well as a small amount of pre-treatment and RO membrane cleaning waste. The waste brine from the desalination process would be transferred via a pipeline to the existing nearby Belmont WWTW for disposal via the existing ocean outfall pipe.
- Power supply – Power requirements of the plant would be met by a minor upgrade to the existing power supply network in the vicinity of Hudson and Marriot Streets. A power line extension from the existing line along Ocean Park Road into a new substation within the proposed drought response desalination plant would also be required.
- Ancillary facilities – including a tank farm, chemical storage and dosing, hardstand areas, stormwater and cross drainage, access roads, and fencing, signage and lighting.

Key features of the Project are shown on Figure 2-3 while a description of each of the key components of the Project is provided in Section 4 of the EIS.

The potable water pipelines connecting the Project to the potable water network do not form part of the Project and would be constructed separately. The construction and operation of the potable water pipeline would be part of a separate design and approvals process.

3. Methodology

A desktop assessment has been undertaken to inform the existing legislative framework and environmental conditions relevant to marine ecology associated with the WWTW outfall. Relevant legislation, databases, searches, historical studies and more recent Project related modelling and surveys were reviewed in support of this assessment and to understand potential impacts from the construction and operation of the Project on the marine environment.

3.1 Review of relevant legislation

State and Commonwealth environmental legislation of relevance to the Project was identified and reviewed. This included the following:

- *Environmental Planning and Assessment Act 1979* (EP&A Act 1979)
- *Fisheries Management Act 1994* (FM Act 1994)
- *Biodiversity Conservation Act 2016* (BC Act 2016)
- *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act 1999)

3.2 Review of databases and searches

A database review was undertaken to identify threatened marine ecology (flora and fauna) species, populations and ecological communities (biota) listed under the FM Act 1994, BC Act 2016 and EPBC Act 1999, which could be expected to occur in the vicinity of the WWTW outfall. This review considered previous records, known distribution ranges, and habitats present. Resources pertaining to the project area and locality (i.e. within a 10 km radius of the site) that were reviewed included:

- Office of Environment and Heritage (OEH) BioNet Atlas (licensed) for records of threatened species, populations and endangered ecological communities listed under the BC Act 2016 and FM Act 1994 that have been recorded within the project area (OEH, 2019), http://www.bionet.nsw.gov.au/.
- Department of the Environment and Energy (DoEE) Protected Matters Search Tool (PMST), for Matters of National Environmental Significance (MNES) by the EPBC Act 1999 predicted to occur in the locality, http://www.environment.gov.au/webgis-framework/apps/pmst/pmst.jsf.
- DoEE online species profiles and threats database, https://www.environment.gov.au/cgi-bin/sprat/public/sprat.pl.

3.3 Review of previous marine ecology reports

3.3.1 Belmont Outfall Marine Reports

A number of previous marine studies have been conducted to review and assess the conditions of the marine environment at the Belmont WWTW Outfall, its surrounds and relevant reference locations. Previous studies listed in Table 3-1 were reviewed to evaluate existing marine environment conditions at the outfall.

Table 3-1 Previous marine ecology studies at Belmont WWTW outfall

Title	Author and year of study	Scope
Belmont WWTW Review of Environmental Factors	Patterson Britton and Partners, 2003	Review of habitat around the Belmont Outfall plus a 66 m seaward for a potential extension.
Belmont WWTW Infauna and Sediment Studies	BioAnalysis, 2006 – 2007	Benthic biodiversity and sediment quality investigations as part of a broader study for Boulder Bay, Burwood Beach and Belmont WWTWs.
Belmont WWTW Ocean Outfall Benthic Survey of Infauna and Marine Sediments	Advisian, 2016- 2019	Sediment and infauna sampling at the outfall has been undertaken annually from 2016-now; and will be continued until 2021 as part of Environmental Protection Licence (EPL) monitoring requirements for a Pollution Reduction Scheme (PRS). The study comprises a gradient style design with 12 sites located to the north and south of the Belmont Ocean Outfall diffusers at varying distances (outfall - 5 m, 20 m, 100 m, 200 m, 500 m and reference sites – > 2 km; Redhead and Swansea Heads).

3.3.2 Burwood Beach Marine Environmental Assessment Program

The Burwood Beach Marine Environment Assessment Programs (MEAPs) were undertaken in 2011-2013 and 2017 – 2019 (ongoing). Burwood WWTW is approximately 12 km north from Belmont WWTW and comprises a separate WWTW owned by Hunter Water with a corresponding ocean outfall. Ongoing marine environmental monitoring is undertaken at the Burwood WWTW outfall, which includes reference sites for comparison. Given the relatively close proximity of the Burwood WWTW outfall to the Belmont WWTW outfall, some of the results of the monitoring program were utilised to review ambient marine environmental conditions.

The scope of the marine environmental assessment program at Burwood WWTW comprises:

- Ecotoxicology
- Fish Ecology (2011-2013)
- Infauna ecology
- Reef ecology
- Sediment contamination
- Water quality
- Seafood contamination

With the exception of the fish ecology study, all studies have been undertaken in 2011-2013 and 2017-2019.

Importantly, the Burwood WWTW outfall discharges biosolids in addition to effluent, while Belmont WWTW discharges effluent only. As such, some of the at-outfall assessments focussing on less mobile elements were not reviewed or considered in relation to Belmont outfall ambient conditions due to the impact that the biosolids could have on the environment there.

Water quality at the Burwood reference locations was the key parameter reviewed in relation to this assessment. Ambient seawater quality was characterised on the basis of quarterly measurements during July 2011-April 2013 and August 2017-July 2018 of surface and mid-water samples at four (4) reference sites. These reference sites are about 2 km from the Burwood WWTW outlet and about 10 to 14 km from the Belmont WWTW outfall; they characterise ambient seawater conditions and are not impacted by the Burwood outfall.

3.3.3 Belmont WWTW Outfall videos

Gray Diving Services were commissioned by Hunter Water to clean biofouling from the diffusers along the Belmont WWTW outfall pipe in December 2018. The process was recorded using head mounted cameras; footage from the works was reviewed as part of the marine environmental assessment to evaluate the epi-benthic ecology and fish assemblages that are present on and around the outfall.

3.3.4 Other general literature review

In addition to specific studies completed for Hunter Water in vicinity of the Belmont and Burwood WWTWs, a general review of available literature and databases was conducted to assess the broader marine environment of the area. Some of the key resources reviewed include:

- Seabed habitat mapping of the continental shelf of NSW (Department of Environment, Climate Change and Water NSW, 2010)
- National Conservation Values Atlas (DoEE, 2015)
- New South Wales State of the Environment 2018 (EPA, 2018)
- Marine bioregional plan for the Temperate East Marine Region (Department of Sustainability, Environment, Water, Population and Communities, 2012)
- Department of Primary Industries factsheets and spatial datasets

3.4 Review of EIS relevant modelling and surveys

3.4.1 Brine discharge modelling

To inform the potential to impact upon the marine environment from the Project, brine discharge modelling was completed. This has been used to simulate and assess dispersion of the existing WWTW discharge with the additional brine from the proposed temporary desalination plant. Model simulations were conducted for existing conditions (WWTW discharge only) and post-project conditions (WWTW discharge, plus brine discharge) for two desalination plant capacities and under a range of meteorological and WWTW discharge flow rate conditions. The key objective of the modelling was to assess the post-project conditions against set water quality objectives, which were based on existing EPL conditions, relevant marine water quality guidelines and trigger values, ambient water quality and existing pre-project conditions.

The modelling report was reviewed to inform the assessment of potential impacts of the Project on the marine environment. The full modelling report with detailed methodology is provided in the Brine Discharge Modelling report (GHD, 2019b).

3.4.2 Ocean data

Ocean data was collected by Oceanographic Field Services Pty Ltd using thermistor strings (co-located with acoustic doppler current profilers) at the Belmont outfall location between 14 February 2018 to 11 April 2018 and 24 April 2018 to 27 June 2018. Water temperature data was recorded at two m intervals between 2 and 16 m above the seabed, which was approximately 25 m deep. Sub-sampled water temperatures were then reviewed to assess existing environmental conditions of the area and inform the brine discharge modelling.

The complete ocean data is provided in Section 7.4.2 of the EIS Report.

3.4.3 Groundwater data

To inform the potential to impact upon the marine environment from the Project, groundwater testing was conducted. Groundwater data was collected by GHD across eight (7) sampling events between October 2018 and May 2019. Groundwater samples were analytically tested for a range of parameters including salinity, ammonia, nitrogen oxides, total nitrogen, total phosphorous, faecal coliforms, enterococci, copper, lead, zinc and turbidity.

The key objective of the sampling was to compare the groundwater quality to the ANZECC and ARMCANZ 2000 water quality guidelines and the outlet pipe water quality. This would then inform the potential impacts of pumping groundwater directly to the outfall pipe (without treatment from the WWTW) on the marine environment.

A more detailed investigation into the groundwater relevant to the Project is provided in Section 7.2 of the EIS Report and the Groundwater Assessment report (GHD, 2019c).

4. Statutory context

4.1 New South Wales legislation

4.1.1 *Environmental Planning and Assessment Act 1979*

The *Environmental Planning and Assessment Act 1979* (EP&A Act 1979) is the primary legislation regulating land-use planning and development assessment in New South Wales (NSW). As described in the EIS, the proposal is declared to be State Significant Infrastructure in accordance with Section 5.12 of the EP&A Act 1979. Part 5, Division 5.2 provides for the assessment of State significant infrastructure, which must be approved by the Minister for Planning.

In addition, Section 5.7(1) of the EP&A Act 1979 states that an EIS must be prepared for an activity likely to significantly affect the environment. A determining authority (such as Hunter Water) shall not carry out an activity or grant an approval in relation to an activity that is likely to significantly affect the environment, prior to the approval of an EIS by the Minister for Planning.

This report comprises the marine environment assessment that forms part of the Project EIS. SEARs issued by the Minister for Planning for the EIS set out the minimum assessment requirements, which have been addressed herein in respect of potential impacts upon the marine environment (see Section 1.3).

4.1.2 *Fisheries Management Act 1994*

The *Fisheries Management Act 1994* (FM Act 1994) aims to conserve, develop and share the fishery resources of the state for the benefit of present and future generations. It provides legal status for aquatic and marine biota of conservation significance in NSW (including fish species and ecological communities), and makes provision for the protection of key fish habitat, marine vegetation, and fish passage by regulating developments and activities through obtaining permits and/or undertaking consultation with the NSW Department of Primary Industry (DPI).

Schedule 4, 4A and 5 of the FM Act 1994 provides lists of critically endangered, endangered and vulnerable species, populations and ecological communities occurring in NSW. Those of relevance to the Project have been identified and assessed under the FM Act 1994 assessment criteria for likelihood of occurrence within project area in Section 5.2.6 and Appendix B.

4.1.3 *Biodiversity Conservation Act 2016*

The *Biodiversity Conservation Act 2016* (BC Act 2016) aims to conserve biodiversity at a bioregional and state scale and lists a number of threatened species, populations and ecological communities to be considered in deciding whether there is likely to be a significant impact on threatened biota, or their habitats.

Schedule 1 of the BC Act 2016 provides lists of critically endangered, endangered, vulnerable species and populations occurring in NSW. Those of relevance to the Project have been identified and assessed under the BC Act 2016 assessment criteria for likelihood of occurrence within the project area (refer to Section 5.2.6 and Appendix A).

4.2 Commonwealth legislation

The purpose of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act 1999) is to ensure that actions likely to cause a significant impact on MNES or the environment of Commonwealth land undergo an assessment and approval process.

Under the EPBC Act, an action includes a proposal, a development, an undertaking, an activity or a series of activities, or an alteration of any of these things. An action that 'has, would have or is likely to have a significant impact on a matter of national environmental significance' or a significant impact to the environment of Commonwealth land is deemed to be a 'controlled action' and may not be undertaken without prior approval from the Australian Minister for the Environment.

Consideration of potential impacts upon listed threatened species and communities and any other MNES potentially impacted by the Project has been undertaken as part of the EIS (refer to Section 5.2.6 and Appendix C). The Project is not considered likely to have a significant impact on MNES, therefore the Project has not been referred to the Minister under the EPBC Act 1999.

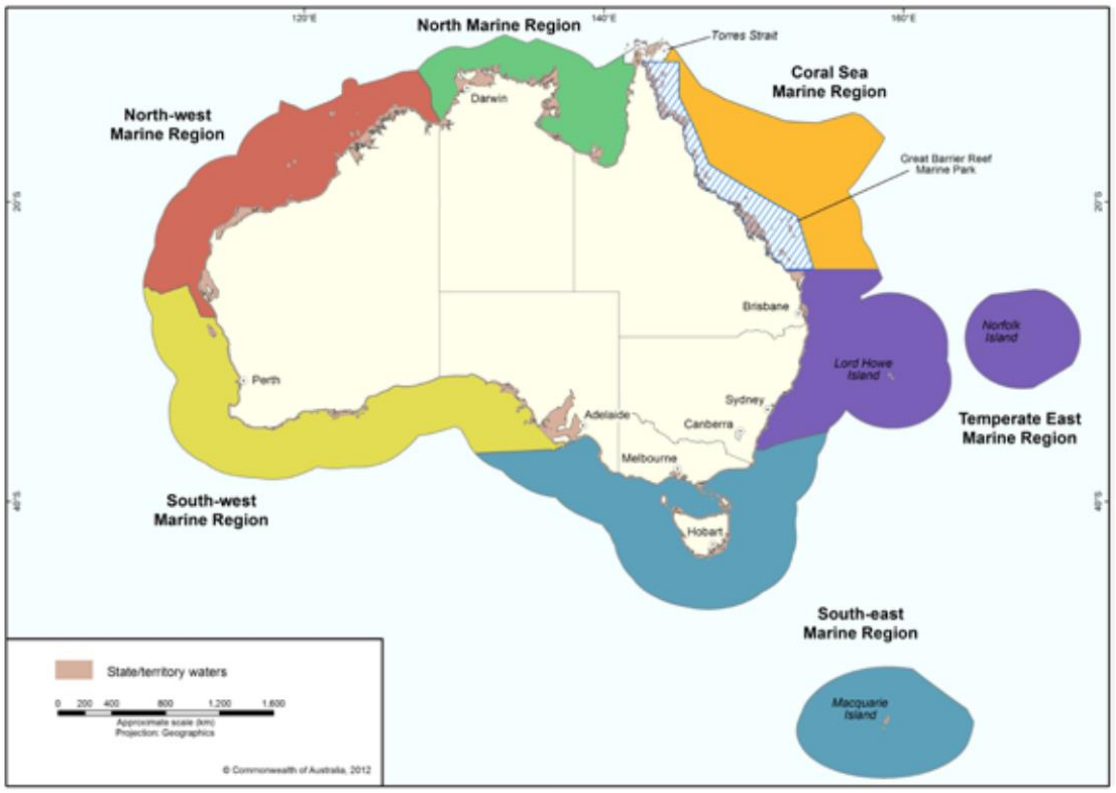
5. Existing environment

A description of the broader NSW marine environment is provided in Section 5.1 for context, while the marine environment of the Project locality is discussed in Section 5.2.

5.1 NSW marine environment

Overall, the water quality and ecosystem health of the NSW marine and coastal environment is considered to be good (EPA, 2018). Most coastal, estuarine, and marine systems in NSW have been modified to some extent, and they continue to come under increasing pressure from coastal development. The coastal, estuarine and marine waters of NSW contain high levels of biodiversity because of their wide range of oceanic, shoreline and estuarine habitats, combined with the strong influence of both subtropical and temperate currents (EPA, 2018).

The majority of the NSW coastline and marine environment is within the Temperate East Marine Region (Figure 5-1), which is characterised by a narrow continental shelf, significant variation in sea-floor features (including seamount chains and canyons), dynamic oceanography, and a unique mix of tropical and cold water reef systems. The region supports high levels of species richness and diversity, particularly among corals, crustaceans, echinoderms, molluscs, sea sponges and fish. Due to the latitudinal range of the region, this diversity includes both tropical and temperate species (Department of Sustainability, Environment, Water, Population and Communities, 2012).



Source: Department of Sustainability, Environment, Water, Population and Communities (2012)

Figure 5-1 Australia's Marine Regions

5.1.1 Central NSW marine environment

The extent, distribution and structure of reef and unconsolidated habitats within the central NSW region reflects the patterns of bedrock geology, geological history, coastal inputs and sediment transport. Seabed mapping of the continental shelf of NSW (DECCW, 2010) found that there was evidence of a considerable amount of shallow nearshore reef along the coast between Newcastle and Broken Bay, particularly around the Newcastle, Swansea, Catherine Hill Bay, Norah Head, The Entrance, Wamberal and Terrigal regions. Most of the reef is shallow and continuous to the shore from 200 m up to about 1.8 km offshore. Within and immediately adjacent to the numerous rocky reef complexes, the unconsolidated habitats consist mostly of a combination of fine and coarse sand. The coarse sand tends to dominate the large areas between the reef systems and finer sand occurs further from the reef edge, although this is not the consistent pattern across the region. From Newcastle south, the majority of the coastline contains subtidal reef which is broken up by small areas of ocean beaches such as Nine Mile Beach (DECCW, 2010). Overall, it is likely there are large areas of reef yet to be mapped within the central region (DECCW, 2010).

The distribution of benthic communities in the NSW region reflects the presence of shallow, intermediate or deep reefs. Shallow continuous reef habitats are dominated by urchin barrens, turf and ascidian habitat. A diverse range of sponges and other sessile invertebrates are also common on the shallow reefs. Intermediate reefs generally contain a mosaic of erect, massive, branching and encrusting sponges, and other sessile filter feeders such as bryozoans and gorgonians (DECCW, 2010).

5.1.2 Redhead marine environment

Redhead is situated approximately 6 km north of the Project. Whilst not directly related to the Project site, Redhead has been used as a reference location for both the long term Marine Environmental Assessment Program at Burwood Beach and the benthic infauna and sediment investigations at the Belmont outfall. Redhead presents a similar sandy environment to the Project locality which may benefit additional understanding of the marine environment at Belmont. Further description of the Redhead marine environment is provided in the relevant sections following.

5.2 Project locality

5.2.1 Seawater quality

Temperature

Seawater temperature measurements collected from the vicinity of the Belmont WWTW outfall between February and June 2018 showed that water temperatures ranged from a minimum of 15-16°C to a maximum of 22-23°C. Weakly thermally stratified to well-mixed conditions through the water column typically occur from late autumn to start of winter (May-June) and spring (October). During late spring (November) to early autumn (April), the temperature difference between 2 m and 17 m above the seabed can exceed 3°C for brief periods, but typically are less than 3°C, interspersed with periods of relatively uniform temperature through the water column (refer to Brine Discharge Modelling report (GHD, 2019b) for further details).

Several cooling events were identified in February 2018 where the temperatures rapidly decreased from 21-22 °C to 15-16 °C. These cooling events are likely due to persistent north-easterly winds that drive the surface layer (about 30 m) of the ocean offshore due to the Coriolis force, which causes upwelling of colder, more nutrient-rich water to the surface. Further, a topographic driven back-eddy to the south of Port Stephens in the lee of the East Australian Current is known to cause upwelling events of cooled water (Lee *et al*., 2007). These cooling events are short-lived.

In summary, the thermal stratification dynamics of the nearshore waters in proximity to the outlet (diffuser) undergo relatively brief periods of temperature stratification from mid-spring to mid-autumn interspersed with mixing events that yield relatively isothermal conditions. During mid-autumn to mid-spring, isothermal to weakly stratified conditions are the norm.

Ambient seawater quality

Ambient seawater quality samples were collected from surface and mid-water at four reference sites (WQ29-WQ32) located approximately 2 km from the Burwood WWTW outfall (12 km from the Belmont WWTW outfall). Seawater quality for 11 parameters collected across quarterly measurements during July 2011-April 2013 (Worley Parsons, 2014) and August 2017-July 2018 (Burwood Beach Marine Environmental Assessment Program 2017-2019) are summarised in Table 3-3 in the Brine Discharge Modelling report (Appendix L - GHD, 2019b). In summary, the findings were as follows:

- Salinity was relatively variable, ranging from 32.7 to 36.4 practical salinity units (PSU), with a median of 35.63 PSU.
- The median of ammonia (NH_X) was below limit of reporting 0.005 mg/L, and below the recommended guideline value.
- Concentrations of nitrogen oxides (NO_X) varied quite considerably, with the median lower than the recommended water quality guideline of 0.025 mg/L.
- Total nitrogen concentrations were relatively high, with the median exceeding the recommended water quality guideline of 0.120 mg/L.
- Total phosphorus concentrations were below guideline water quality values.
- The medians of total copper, lead and zinc were lower than their respective laboratory limits of reporting and corresponding water quality guidelines.
- The medians of faecal coliforms and enterococci were lower than respective limits of reporting (<1 colony forming units/100 ml), and below the guideline for enterococci.
- The median turbidity of 0.5 nephelometric turbidity units (NTU) was within the recommended water quality guideline range of 0.5-10 NTU.

Table 5-1 Ambient seawater quality descriptive statistics for Burwood WWTW from data collected 2011-2013 and 2017-2018

Parameter	Unit	20th percentile	Median	80th percentile	Average	Water quality guideline
Salinity	PSU	32.65	35.63	36.36	34.94	-
Ammonia (NH_X)	mg/L	<0.005	<0.005	0.009	0.008	0.015[1]
Nitrogen oxides (NO_X)	mg/L	<0.001	0.005	0.049	0.055	0.025[1]
Total nitrogen	mg/L	0.079	0.121	0.334	0.215	0.120[1]
Total phosphorus	mg/L	<0.005	0.005	0.012	0.007	0.025[1]
Faecal coliforms	CFU/ 100 mL	<0.5	<1	<1	5.1	
Enterococci	CFU/ 100 mL	<1	<1	3	7.8	≤40 (very good)[2] 41-200 (good)[2]
Total copper	mg/L	<0.001	<0.001	<0.001	-	0.0013[3]
Total lead	mg/L	<0.0002	<0.0002	0.0006	-	0.0044[3]
Total zinc	mg/L	<0.005	<0.005	0.01	-	0.015[3]
Turbidity	NTU	0.2	0.5	2.7	7.8	0.5-10[1]

Red text indicates values above guideline value
[1] ANZECC & ARMCANZ (2000) default marine trigger values (DTV) for the marine waters of south-east Australia
[2] NHMRC (2006) Beach Watch Guidelines for recreational waters - 95th percentile
[3] ANZECC & ARMCANZ (2000) Marine toxicant trigger values (MTTV) for a 95% species protection level

In general, low nutrient, metals and pathogen levels characterise the ambient seawater quality in the locality of Burwood WWTW, although occasional events of elevated total nitrogen, nitrites and nitrates occur. These are suspected to be related to upwelling events at the reference locations (Worley Parsons, 2014). The concentrations were determined to be temporally variable (i.e. change over time, often day to day), which is relatively common in marine water quality. It was noted that the daily variability seen in the water quality could be due to natural variation (e.g. currents, tides, upwelling etc.), particularly given the nutrient rich eddies that form from the East Australian Current, which are known to be seasonal (Worley Parsons, 2014). However, elevated values could also potentially be due to alternative sources such as terrestrial runoff, effluent from the WWTW or other natural processes (Worley Parsons, 2014).

Fluctuations in nutrient concentrations of coastal waters (either of natural or anthropogenic origin) can lead to changes in species composition and abundance of microalgae, which can result in algal blooms that threaten fish resources, human health, ecosystem function and recreational amenity (Ajani *et al*., 2001). Algal blooms (both harmless and harmful species) have been recorded along the Newcastle/Lake Macquarie coastline and have resulted in temporary beach closures, although marine and estuarine blooms would often move with the wind and tides so the source is generally unknown (WaterNSW, 2019). The nearest beaches to the Project area that are monitored as part of the Beachwatch programme were graded as good and very good for Redhead Beach and Blacksmiths Beach, respectively (OEH, 2018). Water quality at these sites was noted as suitable for swimming most of the time, but was occasionally impacted by stormwater pollution following rainfall.

Belmont WWTW Outlet water quality

Weekly measurements of total reduced inorganic nitrogen (ammonia + ammonium or NH_X=NH_4+NH_3), total suspended solids (TSS), total phosphorus (TP), total oxidised inorganic nitrogen (nitrate+nitrite or NO_x=NO_3+NO_2), enterococci (E), copper (Cu), lead (Pb) and zinc (Zn) in effluent are collected at the Belmont WWTW outfall. A descriptive statistical summary of these parameters is provided in Table 3.2 in the Brine Discharge Modelling report (GHD, 2019b).

General observations of the WWTW effluent quality include:

- NH_X is generally low (<1 mg/L up to 90th percentile) though elevated levels occurred for a prolonged period from January-February 2018, which resulted in a substantially greater average of 0.29 mg/L than the median of 0.05 mg/L.
- NO_X generally ranged from 5-10.5 mg/L (10th-90th percentiles) with an average and median of 8.0 mg/L and 8.1 mg/L, respectively.
- TN generally ranged from 6.5-13.5 mg/L (10th-90th percentiles) with an average and median of 10.0 and 9.8 mg/L, respectively.
- TP generally ranged from 1.5-3.5 mg/L (10th-90th percentiles) with an average and median of 2.6 mg/L.
- TSS generally ranged from 2-21 mg/L (10th-90th percentiles) with an average and median of 11.6 mg/L and 10.0 mg/L, respectively.
- E generally ranged from 594-1,622 MPN/100 ml (10th-90th percentiles) with an average and median of 1,065 MPN/100 ml and 938 MPN/100 ml, respectively.
- Cu generally ranged from 0.9-4 mg/L (10th-90th percentiles) with an average and median of 2.4 mg/L and 2.2 mg/L, respectively.
- Pb generally ranged from 0.1-0.59 mg/L (10th-90th percentiles) with an average and median of 0.25 mg/L and 0.1 mg/L, respectively.
- Zn generally ranged from 2-21 mg/L (10th-90th percentiles) with an average and median of 38.2 mg/L and 29.5 mg/L, respectively.

Table 5-2 WWTW final effluent water quality descriptive statistics

Parameter and unit	Units	20th percentile	Median	80th percentile	Average
Ammonia (NH_X)	mg/L	0.02	0.05	0.14	0.29
Nitrogen oxides (NO_X)	mg/L	6.30	8.10	9.80	8.00
Total nitrogen	mg/L	7.80	9.80	11.90	10
Total phosphorus	mg/L	1.90	2.60	3.20	2.62
Enterococci[1]	MPN[2]/ 100 mL	761	938	1,390	1,065
Total copper	mg/L	1.20	2.20	3.30	2.40
Total lead	mg/L	0.10	0.10	0.30	0.25
Total zinc	mg/L	27.60	29.50	43.40	38.20
Total suspended solids	mg/L	5	10	17	11.60

[1] Enterococci data from 17-19 December 2001, 16-17 January 2002, 25-26 February 2002, and 6 & 11 May 2019.
[2] Most probable number.

5.2.2 Groundwater characteristics

A description of groundwater data collected across seven sampling events between October 2018 and May 2019 is provided below to inform assessment potential impacts of discharging raw groundwater into the marine environment during project commissioning phase (Table 5-3). Monitoring wells were installed across the Project site with three wells near the proposed intakes, four wells across the plant area and one well located up-gradient of the plant area. A more detailed investigation of the groundwater relevant to the Project is provided in Section 7.2 of the EIS Report and Groundwater Assessment report (GHD, 2019c).

To understand the potential for impact on receiving waters associated with release of untreated groundwater during commissioning, a comparison against ANZECC 2000 guideline values has been undertaken. In summary, the findings were as follows:

- Faecal coliforms, enterococci and turbidity were all within range of the water quality guidelines (Table 5-3), and well below levels being discharged from the WWTW outlet (Table 5-2).
- Salinity was generally consistent with ambient marine water measures (Table 5-3, Table 5-1).
- Nitrogen oxides (NOx) were markedly above water quality standards across all percentiles (Table 5-3), but below levels being discharged from the WWTW outlet (Table 5-2).
- Ammonia (NHx), total nitrogen, total phosphorous, total copper, lead and zinc were all analysed at limits of reporting higher than the guideline value. Therefore a comparison to the guideline values was not possible. However, levels reported from the groundwater (Table 5-3) were well below levels being discharged from the WWTW outlet (Table 5-2).

Table 5-3 Groundwater descriptive statistics from sampling events 1-7

Parameter	Unit	20th percentile	Median	80th percentile	Average	Water quality guideline
Salinity	PSU	32.03	34.57	35.17	33.62	-
Turbidity	NTU	0.7	2.9	203.4	190.75	0.5-10[1]
Total suspended solids	mg/L	2.5	6.0	316.8	181.1	-
Ammonia (NH_X)	mg/L	0.05	0.05[2]	0.05	0.04	0.02[1]
Nitrogen oxides (NO_X)	mg/L	0.396	0.64	0.88	0.667	0.025[1]
Total nitrogen	mg/L	0.5	0.5[2]	0.9	1.15	0.12[1]
Total phosphorus	mg/L	0.05	0.05[2]	0.19	0.14	0.025[1]
Faecal coliforms	CFU/ 100 mL	1	1	1	151	150 or 1000
Enterococci	CFU/ 100 mL	0.5	0.5	4.2	303.9	35 or 230
Total copper	mg/L	0.005	0.005[2]	0.005	0.0067	0.0013[3]
Total lead	mg/L	0.005	0.005[2]	0.005	0.007	0.0044[3]
Total zinc	mg/L	0.0025	0.025[2]	0.025	0.031	0.015[3]

Red text indicates values above guideline value

[1] ANZECC & ARMCANZ (2000) default marine trigger values (DTV) for the marine waters of south-east Australia

[2] = Parameter tested at limit of reporting higher than the nominated ANZECC and ARMCANZ (2000) guideline values for marine water

[3] ANZECC & ARMCANZ (2000) Marine toxicant trigger values (MTTV) for a 95% species protection level

5.2.3 Substrate and sediment quality

The Belmont WWTW is located on Nine Mile Beach, with the ocean outfall extending approximately 1.5 km offshore. Nine Mile Beach is an ocean beach dominated by soft sediment habitat, located between areas of shallow reef habitat at Newcastle and Swansea (Figure 5-2).

Source: DECCW, (2010)

Figure 5-2 Seabed habitats

The sites assessed as part of the benthic survey completed from 2016-2019 (Advisian, 2019) showed that the area is dominated by soft sediments with some rocky rubble/gravel (Plate 5-1). The existing ocean outfall, which has been in place since 1982 with an upgrade in 1993, provides a hard substrate within an otherwise open area of soft sandy substrate (Plate 5-2).

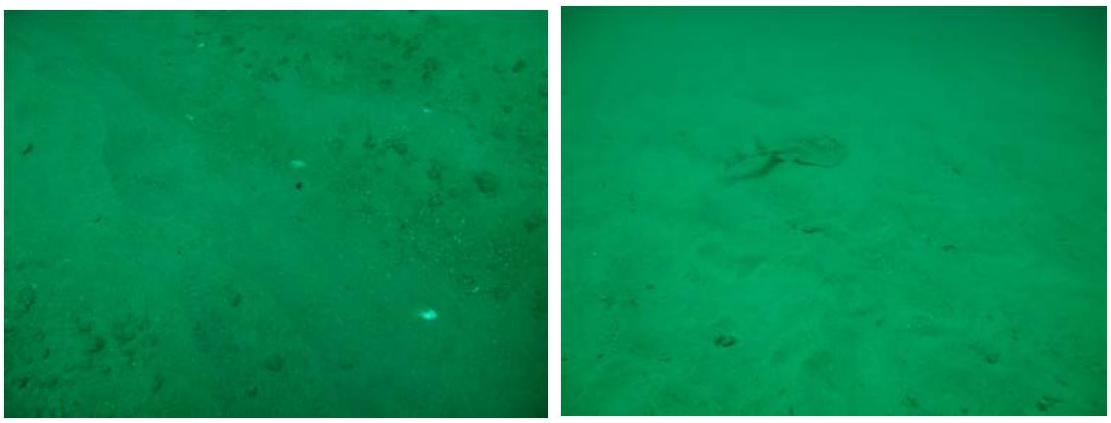


Plate 5-1 Example of soft sand substrate within 20 - 100 m of the outfall (from Advisian, 2016)

Plate 5-2 Outfall pipeline, providing hard substrate (from Advisian, 2016)

The soft sediment habitat around the Belmont WWTW outfall is predominantly (>90%) comprised of sand fractions (0.06 to 2.00 mm particle size), rather than larger gravel/cobbles or smaller silt and clay fractions (Advisian, 2019). Sediments were tested in 2016 for the following parameters:

- Total organic carbon
- Metals (aluminium, antimony, arsenic, barium, beryllium, cadmium, chromium, hexavalent chromium, cobalt, copper, iron, lead, magnesium, manganese, mercury, nickel, selenium, silver, vanadium and zinc)
- Microbiological:
  - Enterococci, *Escherichia coli* and *Clostridium perfringens* (Advisian, 2016)

All contaminants tested were below their relevant ANZECC (2000) Interim Sediment Quality Guidelines low and high guideline values. The following table provides a summary of the average of four replicates within the 0-5 cm interval at locations north and south of the outfall and the reference location Redhead.

Table 5-4 Sediment quality at WWTW outfall and reference locations (modified from Advisian, 2016)

			ANZECC 2000 Guidelines		Location		
Metal	Units	LOR	ISQG - Low	ISQG - High	Redhead	Outfall N	Outfall S
Aluminium	mg/kg	50	NA	NA	780	287.5	357.5
Antimony	mg/kg	5	2	25	2.5	2.5	2.5
Arsenic	mg/kg	5	NA	NA	2.5	2.5	2.5
Barium	mg/kg	10	NA	NA	5	5	5
Beryllium	mg/kg	1	NA	NA	0.5	0.5	0.5
Cadmium	mg/kg	1	1.5	10	0.5	0.5	0.5
Chromium	mg/kg	2	80	370	1	1	1
Hexavalent Chromium	mg/kg	0.5	NA	NA	0.25	0.25	0.25
Cobalt	mg/kg	2	NA	NA	1	1	1
Copper	mg/kg	5	65	270	2.5	2.5	2.5
Iron	mg/kg	50	NA	NA	1410	1027.5	1237.5
Lead	mg/kg	5	50	220	2.5	2.5	2.5
Magnesium	mg/kg	10	NA	NA	227.5	280	312.5
Manganese	mg/kg	5	NA	NA	14.5	4.25	6.5
Mercury	mg/kg	0.1	0.15	1	0.05	0.05	0.05
Nickel	mg/kg	2	21	52	1	1	1
Selenium	mg/kg	5	NA	NA	2.5	2.5	2.5
Silver	mg/kg	2	1	3.7	1	1	1
Vanadium	mg/kg	5	NA	NA	2.5	2.5	2.5
Zinc	mg/kg	5	200	410	2.5	2.5	2.5

Overall, it was determined that there is no evidence to suggest that the Belmont outfall is a point source for the contaminants tested (Advisian, 2016). Differences in total organic carbon and metals observed between Redhead and other sampling sites were largely attributable to the difference in particle size distribution at Redhead and were deemed unrelated to the presence or operation of the outfall (Advisian, 2016).

5.2.4 Epi-benthic and benthic ecology

Epi-benthic ecology

The Belmont WWTW outfall pipe provides a hard substrate in an area that is otherwise comprised of soft sediment habitat. Since its installation, a variety of filter feeding organisms have recruited to the pipe, such that there is now a locally dense and diverse community established. A review of the 2018 footage of the pipe has identified a community dominated by a variety of sponges from the class Demospongiae, including *Tethya* sp.*, Holopsamma laminaefavosa*, *Cliona* sp., *Callyspongia* sp. and *Ircinia* sp. (Plate 5-3, a and b). Other sessile organisms present within the sponge garden include encrusting and solitary ascidians (e.g. *Pyura spinifera,* Plate 5-3, c), and a variety of encrusting and erect algal species.

Together, these sessile organisms form a diverse biogenic habitat that supports an array of invertebrate and fish species. Crinoids, which are slow moving filter feeders closely related to sea stars are present in high numbers. Whilst not observed on the video (due to the nature of the filming and resolution of imagery), it is expected that small crustaceans, molluscs and other echinoderms would also be present. The soft sediment adjacent to the pipeline supports occasional seapens (Pennatulacea, Plate 5-3, d), a type of filter feeding soft coral.

The filter feeding organisms are likely taking advantage of the additional nutrient input entrained in the WWTW effluent. The assemblage would also be providing an ecosystem service of filtering bioavailable nutrients from the water column, forming an important part of the local nutrient cycle.

(a)

(b)

(c)

(d)

Plate 5-3 Examples of biogenic habitat (a) and (b) diverse sponge gardens, (c) stalked ascidians, (d) seapens

Benthic infauna

Benthic infaunal communities, being sessile, tend to respond to point source influences on the environment. For this reason, they are frequently used both as an indicator of, and to assess, aquatic environmental condition. The parameters most consistently used comprise the following indicators (Weisberg *et al.*, 2008):

- Dominance by tolerant taxa
- Presence of sensitive taxa
- Species richness
- Total abundance

Annual infauna monitoring at the Belmont WWTW outfall has been undertake across 12 sites (five samples collected per site) since 2016. Assemblages are typically dominated by marine worms (e.g. Polygordiidae and Spionidae annelids), and small crustaceans (e.g. Amphipod spp. - Arthropoda) (Table 5; Advisian, 2019). The surveys identified that a few prevalent taxa (Polygordiidae, Phoronidae and Spionidae) varied with increasing distance from the outfall. Across all sampling years polychaete ratios have been highest adjacent to the outfall (Advisian, 2019).

Among the macro-invertebrates used for the assessment of soft-bottom communities, most polychaetes are classified as tolerant/opportunistic to pollution (Dauvin et al., 2016). Assessment of infauna undertaken to date indicates that effluent discharge has a localised effect on infaunal assemblages in proximity to the point of discharge (Advisian, 2019). This influence has been detected across a number of indices in multiple surveys, and indicates that infaunal assemblages within 100 m of the point of discharge have adapted to the ongoing input of effluent from the WWTW.

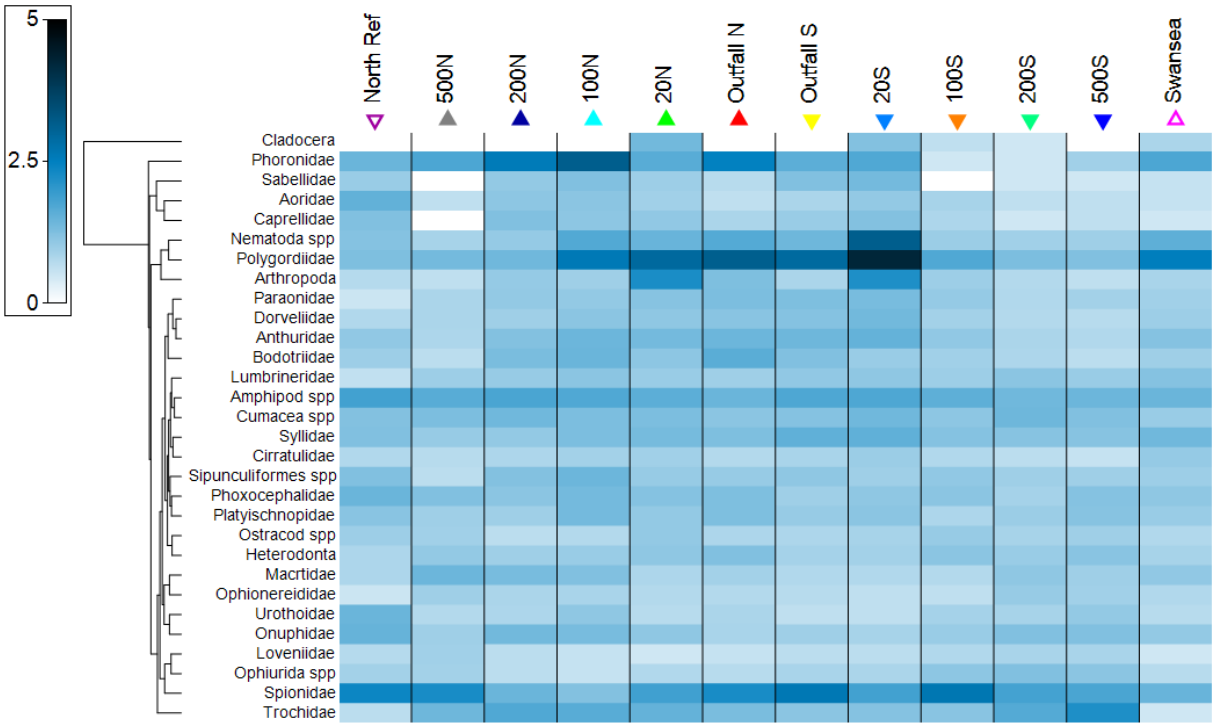


Figure 5-3 Shade Plot of the relative abundance of 30 most important infauna taxa groups for all sampling events among sites (pooled sampling events) from 2016-2019. Group abundance is represented by a spectrum of shades of blue, from white (absent) to dark blue (most abundant) (reproduced from Advisian, 2019)

Table 5-5 Summary of infauna phylum identified in 2019 including the number of families (richness) and total number of individuals (abundance) (reproduced from Advisian, 2019)

Phylum	Richness	Abundance	Richness	Abundance	Richness	Abundance	Richness	Abundance
	2019	2019	2018	2018	2017	2017	2016	2016
Annelida	29	10620	31	2825	24	2786	31	4943
Arthropoda	35	2085	35	968	23	2487	28	1376
Bryozoa	0	0	0	0	1	3	1	1
Chaetognatha	1	1	1	2	0	0	1	4
Chordata	4	14	4	8	0	0	0	0
Cnidaria	2	14	1	1	2	13	2	12
Echinodermata	6	60	4	64	5	114	5	115
Mollusca	26	357	19	1297	24	340	23	221
Nematoda	1	2025	1	405	1	109	1	164
Nemertia	2	77	1	61	1	59	1	73
Phoronida	1	2163	1	222	1	935	1	1127
Platyhelminthes	1	22	1	8	1	17	1	44
Porifera	2	4	0	0	0	0	1	1
Sipuncula	1	240	1	42	1	22	1	23
Total	111	17688	100	5903	84	6885	97	8104

5.2.5 Fish assemblages

Fish assemblages associated with the pipeline include those that are using the structure of sponge gardens as refugia, those that are actively feeding on the sessile organisms, and higher order predators which are attracted to this prey. Species observed on the video include the highly abundant Mado (*Atypichthys latus,* Plate 5-4, a) which were ubiquitous across the pipe. The next most commonly observed fish was the Australian Salmon (*Arripis* sp., Plate 5-4, b), which were schooling in the water column above the pipe. Less commonly observed fish include the Stripey (*Microcanthus strigatus*), striped catfish (*Plotosu lineatus,* Plate 5-4, c), Eastern fortescue (*Centropogon australis*), wrasse (*Notolabrus tetricus*), gobies (Gobiidae), leatherjackets (Monacanthidae), moray eel (Muraenidae, Plate 5-4, d), sergeant baker (*Latropiscis purpurissatus,* Plate 5-4, e), and Port Jackson shark (*Heterodontus portusjacksoni,* Plate 5-4, f).

(a) Gray Diving video screenshot

(b) Gray Diving video screenshot

(c) Gray Diving video screenshot

(d) Gray Diving video screenshot

(e) (from Advisian, 2016)

(f) (from Advisian, 2016)

Plate 5-4 Examples of fish species associated with the pipe (a) Mado, (b) Australian salmon, (c) Striped catfish, (d) Moray eel (e) Sargent Baker, (f) Port Jackson shark

Fish assemblage studies undertaken at Redhead Beach, approximately 6 km north of Belmont, provide a baseline assessment of fish communities likely to inhabit Belmont WWTW receiving environment. These studied formed part of the Burwood Beach MEAP Fish study in 2011-2013 and included a combination of underwater visual census (UVC) and Baited Underwater Video Survey (BRUVs) to identify the fish assemblages around the outfall and at reference locations. The UVC method was based on four replicate 5 m x 25 m belt transects and one 1 m x 25 m belt transect per event. The BRUVs method was based on three replicate deployments per site which were spaced 200 m apart.

The following summary was collated for the southernmost reference sites at Redhead.

Table 5-6 Summary of fish assemblages in the sandy seabed near Redhead, NSW (based on Advisian, 2013)

Fish Species		Total Abundance	Survey	Method
Scientific Name	Common Name			
Austrolabrus maculatus	Black Spot Wrasse	10	Apr 13 and May 12	UVC
Acanthistius ocellatus	Eastern Wirrah	1	Oct-11	BRUVs
Acanthopagrus australis	Bream	43	Oct 2011, May 12 and Apr 13	UVC & BRUVs
Achoerodus viridis	Eastern Blue Groper	9	Oct 2011, May 12 and Apr 13	UVC & BRUVs
Atypichthys strigatus	Australian Mado	3	Apr-13	UVC
Aulopus purpurissatus	Sergeant Baker	3	Oct-11	BRUVs
Cheilodactylus fuscus	Red Morwong	12	Oct 2011, May 12 and Apr 13	UVC & BRUVs
Chelmonops truncatus	Eastern Talma	2	Oct-11	BRUVs
Cleidopus gloriamaris	Pineapple Fish	4	May-12	UVC
Dinolestes lewini	Longfin Pike	13	Oct 11 and May 12	UVC & BRUVs
Enoplosus armatus	Old Wife	23	Oct 11, Dec 11, May 12 and Apr 13	UVC & BRUVs
Heterodontus portusjacksoni	Port Jackson Shark	2	Oct 11 and Apr 13	UVC & BRUVs
Hypoplectrodes maccullochi	Halfbanded Perch	2	May-12	UVC
Hypoplectrodes nigroruber	Banded Sea Perch	1	Apr-13	UVC
Lotella rhacina	Large Tooth Beardy	2	Apr-13	UVC
Meuschenia freycineti	Sixspine Leatherjacket	4	Oct-11	BRUVs
Nemadactylus douglasii	Grey Morwong	3	Oct-11	BRUVs
Notolabrus gymnogenis	Crimson-banded Wrasse	14	Oct 11, May 12 and Apr 13	UVC & BRUVs
Ophthalmolepis lineolata	Maori Wrasse	28	Oct 11, May 12 and Apr 13	UVC & BRUVs
Pagrus auratus	Australasian Snapper	7	Oct 11 and Apr 13	UVC & BRUVs
Paraplesiops sp.		1	May-12	UVC
Parma microlepis	White Ear	29	Dec 11, May 12 and Oct 11	UVC & BRUVs
Parupeneus signatus	Blackspot Goatfish	1	Apr-13	UVC
Parupeneus spilurus	Blacksaddle Goatfish	2	Oct-11	BRUVs
Pempheris multiradiata	Big scale Bullseye	2	Apr-13	UVC
Phyllacanthus parvispinus	Eastern Slate-Pencil Urchin	9	Apr-13	UVC
Pseudocaranx dentex	White Trevally	25	Oct-11	BRUVs
Rhabdosargus sarba	Eastern Pomfred	5	Oct-11	BRUVs
Scorpis lineolata	Silver Sweep	48	Oct 11 and Apr 13	UVC & BRUVs
Trachichthys australis	Southern Roughy	2	May-12	UVC
Trachurus novaezelandiae	Yellowtail	138	May 12 and Oct 11	UVC & BRUVs
Upeneichthys lineatus	Stingaree	2	Oct 11 and Apr 13	UVC & BRUVs

UVC - sum of total abundance from four transects which separately targeted large fish, small fish and echinoids

BRUVs - sum of fish abundance from three Redhead sites undertaken in October 2011

5.2.6 Conservation values

The Belmont ocean outfall and area of potential direct impact of the Project are not located within any of the key ecological features or protected places of the Temperate East Marine Region as described in Section 5.1. However, marine biologically important areas for some of the region's protected species (DoEE, 2015) do cover the Project locality, comprising:

- Humpback whale migration
- Short-tailed shearwater bird foraging
- Sooty shearwater foraging
- Wedge-tailed shearwater foraging
- Indo-Pacific/Spotted Bottlenose dolphin breeding and calving
- Grey nurse shark breeding

Biologically important areas are those that are particularly important for the conservation of protected species and where aggregations of individuals display biologically important behaviour such as breeding, foraging, resting or migration.

Further, the Project is located within a broad area that is designated by the Department of Primary Industries as key fish habitat, which comprises aquatic and riparian habitats that are important to the sustainability of the recreational and commercial fishing industries, the maintenance of fish populations generally and the survival and recovery of threatened aquatic species. Riparian habitats are fully described in Section 8.3 of the BDAR report, and have thus been excluded from this marine assessment.

To inform potential presence of matters of National Environmental Significance (MNES) within the project area, a likelihood of occurrence assessment was conducted to determine the likelihood of species identified by desktop searches as occurring within the project area. This was undertaken for each species identified in the EPBC Protected Matters Search Tool (PMST) and also for species protected under State legislation found from a BioNet search to provide a conservative and robust assessment for protected species. This assessment took consideration of migratory behaviours, transient potential and foraging behaviours as well as use of habitats that may occur in the project area.

The likelihood of occurrence ranking was attributed to each species based on the following framework:

- Unlikely to occur: species has not been recorded in the region AND/OR current distribution does not encompass the project area AND/OR suitable habitat is generally lacking from the project area.
- May occur: mapped species' distribution incorporates the project area AND potentially suitable habitat occurs within the project area.
- Likely to occur: species has been recorded in the region and potentially suitable habitat is present within the project area. Captures those species also known to occur.

The following sections summarise the findings of this assessment.

State only listed threatened species

One hundred and forty-two (142) listed threatened species were identified by the BC and FM BioNet as having the potential to occur within the project area (Table 5-8). The 10 km buffer width applied to the area included 28 exclusively terrestrial species (two amphibians, one reptile, 13 plants, one insect and 11 mammals). These have been omitted from further consideration in this report given the focus of this assessment is on the marine environment. A further 56 species were also listed in the PMST search and are, therefore, subsequently addressed in Table 5-9. Of these 56 species, 19 of them were exclusively terrestrial (one amphibian, 12 plants and six mammals) and were not assessed as per the reasoning described above.

The remaining 58 species include:

- Two seals
- 56 birds

Table 5-7 contains two additional hammerhead shark species protected under the FM Act 1994 that were not picked up from the BioNet or PMST searches. These species were included given they represent biodiversity values relevant to the Project protected under the FM Act 1994.

Overall, one species, the New Zealand fur seal, is considered likely to occur in the project area.

Table 5-7 Potential for threatened species listed under the FM Act 1994 to occur in the vicinity of the WWTW outfall

Species	FM Act status	Description	Likelihood of occurrence
Sharks			
Great Hammerhead Shark (*Sphyrna mokarran*)	V	This species inhabits coastlines and continental shelves to depths of 80 m (DPI 2012b), and during the warmer months is likely to likely to inhabit coastal regions north of Sydney.	**May occur** Individuals may transit or be present within the outfall area.
Scalloped Hammerhead Shark (*Sphyrna lewini*)	E	Adults of the species inhabit deep waters of the continental shelf however juveniles inhabit nearshore environments in nursery habitats (DPI 2012c). Nursery habitat comprises nearshore sheltered environments such as inshore estuaries and bays; adult females give birth between October – January and juveniles inhabiting the nursery area for up to a year (DPI, 2012c).	**May occur** Juveniles and adults of the species may transit or be present within the outfall area.

E1 – Endangered; V – Vulnerable

Table 5-8 Potential for threatened species listed under the BC Act 2016 to occur in the vicinity of the WWTW outfall

Species	BC Act status	Description	Likelihood of occurrence
Marine mammals			
New Zealand fur seal (*Arctocephalus forsteri*)	V	This species mostly occurs from southern Australia through to mid NSW and coastal waters in the Tasman Sea where it breeds (Atlas of Living Australia (ALA), 2019). It resides on rocky coastlines and offshore islands with large, jumbled and angular rocks and smooth rocky platforms.	**Likely to occur** Suitable rocky/complex habitat is not present within the Project area. Although it may transit past the Project area along the coast as a transient visitor as it has been recorded within 10 km of the site.
Australian fur seal (*Arctocephalus pusillus doriferus*)	V	This species exclusively breeds within the Bass Strait off the coasts of Victoria and Tasmania. The greater range of this species includes South Australia, southern Tasmania and Jervis Bay, New South Wales. This species prefers rocky islands to rest on land and forages in oceanic waters off the continental shelf.	**May occur** Foraging and resting habitat is not present within the Project area and this species is not generally found as far north as the project area. However it may transit past the project area along the coast as a transient visitor as it has been recorded once within 10 km of the site.
Birds			
56 species			**May occur** Marine, wetland and terrestrial bird species may fly over, forage and rest on the foreshore within the project area. The project area is not however considered to provide core habitat for protected bird species.

V – Vulnerable

Commonwealth and State listed threatened species

Seventy-eight (78) listed threatened species were identified by the EPBC PMST as MNES having the potential to occur within the project area (Table 5-9). The 10 km buffer width applied to the area included 30 exclusively terrestrial species (three amphibians, eight mammals and 19 plants). These have been omitted from further consideration in this assessment given the focus on the marine environment.

The remaining 48 species include:

- One fish
- Six marine mammals
- Five marine reptiles
- Three sharks
- 33 birds (addition of the recently listed threatened white-throated needle-tail (*Hirundapus caudacutus)* to the MNES threatened species list has not yet been updated in the PMST database but has still been considered here)

The 37 species identified by the State BioNet search for species protected under the FM and BC Acts that were also identified by the PMST search have been included here (Table 5-9).

Overall, eight EPBC listed species or groups of species are considered likely to occur in the project area, including:

- One shark (Great white shark)
- Three reptiles (Loggerhead turtle, Green turtle, Hawksbill turtle)
- Three mammals (Southern right whale, Dugong, Humpback whale)
- Syngnathids

Table 5-9 Potential for threatened species listed under the EPBC Act 1999 to occur in the vicinity of the WWTW outfall

Species	EPBC Act status	FM Act status	BC Act status	Description	Likelihood of occurrence
Fish					
Black rock cod *(Epinephelus daemelii)*	V	V		Known to occur throughout the NSW coast on rocky reefs as well as gutters and caves in nearshore environments to depths of up to 100 m (DPI, 2012a). Black Rock Cod are highly territorial and are known to inhabit their chosen location, such as a particular overhang, for the majority of their lives (DPI, 2012a).	**Unlikely to occur** It is unlikely that suitable habitat for the species exists within the outfall area; as the nearshore benthic environment consists primarily of sandy habitat (Advisian, 2016). The outfall pipe provides hard substrate, however pipe lacks the complex structure (gutters, caves and overhangs) where this species is usually found.
Sharks					
Grey nurse shark (*Carcharias taurus*)	CE	CE		Known to inhabit inshore waters, with preferred habitats comprising sandy-bottom gutters and caves (DPI, 2016). There are no known aggregation sites for the species in the region, however, the species are known to migrate between sites (DPI, 2016).	**May occur** Habitat provided by the outfall pipe is potentially suitable habitat for the species; furthermore, individuals of the species may transit the area during migrations between aggregation sites. As such, the species may be present in the area.
Great white shark (*Carcharodon carcharias*)	V, Mig	V		The species can be found in nearshore environments to the continental shelf and travel extensively throughout their habitat range (DPI 2015). The nearshore environment in the vicinity of Hawks Nest and Stockton Beach are a known primary residency region for juveniles of the species (DPI 2015).	**Likely to occur** It is likely that the species would be present within the outfall area as a transient visitor.
Whale shark *(Rhincodon typus)*	V, Mig			The whale shark is an oceanic and coastal, tropical to warm-temperate pelagic shark known from NSW, QLD, NT, WA and occasionally VIC and SA. Western Australian coast, is the main known aggregation site of Whale Sharks in Australian waters (DoEE, 2019).	**May occur** This species may occur in the area as a transient visitor

Species	EPBC Act status	FM Act status	BC Act status	Description	Likelihood of occurrence
Reptiles					
Loggerhead turtle *(Caretta caretta)*	E, Mig		E1	Widely distributed throughout Australian coastal and offshore zones (DoEE, 2019). Female turtles recorded from nesting sites in south east Queensland, have been observed in Australian waters off NT, QLD and NSW (Limpus, 2008a). Suitable habitat includes coral reefs, rocky reefs, seagrass beds and inshore embayment's (DoEE, 2019). The local turtle nesting season for the region occurs between December – February (DES, 2019).	**Likely to occur** This species is likely to forage and transit the area and has been recorded within 10 km of the site.
Green turtle (*Chelonia mydas*)	V, Mig		V	Species is distributed throughout Australian coastal warm temperate to tropical seas. Nesting occurs throughout northern Australia between December and February (DES, 2019). Following hatching, neonate and juvenile turtles remain in pelagic and offshore waters until they reach approximately 30 to 40 cm carapace length (DoEE, 2019). Adults are commonly encountered in seagrass beds and in proximity to macroalgal benthic habitats.	**Likely to occur** This species is likely to transit through the area and has been frequently recorded within 10 km of the site.
Leatherback turtle (*Dermochelys coriacea*)	E, Mig		E1	Circum-globally distributed in warm temperate to tropical seas for pelagic foraging. Foraging is common at high latitudes in the Southern Pacific Ocean. The species occurs in open ocean basins, making landfall to nest at scattered, infrequently used locations north of Ballina (DoEE, 2019). This species is most commonly reported from coastal waters in central eastern Australia.	**May occur** This species may transit through the area.
Hawksbill turtle (*Eretmochelys imbricata*)	V, Mig			Nesting for this species occurs in far north QLD, NT and WA between December and February with individuals migrating up to 2400 km between foraging areas and nesting beaches (DES, 2019). Juvenile turtles remain in pelagic and offshore waters for the first five to ten years, drifting on ocean currents. This species prefers to feed on sponges and algae (DoEE, 2019).	**Likely to occur** This species is likely to transit and forage within the area and has been recorded within 10 km of the site.

Species	EPBC Act status	FM Act status	BC Act status	Description	Likelihood of occurrence
Flatback turtle (*Natator depressus*)	V, Mig			Nesting sites occur between Bundaberg in the south and northwards to Torres Strait. Nesting also occurs along the NT and north WA (DoEE, 2019). Feeding grounds are mostly over the Australian continental shelf and off eastern Indonesian waters. Migration is usually restricted to the continental shelf although there are numerous records of the species in waters off the continental shelf. This species rests and forages on soft bottom habitat typically above latitude 25° S (DoEE, 2019).	**Unlikely to occur** Suitable habitat for this species is not found within the project area.
Marine mammals					
Sei whale (*Balaenoptera borealis*)	V, Mig			Primarily found in deep water, oceanic habitats. Migration details are not well understood, however it is speculated that this species occurs in tropical/subtropical waters in winter and temperate and subpolar waters during summer, This species is believed to migrate similarly to other baleen whales (north-south migration pattern). They have most commonly been sighted in the Australian Antarctic waters and Commonwealth waters and more infrequently off the south and east coasts of Australia (DoEE, 2019).	**Unlikely to occur** This species is unlikely to occur close to the shore within the project area
Blue whale (*Balaenoptera musculus*)	E, Mig		E1	Distribution is widespread, however migration patterns are not well understood. Foraging areas are concentrated along the south - southwest Australian coast. It is likely they may migrate along the west Australian coast polar waters to the tropic waters of Indonesia between November and May (DoEE, 2019).	**Unlikely to occur** This species is unlikely to occur close to the shore within the project area

Species	EPBC Act status	FM Act status	BC Act status	Description	Likelihood of occurrence
Fin whale (*Balaenoptera physalus*)	V, Mig			Fin whales have been observed in south Australian waters between November and May, however distribution has been largely determined by strandings around Australia. They are often sighted in Antarctic waters where they are believed to be foraging. They have a well-defined migratory north-south pattern between polar and tropical waters. Reported sightings of this species in Australia have included all states except NSW and NT; available information suggests that this species is more commonly present in deeper waters (DoEE, 2019).	**Unlikely to occur** This species is unlikely to occur close to the shore within the project area
Southern right whale (*Eubalaena australis*)	E, Mig		E1	This species has been sighted in the coastal waters of all Australian states, with the exception of the NT during migrations between May and November (Bannister et al., 1996). However their primary habitat occupancy is off the coasts of south Western Australia, South Australia and Victoria (DoEE, 2019e). Belmont is at the very northern tip of this species distribution.	**Likely to occur** This species is likely to forage and transit the area during migrations and has been recorded within 10 km of the area.
Dugong (*Dugong dugon*)	Mig		E1	This species is closely associated with seagrass meadows and is typically found along the coastline of northern Australia (DoEE, 2019). This species migrates in response to the changing availability of suitable seagrasses, or in response to water temperature (Marsh et al., 2002). Known to undertake long-distance migration/dispersal events (DoEE, 2019).	**Likely to occur** This species may transit the project area to forage and has been recorded within 10 km of the project area.
Humpback whale (*Megaptera novaeangliae*)	V, Mig		V	This species annually migrates up the east and west coast of Australia. The east coast population occurs in subtropical Australia from around July to November. This species feeds in Antarctic waters (Chittleborough 1965; Dawbin 1966). The coast of southern NSW to northern QLD is listed as a Biologically Important Area (BIA) for humpback whales (DoEE, 2019).	**Likely to occur** The coast of southern NSW to northern QLD is listed as a Biologically Important Area (BIA) for humpback whales. This species is likely to transit the area during migrations and has been recorded within 10 km of the project area.

Species	EPBC Act status	FM Act status	BC Act status	Description	Likelihood of occurrence
Birds					
33 species					**May occur** Marine, wetland and terrestrial bird species may fly over and forage within the project area. The marine project area is not however considered to provide core habitat for protected bird species.
Others					
Syngnathids	M	P		Inhabit tropical to warm waters, commonly associated with complex vegetated rocky habitats and coral reefs as well as coastal algae, seagrasses and manmade structures. There are currently 31 known syngnathids species that inhabit NSW waters, with three species endemic to NSW (DPI, 2019).	**Likely to occur** The hard substrate of the outfall pipe and associated assemblages provide potentially suitable habitat for Syngnathids. Due to the cryptic nature and substantial survey effort required to confirm species presence, widely accepted practice takes a conservative approach when potentially suitable syngnathid habitat is present. Thus, it is considered that syngnathids are likely to be present near the existing WWTW outfall.

Notes: EPBC Act: CE – Critically Endangered; E – Endangered; V – Vulnerable; Mig – Migratory; M - Marine
BC/FM Act: CE – Critically Endangered; E1 – Endangered; V – Vulnerable
National Parks and Wildlife Act 1974: P - Protected

Commonwealth listed migratory only species

Seventy-one (71) listed migratory species were identified by the EPBC Act 1999 PMST search as MNES having the potential to occur within the project area (Table 5-10). 31 species (five marine mammals, two sharks, five marine reptiles and 19 birds) were omitted as they also came up in the PMST search as being threatened and have been previously included in Table 5-9. No migratory species were identified.

The remaining 40 species include:

- Five marine mammals
- One shark
- Two rays
- 32 birds

FM Act 1994 and BC Act 2016 species that are also listed as migratory under the EPBC Act 1999 have been previously addressed in Table 5-9. None of these species are considered likely to occur in the project area.

Table 5-10 Potential for migratory species listed under the EPBC Act 1999 to occur in the vicinity of the WWTW outfall

Species	Description	Likelihood of occurrence
Marine mammals		
Bryde's whale *(Balaenoptera edeni)*	Inhabits tropical and warm temperate waters. Small population estimated from Australian waters (DoEE, 2019). Patterns of migration are not clearly understood. Some evidence that the offshore form may migrate to tropical water during winter (DoEE, 2019). However, it appears that this species occurs in waters containing prey, mostly pelagic shoaling fish.	**Unlikely to occur** This species is unlikely to occur close to the coast within the project area.
Pygmy right whale *(Caperea marginata)*	Pygmy right whales have primarily been recorded in areas associated with upwellings and with high zooplankton abundance (DoEE, 2019). Patterns of migration are not clearly understood (DoEE, 2019). In Australian waters, weaned juveniles migrate south where prey is more abundant (Kemper, 2002).	**Unlikely to occur** This species is unlikely to occur close to the coast within the project area.
Dusky dolphin *(Lagenorhynchus obscurus)*	Species mainly found in temperate and subAntarctic waters, generally inshore. Rarely reported in Australia, no calving areas have been identified in Australian waters (DoEE, 2019). Long distance migrations have been reported from around the world. Little information is available on migratory movements or timing of this species in the spill trajectory area, all though there is a potential seasonal link (DoEE, 2019).	**Unlikely to occur** This species has only been recorded in Australian waters 13 times since 1828. The project area is also within the species most northerly distribution.
Killer whale *(Orcinus orca)*	Pelagic species often inhabiting waters on the continental shelf. Distributed along the Australian coast, but most frequently observed around Tasmania, South Australia and Victoria. Macquarie Island (southern Indian Ocean) is an important region for the species (DoEE, 2019). Killer whales make seasonal migrations, and may follow regular migratory pathways; however this has not been proven. No specific information on migratory information pathways along the NSW coast is documented. Killer whales have been recorded relocating to Antarctic waters during summer months and back to warmer waters during winter (Kasamatsue and Joyce 1995). This suggests that during the winter months would be the highest likelihood of occurrence of killer whales outside of the Antarctic.	**Unlikely to occur** This species is unlikely to occur close to the coast within the project area.
Indo-Pacific humpback dolphin *(Sousa chinensis)*	Humpback dolphins are known to occur along the northern Australian coastline. This species primarily occurs in shallow and protected habitats, including estuaries, rivers, shallow bays and inshore reefs (DoEE, 2019). Humpback dolphins do not undertake large scale seasonal migrations, however seasonal changes in abundance occurs (DoEE, 2019).	**Unlikely to occur** This species is not commonly recorded as far south as the project area.
Sharks		
Porbeagle *(Lamna nasus)*	Temperate and cold-temperate shark species, world-wide distribution. Coastal and oceanic species, more common on the edge of continental shelves (Last and Stevens, 2009). This species can occur in coastal waters temporarily. Known to move thousands of kilometres around temperate water band surrounding the globe. No information is available on migratory timing.	**Unlikely to occur** This species is unlikely to occur close to the coast within the project area.
Rays		
Reef manta ray (*Manta alfredi)*	The species is found in all three of the world's major oceans, although most commonly encountered in the Indian Ocean and south Pacific. Key aggregation sites include: Hawaii, Australia, Komodo, Maldives, Yap, Palau, Bali, and Southern Mozambique (Mantaray-World, 2014). This species is known to occur off the eastern coast of Australia.	**Unlikely to occur** This species is unlikely to occur close to the coast within the project area.

Species	Description	Likelihood of occurrence
Giant manta ray (*Manta birostris)*	The species has a circum-tropical distribution, with the most frequently reported records occurring off tropical Australia (Last and Stevens, 2009). This species is known to occur off the eastern coast of Australia.	**Unlikely to occur** This species is unlikely to occur close to the coast within the project area.
Birds		
31 species		**May occur** Marine, wetland and terrestrial bird species may fly over, forage and rest on the foreshore within the project area. The marine project area is not however considered to provide core habitat for protected bird species.

6. Impact assessment and mitigation measures

6.1 Construction

The Project would require land based construction works to support installation of a pipeline connecting the desalination plant to the existing WWTW outfall, a subsurface intake, hardstand areas for installation of the pre-fabricated plant and installation of support infrastructure including power.

Construction activities would generally comprise vegetation clearing, earthworks, trenching, pipeline installation, dewatering, soil treatment (if required) and rehabilitation/revegetation. None of these works are marine based. The facility design intends to use a land based connection into an existing ocean outfall pipeline currently in operation for the Belmont WWTW. As no in-water construction is planned to occur direct impacts to the marine environment during construction are not expected.

Coastal vegetation provides benefit to fisheries assemblages and mitigates risk of coastal erosion affecting water quality. Removal of coastal vegetation during construction may therefore pose risk of indirect impact to marine values via changes to water quality.

Potential risk of impacting upon land based environmental values, including removal of coastal vegetation, has been assessed as part of the EIS and reported separately to this Marine Assessment. No threatened flora species listed under the BC Act 2016 or EPBC Act 1999 were identified in the study area. Adjacent coastal seabed habitats, with the exception of the outfall pipe, were noted to be open sandy seabed environments.

The subsurface intake would be installed using drilling from behind the dune system such that coastal vegetation stabilising the local beach environment is not expected to be affected. Dune vegetation is therefore not expected to be impacted by the proposed land based construction works.

Due to the close proximity of the proposed temporary desalination plant to the marine environment, there is potential that any accidental spillage of hazardous materials or inappropriately managed waste released during construction could impact upon the marine environment or groundwater. However, the construction footprint would be a minimum of 100 m from the ocean and, when considering the placement behind the dune system, the risk of any accidental spills reaching the ocean is reduced. Further, spill prevention and management measures and the implementation of standard guidelines for the storage and management of waste and hazardous materials would further minimise the risk of impact.

Given the avoidance of impacting upon dune systems combined with the application of standard industry controls for management of release of hazardous and waste materials during construction, the risk of indirectly impacting the marine environment as a result of the proposed construction work is considered to be as low as reasonably practical.

6.2 Commissioning

Commissioning of the facility would occur over an estimated two month duration. During commissioning operational performance of installed intake well and pumping systems would be tested. During this period a small percentage of sludge by-product would go to the existing Belmont WWTW inlet works. As that material would be treated via standard operations of the WWTW this is not expected to have any influence on the marine environment.

During testing the majority of the intake water would bypass treatment and be released direct to marine environment via the Belmont WWTW outfall. Transference of this raw water from the intake to the outfall would increase discharge to between 45-50 ML/day compared to an average of 30 ML/day during normal outfall operations. Change in volume of water released at the outfall is not expected to have any influence on the marine environment as long as quality of the raw water released is equivalent to existing conditions at the outfall. Modelling indicated that diffusers at the outfall have been designed to primarily rely on buoyancy driver plume mixing upon release of effluent from the outfall into receiving waters, and not jet-induced mixing. As such, added volume should integrate into surrounding waters with rate of mixing driven by current conditions.

Water quality sampling of the saline aquifer supply completed late 2018-2019 across a number of events identified that salinity was consistent with ambient seawater quality conditions (Table 6-1). Further, levels of potential contaminants within the intake groundwater (e.g. nutrients, metals, faecal coliforms, suspended solids, etc.) were well below those entrained within the effluent stream currently being discharged from the WWTW outlet (Table 6-1).

Table 6-1 Ambient seawater, outlet and intake quality descriptive statistics

Parameter	Unit	Median ambient water quality (from Table 5-1)	Median effluent quality (from Table 5-2)	Intake groundwater median water quality (from Table 5-3)	Water quality guideline
Salinity	PSU	35.63	-	34.57	-
Ammonia (NH_X)	mg/L	<0.005	0.05	0.05[1]	0.020[2]
Nitrogen oxides (NO_X)	mg/L	0.005	8.10	0.64	0.025[2]
Total nitrogen	mg/L	0.121	9.8	0.5[1]	0.120[2]
Total phosphorus	mg/L	0.005	2.6	0.05[1]	0.025[2]
Faecal coliforms	CFU/ 100 mL	<1	-	1	150 or 1000
Enterococci	CFU/ 100 mL	<1	938	0.5	35 or 230
Total copper	mg/L	<0.001	2.2	0.005[1]	0.0013[3]
Total lead	mg/L	<0.0002	0.10	0.005[1]	0.0044[3]
Total zinc	mg/L	<0.005	29.50	0.025[1]	0.015[3]
Turbidity	NTU	0.5	-	2.9	0.5 – 10[3]
Total suspended solids	mg/L	-	10	6	-

[1] = Parameter not tested at low enough concentrations to determine comparison to guidelines
Red text indicates values above guideline value
[2] ANZECC & ARMCANZ (2000) default marine trigger values (DTV) for the marine waters of south-east Australia
[3] ANZECC & ARMCANZ (2000) Marine toxicant trigger values (MTTV) for a 95% species protection level

Data indicates that the quality of intake groundwater is within the ranges currently delivered to the receiving environment by the WWTW outlet. Accordingly, as long as raw water conditions are not significantly different during commissioning, the release of additional flow of intake groundwater during the two month testing phase should not have detectable impact upon the marine environment. However, groundwater testing indicates that there are nutrients present in the intake water. Therefore, if nutrient concentrations in raw water are elevated at time of release consideration may need to be given to risk of triggering algal bloom risk at the outfall; depending on extant conditions of the environment and quality of effluent with which raw water would be mixed.

Further to the above, commissioning of the Reverse Osmosis (RO) plant would require release of pre-treated permeate (desalinated water output from the RO) into the WWTW outfall over a period of two weeks. This activity is likened to release of freshwater into the marine environment similar to that of a stormwater event. As such the release of permeate during this period is not expected to impact on the surrounding waters with a rate of mixing driven by current conditions and reflective of natural variance of ambient conditions.

6.3 Operation

6.3.1 Water quality

Estimates of the discharge and salinity for the WWTW treated wastewater discharge and the normal full operation capacity of the temporary desalination plant were modelled to understand how operation of the plant may influence the environment from current operations. The full report on modelling is provided as the Brine Discharge Modelling Report (Appendix L – GHD, 2019b).

In that assessment water quality objectives (WQOs) were estimated from water quality measurements of the existing WWTW effluent and the proximal ambient marine waters, the anticipated design water quality of the plant brine, and trigger values on the basis of the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC & ARMCANZ 2000). The assessment gave consideration to potential changes in water quality conditions that would impact upon marine toxicity, ecosystem productivity and salinity. A conservative numerical tracer of the discharge through the diffuser was utilised to predict the spatial extent of the area of impact for each of the WQOs and simulate the dilution factor of the WWTW treated effluent and comingled effluent.

A salinity difference of 1 PSU between the outlet plume and ambient seawater ($\triangle$S) was adopted for the project (GHD, 2019d), in line with $\triangle$S used for the Sydney (GHD, 2005) and Perth desalination plants. This is referred to as the ambient salinity WQO and was set as a conservative objective for marine ecology health.

Two discharge scenarios were evaluated via near-field and 3D far-field modelling:

- Existing (baseline) discharge baseline conditions of the WWTW effluent, and
- Normal full operation of the proposed plant with a design brine discharge of 25.2 ML/day that is comingled with the WWTW effluent prior to discharge into the marine environment.

To compare the near-field mixing performance of the baseline effluent and proposed comingled effluent-brine discharges, near-field modelling used the high discharge (90th percentile) and low discharge (10th percentile) as inputs into the model. The low discharge (10th percentile) conditions are by definition infrequent and of short duration.

The far-field region beyond the near-field is where mixing and dilution of the diffuser waters is driven by ambient mixing and transport processes associated with tides, winds, surface heat fluxes and waves. 3D far-field modelling considered both dry weather vs wet weather

conditions. The area of impact (or effect) of WWTW discharge on the marine environment during dry weather conditions was predicted for a combination of median dry weather effluent discharge and poor effluent water quality (90th percentile). For wet weather conditions, the area of impact (or effect) was predicted on the basis of the median wet weather effluent discharge and the 20th percentile effluent water quality. During wet weather conditions with elevated stormwater flows, effluent quality is reasonably characterised by the 10th to 20th percentile water quality.

The dilution factors to meet the marine toxicity, marine ecosystem and ambient salinity WQOs for both the baseline and proposed scenarios during wet and dry weather periods are summarised in Table 6-2. The dilution factors for each WQO use the same analyte across the baseline and proposed scenarios. Generally, the addition of brine to the WWTW effluent reduces the WQO dilution factors due to lower brine concentrations (pre-dilution) and increased salinity (outflow salinities thereby closer to ambient marine waters) relative to the baseline case.

Table 6-2 Dilution factors to define area of impact (or effect) for marine toxicity, marine ecosystem and ambient salinity WQOs

WQO	Analyte	Dry Weather Baseline Dilution Factor	Dry Weather Proposed Dilution Factor	Wet Weather Baseline Dilution Factor	Wet Weather Proposed Dilution Factor
Marine Toxicity	NH_X	0.8	0.7	0.0	0.1
Marine Ecosystem	NO_X	234	203	142	144
Ambient Salinity (Above Seabed $S_{Diffuser}$<35 psu)	ΔS	31	8	31	18
Ambient Salinity (On Seabed $S_{Diffuser}$>35 psu)	ΔS	NA	14	NA	NA

The key conclusions in regards to the water quality impacts of the release of the proposed brine-effluent discharge into the marine environment via the existing diffuser include (Appendix L – GHD, 2019b):

- The marine toxicity WQO for NHx is met within approximately 1 m of the diffuser. Near-field modelling indicates that the required dilution factor (<1) is met immediately upon release into the marine environment.
- The spatial area of effect of the marine ecosystem WQO for NOx is predicted to be similar across dry and wet season periods and baseline and proposed scenarios. The WQO is met within approximately 1 km of the diffuser for 95% of the time.
- The comingled effluent-brine during high WWTW effluent discharge (90th percentile) yields a characteristic salinity of 19.7 PSU. This salinity is lower than ambient marine waters (35 PSU) so the same mechanism of buoyancy driven mixing (i.e. plume rising through the ambient waters) occurs as during the baseline discharge conditions (i.e. characteristic salinity of 4.8 PSU).
- The comingled effluent-brine during low WWTW effluent discharge (10th percentile) yields a characteristic salinity of 38.0 PSU, which is greater than the ambient marine waters (35 PSU). Under these conditions, a negatively buoyant plume occurs that falls to the seabed with low near-field dilution. The high salinity, low discharge nature of the effluent will be infrequent and of short duration when compared to the overall discharge period; this will mitigate the potentially negative impacts on benthic and epi-benthic communities.
- Far-field modelling indicates that the spatial area to meet the ambient marine salinity WQO (ΔS of 1 PSU) is predicted to be substantially smaller during the dry weather (<100 m for 95% of the time) than the wet weather (<500 m from the diffuser for 95% of the

time) periods. Generally, the largest spatial extent of the WQO is due to buoyant plumes reaching the near-surface and then undergoing dilution under natural mixing processes. Generally, the spatial area of impact of salinity was less (dry season) or similar (wet season) during the baseline relative to the proposed scenarios. For the comingled effluent-brine outflows with high salinity during the dry season (maximum of ~48 PSU), a dilution factor for the ambient salinity WQO of 14 is readily met in the immediate vicinity of the diffusers.

Overall, the key finding from the modelling assessment is that the proposed brine-effluent discharge through the existing diffuser is predicted to have the same or smaller areas of impact (or effect) in terms of marine toxicity, marine ecosystem and ambient salinity WQOs (Appendix L – GHD, 2019b). During the dry season, changes in salinity as a result of effluent input would be improved via the addition of brine, such that discharges would be closer to ambient water quality, and spatial footprints of salinity plumes reduced. During the wet season no changes to current salinity impacts are predicted from input of brine. As is currently the case with discharged effluent, buoyant plumes of lower salinity water are predicted to rise to the near surface, rather than sink to the benthos, where they will then be diluted via natural mixing processes. Therefore significant impacts to WQOs and associated marine ecology are not likely from the proposed brine-effluent discharge. Minor salinity differentials are expected within 1 km of the diffuser. Pelagic species with sensitivities to changes in salinity will be able to disperse, avoid the area around the diffuser. Epi-benthic and benthic species may need to adjust to the higher salinities in the dry weather; however resilience of these species is evident by their encrusting abilities and habitat creation in areas which were otherwise de-pauperate.

6.3.2 Sediment quality

Sediment findings have indicated potential for a change in grain size composition around the outfall that may be attributed to changes in local hydrodynamics from 5 m/s high velocity jet discharges (Clark *et al*., 2018). The current outlet discharge velocity of the WWTW is very low at 0.61 m/s (90th percentile). The corresponding discharge velocity under Normal Full Operation is also predicted to be very low at 0.78 m/s.

Further, the current sediment composition of the outfall region, which has been generally consistent over four annual monitoring events, is dominated by coarse sands, with an absence of fine sediments such as silts and clays. It is these finer sediments that would be more susceptible to mobilisation and displacement from hydrodynamic changes. Therefore, overall changes to sediment composition as a result of operation of the temporary desalination plant are not expected to occur.

Sediment quality may be impacted by the brine-effluent discharge via the addition of water borne contaminants that become entrained in the sediments. The levels of potential contaminants entrained within the brine are currently unknown (Refer Brine Discharge Modelling Report – Table 4-2). However, review of the quality of the source groundwater which will be treated and will form the brine discharge, indicates that levels of metals, nutrients, suspended solids, and faecal coliforms are well below those currently discharged by the WWTW. Therefore, concentrations of potential contaminants in groundwater are not expected to impact on sediment quality by the addition of brine discharge to the effluent.

6.3.3 Ecology

The Belmont WWTW outfall has been operational since the 1994. The local ecology of the region has been influenced by the ongoing presence and operation of the outfall as described in Section 5.2. This includes:

- Provision of hard substrate which supports a locally dense and diverse epi-benthic sponge garden community that would otherwise be absent from the area.
- Provision of habitat refugia for mobile species, food sources for those species grazing directly on the epi-benthic community, and predatory species attracted by the presence of potential prey species.
- Adaptation of the infauna community immediately adjacent to the pipeline such that the community is characterised by lower diversity and higher abundance of polychaete ratio than that at greater distances from the outfall (i.e. >100 m).

While shifts in hydrodynamics can affect grain size composition and associated benthic infaunal communities (Clark *et al*., 2018), use of high pressure jet diffusers that may influence this are not proposed. Hydrodynamics around the outfall area are not expected to change therefore infaunal communities that have established under existing operating conditions are predicted to persist without impact.

Studies undertaken on operational brine discharges indicate that a salinity change of less than 2-3 PSU would be protective of local ecosystems (Jenkins *et al.*, 2012). Brine modelling undertaken for the proposed works adopted a more conservative 1 PSU salinity difference trigger level to quantify the potential effect of salinity differences on the local marine ecosystem. Results of the modelling indicate that the proposed brine-effluent discharge through the existing diffuser will have the same areas of impact (or effect) as effluent discharge alone, in terms of human health, ambient salinity and marine ecosystem water quality objectives. Given that the WWTW outfall is already operational, the proposed comingled brine-effluent discharge is not expected to result in a substantial change to overall hydrodynamics of the region.

Therefore, benthic infauna communities, and epi-benthic pipeline communities are not expected to be impacted by operation of the temporary desalination plant. Flow on effects to higher order taxa such as fish associated with/attracted to the pipeline community are therefore also expected to be negligible.

No specific control measures are therefore proposed for the operation of the temporary desalination plant. However, it is recommended that monitoring of the receiving environment through benthic infauna and sediment quality assessments be continued in accordance with requirements of the EPL 1771. The Belmont ocean outfall benthic monitoring program could be leveraged to provide baseline understanding of existing conditions.

Despite the proximity of the proposed temporary desalination plant to the marine environment, onshore operations of the plant would be completed with regard to standard industry obligations regarding control of potential release of hazardous materials to the environment. As such, operations are not expected to pose significant risk on the marine environment from accidental risks such as spillage of hazardous materials or inappropriately managed waste released during operation. Spill prevention and management measures and the implementation of standard guidelines for the storage and management of waste and hazardous materials would mitigate this risk of impact.

6.4 Decommissioning

Decommissioning of the temporary desalination plant would reinstate flow levels and water quality at the Belmont WWTW outfall location to pre-desalination conditions. Established marine communities in the vicinity and on the outfall are not expected to be impacted by these changes in conditions.

Onshore decommissioning activities of the plant are not expected to impact on the nearby marine environment.

6.5 Significance assessment of state listed species

The potential to significantly impact on state listed species identified within the Project area has been assessed on the basis that impact mitigation controls identified in the previous sections are in place. The assessment was conducted against the BC Act 2016 (Appendix A) and FM Act 1994 (Appendix B) and considered Threatened Species Assessment Guidelines (Department of Environment and Climate Change (DECC), 2013) with relevance to:

- Species distribution and habitat requirements
- Likelihood of interaction with the timing of the proposed works
- Potential impact pathway
- Relevance of Project impact management and mitigation measures at controlling risk of interference

A summary of the assessment findings are presented below.

FM Act

The Great white shark (*Carcharodon carcharias*) listed under the FM Act 1994 and EPBC Act 1999 as threatened, was categorised as being likely to occur within the project outfall area. On the basis of the assessment in Appendix B, this Project has been assessed as unlikely to have significant impact on this species under the FM Act 1994 through all phases of work. This is supported by the findings in Sections 6.1, 6.2, 6.3, and 6.4 which suggested the proposed works are considered to have a low impact risk on the marine environment.

BC Act

Six marine species listed under the BC Act 2016 and EPBC Act 1999 as threatened were categorised as being likely to occur within the project outfall area. These species include:

- Marine mammals
  - New Zealand fur seal (*Arctocephalus forsteri*)
  - Southern right whale (*Eubalaena australis*)
  - Dugong (*Dugong dugon*)
  - Humpback whale (*Megaptera novaeangliae*)
- Marine reptiles
  - Loggerhead turtle *(Caretta caretta)*
  - Green turtle (*Chelonia mydas*)

On the basis of the assessment in Appendix A, operational activities of the plant have been assessed as unlikely to have significant impact on any threatened species under the BC Act 2016 through all phases of work. This is supported by the findings in Sections 6.1, 6.2, 6.3, and 6.4 which suggested the proposed works are considered to have a low impact risk on the marine environment.

6.6 MNES Significant Impact Criteria Assessment

The potential to significantly impact on MNES identified within the project area has been assessed (Appendix C) on the basis that the proposed works are considered to be of low impact to the marine environment as described in Sections 6.1, 6.2, 6.3, and 6.4. The assessment was conducted against the EPBC Act 1999 Significant Impact Assessment Guidelines 1.1 (DoEE, 2013) and considered:

- Species distribution and habitat requirements

- Likelihood of interaction with the timing of the proposed works
- Potential impact pathway
- Relevance of Project impact management and mitigation measures at controlling risk of interference

A summary of the assessment findings is presented below.

One Commonwealth protected species Hawksbill turtle (*Eretmochelys imbricata*) that is not protected by State legislation was identified as likely to occur from the assessment in Section 5.2.6. This species was fully assessed following the EPBC Significant Impact Guidelines (SIG) in Appendix C. The results of this assessment indicate that this Project is unlikely to have significant impact on MNES across all phases of the Project. This is supported by the findings in Sections 6.1, 6.2, 6.3, and 6.4 which suggested the proposed works are considered to have a low impact risk on the marine environment.

The remaining EPBC Act 1999 threatened and migratory species have been assessed under the NSW FM Act 1994 or BC Act 2016 Assessments of Significance, which include consideration of nearly identical criteria to those which make up the EPBC SIG (Appendix A or Appendix B). The results of these assessments indicate that the Project is unlikely to significantly impact on listed threatened and migratory species across all phases of the Project. Additional criteria relevant to the EPBC SIG, not included under the State Assessments of Significance have been addressed in Appendix C for relevant species. The results of this assessment indicate that the proposed activities are unlikely to have a significant impact on any MNES.

6.7 Summary of management and mitigation measures

The following provides a summary of the management and mitigation measures proposed for the project of relevance to the marine ecology:

- Standard industry obligations such as spill prevention and management measures and the implementation of standard guidelines for the onshore storage and management of waste and hazardous materials during construction, operation and decommissioning.
- Continuation of the Ocean Outfall Benthic Monitoring Program (as part of EPL 1771) throughout operation of the project including benthic infauna and sediment quality testing.
- Mitigation measures as outlined in the Construction Environmental Management Plan (CEMP) (refer to Section 8 of the EIS).

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Appendices

Appendix A – Assessment under the BC Act

New Zealand fur seal *(Arctocephalus forsteri)*	Assessment under the BC Act
The following is to be taken into account for the purposes of determining whether a proposed development or activity is likely to significantly affect threatened species or ecological communities, or their habitats:	
a. In the case of a threatened species, whether the proposed development or activity is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction	The New-Zealand fur seal occurs in Australian coastal waters and offshore islands of South and Western Australia as well as southern Tasmania (IUCN, 2018). Small populations also are present along the southern NSW coast, particularly on Montague Island but also other isolated areas north of Sydney (NSW OEH, 2018b). There are no known breeding sites within or around Belmont. Therefore, activities associated with the Project would not disrupt the lifecycle of this species.
b. In the case of an endangered ecological community or critically endangered ecological community, whether the proposed development or activity: (i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or (ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction	No endangered ecological community or critically endangered ecological community is located within the project area.
c. In relation to the habitat of a threatened species or ecological community: (i) the extent to which habitat is likely to be removed or modified as a result of the proposed development or activity, and (ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed development or activity, and (iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species or ecological community in the locality	Habitat for this species generally consists of rocky islands with jumbled rocks for sunbathing. Species feeds on cephalopods, fish, seabirds and occasionally penguins, therefore it also occurs in coastal environments to feed. This species breeding colonies are predominantly in SA between Kangaroo Island and Eyre Peninsula with feeding occurring along the SA and NSW coast up to the QLD border (NSW OEH, 2018b). There are no known core habitat sites within or around the project area and does not display site fidelity to the area. This species is more likely to pass through the area whilst foraging. Therefore, activities associated with the Project would not disrupt the habitats of this species.
d. Whether the proposed development or activity is likely to have an adverse effect on any declared area of outstanding biodiversity value (either directly or indirectly)	No declared areas of outstanding biodiversity value are present within or around the project area.
e. Whether the proposed development or activity is or is part of a key threatening process or is likely to increase the impact of a key threatening process.	The proposed works are not expected to align with any of the key threatening processes nor increase the impact of a key threatened process listed under Schedule 4 of the BC Act 2016 presented in Appendix D for this species.

Southern right whale (*Eubalaena australis*)	Assessment under the BC Act
The following is to be taken into account for the purposes of determining whether a proposed development or activity is likely to significantly affect threatened species or ecological communities, or their habitats:	
a. In the case of a threatened species, whether the proposed development or activity is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction	Feeding grounds of the southern right whale are in deep sub-Antarctic waters. Migratory behaviour generally may occur between 60ºS and 32ºS. Breeding occurs at specific sites along the southern Australian coast. Due to the distance between species breeding and feeding grounds, it is unlikely that the Project would affect the species lifecycle. Individuals may travel through the area during migrations however the species would be able to avoid Project activities and would not be affected by the Project construction and operation works. Therefore, activities associated with the Project would not disrupt the lifecycle of these species.
b. In the case of an endangered ecological community or critically endangered ecological community, whether the proposed development or activity: (i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or (ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction	No endangered ecological community or critically endangered ecological community is located within the project area.
c. In relation to the habitat of a threatened species or ecological community: (i) the extent to which habitat is likely to be removed or modified as a result of the proposed development or activity, and (ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed development or activity, and (iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species or ecological community in the locality	Habitat for the southern right whale generally consists of feeding grounds in the sub-Antarctic waters and breeding grounds along the South Australian coast. The closest known breeding ground for this species is located 480 km south in Eden, NSW (DoEE, 2019). Habitat for this species would not be impacted by the Project activities.
d. Whether the proposed development or activity is likely to have an adverse effect on any declared area of outstanding biodiversity value (either directly or indirectly)	No declared areas of outstanding biodiversity value are present within or around the project area.
e. Whether the proposed development or activity is or is part of a key threatening process or is likely to increase the impact of a key threatening process.	The proposed works are not expected to align with any of the key threatening processes nor increase the impact of a key threatened process listed under Schedule 4 of the BC Act 2016 presented in Appendix D for this species.

Dugong *(Dugong dugon)*	Assessment under the BC Act
The following is to be taken into account for the purposes of determining whether a proposed development or activity is likely to significantly affect threatened species or ecological communities, or their habitats:	
a. In the case of a threatened species, whether the proposed development or activity is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction	Dugongs occur predominantly along the northern Australian coastline from Shark Bay in WA through to the QLD/NSW border. Occurrence records south of this are usually from foraging adults looking for seagrass meadows. Breeding and calving occur at lower latitudes along the northern Australian coastline, usually north of Hervey Bay, QLD. There are no known breeding or seagrass meadows within the project area. Lake Macquarie has seagrass meadows known to be grazed by dugongs, therefore this species may transit through the outfall area to Lake Macquarie. This species can avoid the area and still access Lake Macquarie, therefore it is not anticipated that proposed works would have an effect on the lifecycle of the species.
b. In the case of an endangered ecological community or critically endangered ecological community, whether the proposed development or activity: (i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or (ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction	No endangered ecological community or critically endangered ecological community is located within the project area.
c. In relation to the habitat of a threatened species or ecological community: (i) the extent to which habitat is likely to be removed or modified as a result of the proposed development or activity, and (ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed development or activity, and (iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species or ecological community in the locality	Dugongs occur predominantly along the northern Australian coastline from Shark Bay in WA through to the QLD/NSW border. Occurrence records south of this are usually from foraging adults looking for seagrass meadows. Seagrass meadows occur in Lake Macquarie and dugongs are known to forage on them there. The proposed works outfall area is on the coastal side, not Lake Macquarie, and is therefore not anticipated to impact the seagrass meadows. The dugongs may transit the project area to enter Lake Macquarie, however this species can avoid Project activities and still enter Lake Macquarie unrestricted to access key habitat (DoEE, 2019).
d. Whether the proposed development or activity is likely to have an adverse effect on any declared area of outstanding biodiversity value (either directly or indirectly)	No declared areas of outstanding biodiversity value are present within or around the project area.
e. Whether the proposed development or activity is or is part of a key threatening process or is likely to increase the impact of a key threatening process.	The proposed works are not expected to align with any of the key threatening processes nor increase the impact of a key threatened process listed under Schedule 4 of the BC Act 2016 presented in Appendix D for this species.

Humpback whale (*Megaptera novaeangliae*)	Assessment under the BC Act
The following is to be taken into account for the purposes of determining whether a proposed development or activity is likely to significantly affect threatened species or ecological communities, or their habitats:	
a. In the case of a threatened species, whether the proposed development or activity is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction	Humpback whales transit almost the entirety of the east and west coasts of Australia annually during migrations from April to November. For the remainder of the year they occur in their summer feeding grounds around Antarctica. This species also feeds along the migration journey around Tasmania and Eden, NSW. They also rest around Jervis Bay and south east QLD. Calving for the east coast population occurs off the coast of Mackay, QLD (DoEE, 2019). As this species does not, feed, rest or calve in or around the project area, it is more likely to pass through during migrations. It is therefore considered unlikely that the proposed works would impact the lifecycle of this species.
b. In the case of an endangered ecological community or critically endangered ecological community, whether the proposed development or activity: (i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or (ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction	No endangered ecological community or critically endangered ecological community is located within the project area.
c. In relation to the habitat of a threatened species or ecological community: (i) the extent to which habitat is likely to be removed or modified as a result of the proposed development or activity, and (ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed development or activity, and (iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species or ecological community in the locality	Humpback whales transit almost the entirety of the east and west coasts of Australia annually during migrations from April to November. They migrate predominantly on coastal waters less than 200 m depth and within 20 km of the coast. For the remainder of the year they occur in their summer feeding grounds around Antarctica. This species also feeds along the migration journey around Tasmania and Eden, NSW. They also rest around Jervis Bay and south east QLD. Calving for the east coast population occurs off the coast of Mackay, QLD (DoEE, 2019). As this species does not, feed, rest or calve in or around the project area, it is more likely to pass through during migrations. As this species can avoid the area, it is therefore considered unlikely that the proposed works would impact the habitat of this species.
d. Whether the proposed development or activity is likely to have an adverse effect on any declared area of outstanding biodiversity value (either directly or indirectly)	No declared areas of outstanding biodiversity value are present within or around the project area.
e. Whether the proposed development or activity is or is part of a key threatening process or is likely to increase the impact of a key threatening process.	The proposed works are not expected to align with any of the key threatening processes nor increase the impact of a key threatened process listed under Schedule 4 of the BC Act 2016 presented in Appendix D for this species.

Loggerhead turtle *(Caretta caretta)*	Assessment under the BC Act
The following is to be taken into account for the purposes of determining whether a proposed development or activity is likely to significantly affect threatened species or ecological communities, or their habitats:	
a. In the case of a threatened species, whether the proposed development or activity is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction	This species breeds in northern Australia, with the closest breeding sites being in south-east QLD. This species locally migrates along most of the Australian coastline foraging for sponges on coral reefs, rocky reefs and inshore embayments. This species may forage on the sponges growing on the outfall pipe within the project area. However, Lake Macquarie is known to contain loggerhead turtles as there are also reefs in there for them to forage in, Therefore this species may transit through the outfall area and can avoid proposed works to forage in nearby Lake Macquarie. As the works are not located near a breeding area and feeding areas nearby would not be impacted, it is not anticipated that proposed works would have an effect on the lifecycle of the species.
b. In the case of an endangered ecological community or critically endangered ecological community, whether the proposed development or activity: (i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or (ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction	No endangered ecological community or critically endangered ecological community is located within the project area.
c. In relation to the habitat of a threatened species or ecological community: (i) the extent to which habitat is likely to be removed or modified as a result of the proposed development or activity, and (ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed development or activity, and (iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species or ecological community in the locality	This species breeds in northern Australia, with the closest breeding sites being in south-east QLD. This species locally migrates along most of the Australian coastline foraging for sponges on coral reefs, rocky reefs and inshore embayments. This species may forage on the sponges growing on the outfall pipe within the project area. However, Lake Macquarie is known to contain loggerhead turtles as there is also reefs in there for them to forage in, Therefore this species may transit through the outfall area and can avoid proposed works to forage in nearby Lake Macquarie. As the works are not located near a breeding area and feeding areas nearby would not be impacted, it is not anticipated that proposed works would have an effect on the habitat of the species.
d. Whether the proposed development or activity is likely to have an adverse effect on any declared area of outstanding biodiversity value (either directly or indirectly)	No declared areas of outstanding biodiversity value are present within or around the project area.
e. Whether the proposed development or activity is or is part of a key threatening process or is likely to increase the impact of a key threatening process.	The proposed works are not expected to align with any of the key threatening processes nor increase the impact of a key threatened process listed under Schedule 4 of the BC Act 2016 presented in Appendix D for this species.

Green turtle (*Chelonia mydas*)	Assessment under the BC Act
The following is to be taken into account for the purposes of determining whether a proposed development or activity is likely to significantly affect threatened species or ecological communities, or their habitats:	
a. In the case of a threatened species, whether the proposed development or activity is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction	This species breeds in northern Australia, with the closest breeding sites being in south-east QLD. This species locally migrates along most of the Australian coastline foraging for seagrass in soft sediments. There are no seagrass meadows located within the project area, Lake Macquarie is known to contain green turtles as there are seagrass meadows in there for them to forage in, Therefore this species may transit through the outfall area and can avoid proposed works to forage in nearby Lake Macquarie. As the works are not located near a breeding area and feeding areas nearby would not be impacted, it is not anticipated that proposed works would have an effect on the lifecycle of the species.
b. In the case of an endangered ecological community or critically endangered ecological community, whether the proposed development or activity: (i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or (ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction	No endangered ecological community or critically endangered ecological community is located within the project area.
c. In relation to the habitat of a threatened species or ecological community: (i) the extent to which habitat is likely to be removed or modified as a result of the proposed development or activity, and (ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed development or activity, and (iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species or ecological community in the locality	This species breeds in northern Australia, with the closest breeding sites being in south-east QLD. This species locally migrates along most of the Australian coastline foraging for seagrass in soft sediments. There are no seagrass meadows located within the project area, Lake Macquarie is known to contain green turtles as there are seagrass meadows in there for them to forage in, Therefore this species may transit through the outfall area and can avoid proposed works to forage in nearby Lake Macquarie. As the works are not located near a breeding area and feeding areas nearby would not be impacted, it is not anticipated that proposed works would have an effect on the habitat of the species.
d. Whether the proposed development or activity is likely to have an adverse effect on any declared area of outstanding biodiversity value (either directly or indirectly)	No declared areas of outstanding biodiversity value are present within or around the project area.
e. Whether the proposed development or activity is or is part of a key threatening process or is likely to increase the impact of a key threatening process.	The proposed works are not expected to align with any of the key threatening processes nor increase the impact of a key threatened process listed under Schedule 4 of the BC Act 2016 presented in Appendix D for this species.

Appendix B – Assessment under the FM Act

Great white shark (*Carcharodon carcharias*)	Assessment under the FM Act
The following is to be taken into account for the purposes of determining whether a proposed development or activity is likely to significantly affect threatened species or ecological communities, or their habitats:	
a. In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction	Juveniles, sub-adults and adults appear to aggregate seasonally along the northern half of Stockton Beach up to Hawks Nest in NSW, approximately 30 km north of the project area (DoEE, 2019). Adults can be found close inshore around rocky reefs, surf beaches and shallow costal bays through to outer continental shelf and slope areas. This species is distributed from Mackay, QLD, along the southern coast to north-west WA. This is a widely, but not evenly, dispersed species that does not rely on specific environments for core habitat and is a highly mobile species (DoEE, 2019). Therefore, activities associated with the project would not disrupt the lifecycle of this species.
b. In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction	No endangered population is present within the project area.
c. In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed: (i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or (ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction	No endangered ecological community or critically endangered ecological community is located within the project area.
d. In relation to the habitat of a threatened species, population or ecological community: (i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and: (ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and (iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality	The sharks that occur around Stockton Beach/Hawks Nest show high site fidelity, but not permanent residency to the area. This site is approximately 30 km north of the project area and is not anticipated to be impacted by proposed works (DoEE, 2019). Additionally, this species does not specifically have any core habitat requirements in any particular area, being a highly mobile and adaptive species. Therefore, activities for the proposed works are not anticipated to impact habitat associated with this species such that fragmentation of isolation of populations would occur and affect long-term survival.
e. Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)	The sharks that occur around Stockton Beach/Hawks Nest show high site fidelity, but not permanent residency to the area. This site is approximately 30 km north of the project area and is not anticipated to be impacted by proposed works. Additionally, this species does not specifically have any core habitat requirements in any particular area, being a highly mobile and adaptive species (DoEE 2019). Therefore, activities for the proposed works are not anticipated to impact habitat associated with this species.

Great white shark (*Carcharodon carcharias*)	Assessment under the FM Act
The following is to be taken into account for the purposes of determining whether a proposed development or activity is likely to significantly affect threatened species or ecological communities, or their habitats:	
f. Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan	A recovery plan was developed for this species under the Department of Sustainability, Environment, Water, Population and Communities (DSEWPC) in 2013. The proposed works are not anticipated to interfere with the objectives of this plan.
g. Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process	The proposed works are not expected to align with any of the key threatening processes listed under Schedule 6 of the FM Act 1994 nor increase the impact of a key threatened process on this species.

Appendix C – Assessment under the EPBC Act 1999

Significant Impact Criteria	Impact Outcome
An action is likely to have a significant impact on an endangered species if there is a real chance or possibility that it would:	
Result in invasive species that are harmful to an endangered species becoming established in the endangered species' habitat	**Unlikely** Southern right whale, Loggerhead turtle The proposed works are not expected to introduce or release any invasive species into the project area or surrounding area that may be harmful to an endangered species or increase the risk of an invasive species becoming established in the endangered species' habitat.
Introduce disease that may cause the species to decline	**Unlikely** Southern right whale, Loggerhead turtle The proposed works are not expected to introduce disease that may cause the species to decline into the project area or surrounding area.
Interfere with the recovery of the species	**Unlikely** Southern right whale, Loggerhead turtle The proposed works are not expected to interfere with the recovery of a species.

Significant Impact Criteria	Impact Outcome
An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it would:	
Lead to a long-term decrease in the size of an important population of a species	**Unlikely** Hawksbill turtle This species breeds in northern Australia, with the closest breeding sites being in the northern great Barrier Reef islands. This species locally migrates along most of the Australian coastline foraging for on a variety of animals and plants, including sponges in tropical tidal and sub-tidal coral and rocky reef habitats. This species may forage on the sponges growing on the outfall pipe within the project area. However, Lake Macquarie is known to contain hawksbill turtles as it provides foraging habitat. Therefore this species may transit through the outfall area and can avoid proposed works to forage in nearby Lake Macquarie. As the works are not located near a breeding area and feeding areas nearby would not be impacted, it is not anticipated that proposed works would have an effect on the population of the species.
Reduce the area of occupancy of an important population	**Unlikely** Hawksbill turtle This species breeds in northern Australia, with the closest breeding sites being in the northern great Barrier Reef islands. This species locally migrates along most of the Australian coastline foraging for on a variety of animals and plants, including sponges in tropical tidal and sub-tidal coral and rocky reef habitats. This species may forage on the sponges growing on the outfall pipe within the project area. However, Lake Macquarie is known to contain hawksbill turtles as it provides foraging habitat. Therefore this species may transit through the outfall area and can avoid proposed works to forage in nearby Lake Macquarie. As the works are not located near a breeding area and feeding areas nearby would not be impacted, it is anticipated that proposed works would not effect on the area of occupancy of the species.
Fragment an existing important population into two or more populations	**Unlikely** Hawksbill turtle There is no resident or breeding population within the project area. This is a highly mobile species that may visit Lake Macquarie and can avoid the project area to access habitat within the lake. It is therefore anticipated that proposed works would not fragment an existing population into two or more populations.

Significant Impact Criteria	Impact Outcome
Adversely affect habitat critical to the survival of a species	**Unlikely** Hawksbill turtle There is no core or critical habitat located within the project area. This is a highly mobile species that may visit the close by Lake Macquarie that contains foraging opportunities and resting areas. The proposed works would not inhibit entrance to the lake and this species can avoid the project area to enter the lake. It is therefore anticipated that the proposed works would not adversely affect habitat critical to the survival of this species.
Disrupt the breeding cycle of an important population	**Unlikely** Hawksbill turtle This species breeds in northern Australia, with the closest breeding sites being in the northern great Barrier Reef islands. As the works are not located near a breeding area and feeding areas nearby would not be impacted, it is not anticipated that proposed works would have an effect on the breeding cycle of the species.
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	**Unlikely** Hawksbill turtle There is no core or critical habitat located within the project area. This is a highly mobile species that may visit the close by Lake Macquarie that contains foraging opportunities and resting areas. The proposed works would not inhibit entrance to the lake and this species can avoid the project area to enter the lake. It is therefore anticipated that the proposed works would not adversely affect habitat used by the species to the extent that the species is likely to decline.
Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat	**Unlikely** Great white shark, Green turtle, Hawksbill turtle, Humpback whale The proposed works are not expected to introduce or release any invasive species into the project area or surrounding area that may be harmful to a vulnerable species or increase the risk of an invasive species becoming established in the vulnerable species' habitat.
Introduce disease that may cause the species to decline	**Unlikely** Great white shark, Green turtle, Hawksbill turtle, Humpback whale The proposed works are not expected to introduce disease that may cause the species to decline into the project area or surrounding area.
Interfere with the recovery of the species.	**Unlikely** Great white shark, Green turtle, Hawksbill turtle, Humpback whale The proposed works are not expected to interfere with the recovery of a species.

Significant Impact Criteria	Impact Outcome
An action is likely to have a significant impact on a listed migratory species if there is a real chance or possibility that it would:	
Result in an invasive species that is harmful to the migratory species becoming established in an area of important habitat for the migratory species	**Unlikely** Dugong The proposed works are not expected to introduce or release any invasive species into the project area or surrounding area that may be harmful to a migratory species or increase the risk of an invasive species becoming established in the migratory species' habitat.

Appendix D – State-listed Key Threatening Processes listed under the BC Act

Key threatening process	Type of threat
Alteration to the natural flow regimes of rivers, streams, floodplains & wetlands.	Habitat Loss/Change
Bushrock Removal	Habitat Loss/Change
Clearing of native vegetation	Habitat Loss/Change
Aggressive exclusion of birds from woodland and forest habitat by abundant Noisy Miners *Manorina melanocephala*.	Pest Animal
Alteration of habitat following subsidence due to longwall mining	Habitat Loss/Change
Competition and grazing by the feral European rabbit	Pest Animal
Competition and habitat degradation by Feral Goats, *Capra hircus* Linnaeus 1758	Pest Animal
Competition from feral honeybees	Pest Animal
Death or injury to marine species following capture in shark control programs on ocean beaches	Other Threat
Ecological consequences of high frequency fires	Habitat Loss/Change
Entanglement in, or ingestion of anthropogenic debris in marine and estuarine environments	Other Threat
Forest eucalypt dieback associated with over-abundant psyllids and Bell Miners	Other Threat
Habitat degradation and loss by Feral Horses (brumbies, wild horses), *Equus caballus*	Pest Animal
Herbivory and environmental degradation caused by feral deer	Pest Animal
Human-caused Climate Change	Habitat Loss/Change
Importation of red imported fire ants into NSW	Pest Animal
Infection by *Psittacine circoviral* (beak and feather) disease affecting endangered psittacine species	Disease
Infection of frogs by amphibian chytrid causing the disease chytridiomycosis	Disease
Infection of native plants by *Phytophthora cinnamomi*	Disease
Introduction and establishment of Exotic Rust Fungi of the order Pucciniales pathogenic on plants of the family Myrtaceae	Disease
Introduction of the large earth bumblebee (*Bombus terrestris*)	Pest Animal
Invasion and establishment of exotic vines and scramblers	Weed
Invasion and establishment of Scotch Broom (*Cytisus scoparius*)	Weed
Invasion and establishment of the Cane Toad	Pest Animal
Invasion of native plant communities by exotic perennial grasses	Weed
Invasion of native plant communities by bitou bush & boneseed	Weed
Invasion of native plant communities by African Olive *Olea europaea subsp. cuspidata* (Wall. ex G. Don) Cif.	Weed
Invasion of the yellow crazy ant (*Anoplolepis gracilipes*) into NSW	Pest Animal
Invasion, establishment and spread of Lantana (*Lantana camara* L. *sens. lat*)	Weed
Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants	Weed
Loss and/or degradation of sites used for hill-topping by butterflies	Habitat Loss/Change
Loss of Hollow-bearing Trees	Habitat Loss/Change
Predation and hybridisation by Feral Dogs, *Canis lupus familiaris*	Pest Animal
Predation by feral cats	Pest Animal
Predation by the European Red Fox	Pest Animal
Predation by the Plague Minnow (*Gambusia holbrooki*)	Pest Animal
Predation by the Ship Rat (*Rattus rattus*) on Lord Howe Island	Pest Animal
Predation, habitat degradation, competition and disease transmission by Feral Pigs (*Sus scrofa*)	Pest Animal

Key threatening process	Type of threat
Removal of dead wood and dead trees	Habitat Loss/Change

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